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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

SAE AMS 2759/1B

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Superseding AMS 2759/1A

HEAT TREATMENT OF CARBON AND LOW-ALLOY STEEL PARTS
Minimum Tensile Strength Below 220 ksi (1517 MPa)

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 carbon and low-alloy steel parts to minimum ultimate tensile strengths below 220 ksi (1517 MPa). Parts are defined in AMS 2759.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

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, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 384 Microhardness of Materials

3. TECHNICAL REQUIREMENTS:

3.1 Heat Treatment:

Shall conform to AMS 2759 and the requirements specified herein.

QUESTIONS REGARDING THIS DOCUMENT: (412) 772-7154 FAX (412) 776-0243
TO PLACE A DOCUMENT ORDER: (412) 776-4970 FAX (412) 776-0790

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) degrees, and for tempering shall be ±15 F (±8 C) degrees except shall be ±10 F (±6 C) degrees for H-1, D6AC, and 9Ni-4Co steels.

3.3 Heating Environment:

(R)

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)	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.

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.

3.3.1 (Continued)

Type 4: Parts that are partially machined with both unmachined, as-forged, as-cast, or hot-finished mill surfaces and 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 (R) If part type cannot be determined, the part shall be processed as Type 3.

3.3.2 (R) 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 (R) Protective Coatings: A supplemental coating or plating is permitted when permitted 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 (R) Preheating: Preheating until furnace stablilization 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 (R) 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, 3, or 4 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 (R) Parts coated with copper plate or similar reflective coatings which 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 5, 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 provided 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 5, cooling to a temperature below the critical, holding for sufficient time to complete transformation, and air cooling to ambient temperature.

3.4.4 (R) 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 5, and cooling to ambient temperature. Steel parts of the 9Ni-4Co type shall be subcritical annealed as specified in Table 2.

3.4.5 (R) 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 5, and cooling to ambient temperature.

3.4.6 (R) Normalizing: Shall be accomplished by heating to the temperature specified in Table 2, soaking for the time specified in Table 5, and cooling in air or atmosphere to ambient temperature. Circulated air or atmosphere is recommended for thicknesses greater than 3 inches (76 mm). Normalizing may be followed by tempering or subcritical annealing.

3.4.7 (R) Hardening (Austenitizing and Quenching): 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. Parts identified as damage tolerant, maintenance critical, or fracture critical shall be normalized before hardening. Hardening shall be accomplished by heating to the austenitizing temperature specified in Table 2, soaking for the time specified in Table 5, and quenching as specified in Table 2. The parts shall be cooled to or below the quenchant temperature before tempering.

3.4.8 (R) Tempering: 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). Suggested tempering temperatures for specific tensile strengths for each alloy and quenchant are given in Table 3. Alternate tempering temperatures for listed alloys, based on as-quenched hardness, are given in Table 4. 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 1 hour. Multiple tempering is permitted. When multiple tempering is used, parts shall be cooled to ambient temperature between tempering treatments.

3.4.8.1 (R) Parts may be snap tempered for 2 hours at a temperature, usually 400 °F (204 °C), that is lower than the tempering temperature.

3.4.9 Straightening: For parts having minimum tensile strength below 180 ksi (1241 MPa), straightening may be accomplished cold without stress relieving. When approved by the cognizant engineering organization, for parts hardened and tempered to minimum tensile strength of 180 ksi (1241 MPa) and higher, straightening shall be accomplished at either ambient temperature, during tempering, or by heating to not higher than 50 F (28 C) degrees 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) degrees 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 which 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 (R) 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 0.005 inch (0.13 mm). Intergranular oxidation shall not exceed 0.0007 inch (0.018 mm). Rejection criterion for depth of decarburization shall be the microhardness reading at which there is more than a 20-point Knoop, or equivalent, decrease in hardness from the core hardness. 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 0.002 inch (0.05 mm). Tests shall be in accordance with 3.6.1. These requirements 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 the surface contamination requirements of 3.5.1.

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 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 (R) Furnaces used exclusively to heat treat parts which 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 their 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 (R) Surface Contamination: Testing shall be performed by the microhardness method in accordance with ASTM E 384. 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 decarburization, carburization, and nitriding and the depth of any intergranular oxidation shall be determined by etching with the appropriate etchant and examining at approximately 250X magnification. The required etching procedure for intergranular oxidation is 7 to 20 minutes in a freshly prepared boiling solution proportional to 16 grams of chromic acid and 80 grams of sodium hydroxide in 145 mL of water; however, alternate etchants are acceptable if their effectiveness is substantiated. The chord method and acceptance limits in ARP1820 may be used as an alternate to ASTM E 384 and to enhance the intergranular oxidation examination.

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.

4.1 (R) 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 thru 4.1.3.

4.1.1 (R) Acceptance Tests: In addition to the tests specified in AMS 2759, tests for surface contamination (3.5.1) on damage tolerant or fracture critical parts shall be performed on each lot. It is the responsibility of purchaser to inform the heat treater on the drawing, contract, or purchase order that parts are damage tolerant or fracture critical.

4.1.2 (R) Periodic Tests: In addition to the tests specified in AMS 2759, tests for surface contamination (3.5.1) shall be performed monthly on each furnace in service, 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%.

4.1.3 (R) 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%.

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 This is an editorial revision to correct publication errors in the "A" (September 1996) issue. The (R) symbol is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the original (October 1984) issue of this specification.

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.

PREPARED UNDER THE JURISDICTION OF AMS COMMITTEE "E" AND AMEC

(R) TABLE 2A - Annealing, Normalizing, and Austenitizing Temperatures and Quenchants, Inch/Pound Units

Material Designation	Annealing (1) Temperature, °F	Normalizing Temperature, °F	Austenitizing Temperature, °F	Hardening Quenchant
1025	1625	1650	1600	water, polymer
1035	1600	1650	1550	oil, water, polymer
1045	1575	1650	1525	oil, water, polymer
1095 (2)	1500	1550	1475	oil, polymer
1137	1450	1650	1550	oil, water, polymer
3140	1500	1650	1500	oil, polymer
4037	1550	1650	1550	oil, water, polymer
4130	1550	1650	1575	oil, water, polymer
4135	1550	1650	1575	oil, polymer
4140	1550	1650	1550	oil, polymer
4150	1525	1600	1525	oil, polymer
4330V	1575	1650	1600	oil, polymer
4335V	1550	1650	1600	oil, polymer
4340	1550	1650	1500	oil, polymer
4640	1550	1650	1525	oil, polymer
6150	1550	1650	1600	oil, polymer
8630	1550	1650	1575	oil, water, polymer
8735	1550	1650	1550	oil, polymer
8740	1550	1650	1550	oil, polymer
H-11 (3)	1600	-	1850	air, oil, polymer
98BV40	1550	1600	1550	oil, polymer
D6AC (4)	1550	1725	1625 (5)	oil, polymer
9Ni-4Co-0.20C	(6)	1650	1525	oil, water, polymer (7)
9Ni-4Co-0.30C	(6)	1700	1550	oil, polymer (7)

NOTES:

1. Cool at a rate not to exceed 200 F degrees per hour to below 1000 °F, except 4330V, 4335V, and 4340 to below 800 °F, and 4640 to below 750 °F.
2. 1095 parts should be spheroidize annealed before hardening.
3. H-11 parts shall be in the annealed condition prior to the initial austenitizing treatment, except hot handled parts shall be annealed at 1625 °F and furnace cooled at 50 F degrees per hour maximum to at least 1000 °F.
4. D6AC parts shall be in the normalized or the normalized and tempered condition prior to the initial austenitizing treatment, except that parts only normalized without tempering shall be preheated prior to austenitizing.
5. 1700 °F permitted for D6AC parts when approved by the cognizant engineering organization.
6. 9Ni-4Co 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 and air cooling to ambient temperature.
7. Immediately after quenching 9Ni-4Co parts to below 140 °F, refrigerate parts at -90 °F or lower, hold for not less than 1 hour, and air warm to room temperature.

(R) TABLE 2B - Annealing, Normalizing, and Austenitizing Temperatures and Quenchants, SI Units

Material Designation	Annealing (1) Temperature, °C	Normalizing Temperature, °C	Austenitizing Temperature, °C	Hardening Quenchant
1025	885	899	871	water, polymer
1035	871	899	843	oil, water, polymer
1045	857	899	829	oil, water, polymer
1095 (2)	816	843	802	oil, polymer
1137	788	899	843	oil, water, polymer
3140	816	899	816	oil, polymer
4037	843	899	843	oil, water, polymer
4130	843	899	857	oil, water, polymer
4135	843	899	857	oil, polymer
4140	843	899	843	oil, polymer
4150	829	871	829	oil, polymer
4330V	857	899	871	oil, polymer
4335V	843	899	871	oil, polymer
4340	843	899	816	oil, polymer
4640	843	899	829	oil, polymer
6150	843	899	871	oil, polymer
8630	843	899	857	oil, water, polymer
8735	843	899	843	oil, polymer
8740	843	899	843	oil, polymer
H-11 (3)	871	-	1010	air, oil, polymer
98BV40	843	871	843	oil, polymer
D6AC (4)	843	941	885 (5)	oil, polymer
9Ni-4Co-0.20C	(6)	899	829	oil, water, polymer (7)
9Ni-4Co-0.30C	(6)	927	843	oil, polymer (7)

NOTES:

1. Cool at a rate not to exceed 111 C degrees per hour to below 538 °C, except 4330V, 4335V, and 4340 to below 427 °C, and 4640 to below 399 °C.
2. 1095 parts should be spheroidize annealed before hardening.
3. H-11 parts shall be in the annealed condition prior to the initial austenitizing treatment, except hot handled parts shall be annealed at 885 °C and furnace cooled at 28 C degrees per hour maximum to at least 538 °C.
4. D6AC parts shall be in the normalized or the normalized and tempered condition prior to the initial austenitizing treatment, except that parts only normalized without tempering shall be preheated prior to austenitizing.
5. 927 °C permitted for D6AC parts when approved by the cognizant engineering organization.
6. 9Ni-4Co parts shall be duplex subcritical annealed by heating at 677 °C for 4 hours ± 1/4 , air cooling to ambient temperature, reheating at 621 °C for 4 hours ± 1/4, and air cooling to ambient temperature or shall be annealed by heating at 621 °C for not less than 23 hours, and air cooling to ambient temperature.
7. Immediately after quenching 9Ni-4Co parts to below 60 °C, refrigerate parts at -68 °C or lower, hold for not less than 1 hour, and air warm to room temperature.

(R) TABLE 3A - Suggested Tempering Temperatures, °F

Material Designation	Quenchant	Tensile Strength Range ksi (1) 90.0 to 125	Tensile Strength Range ksi (1) 125 to 150	Tensile Strength Range ksi (1) 150 to 170	Tensile Strength Range ksi (1) 160 to 180	Tensile Strength Range ksi (1) 180 to 200	Tensile Strength Range ksi (1) 200 to 220
1025	water	700	-	-	-	-	-
1035	water	850	-	-	-	-	-
1035	oil, polymer	700	-	-	-	-	-
1045	water	1050	900	700	-	-	-
1045	oil, polymer	1000	800	-	-	-	-
1095	oil, polymer	1250	1150	1000	900	800	700
1137	oil, polymer	900	625	-	-	-	-
1137	water	1000	900	800	700	600	-
3140	oil, polymer	1250	1100	975	875	800	-
4037	oil, polymer	1100	1000	925	825	700	-
4037	water	1200	1100	1000	875	725	-
4130 (2)	oil, polymer	1200	1050	925	800	-	-
4130 (2)	water	1250	1100	975	875	700	-
4135 (2)	oil, polymer	1250	1125	1025	900	800	-
4140 (2)	oil, polymer	1300	1175	1075	950	850	725
4150	oil, polymer	-	1200	1100	975	800	-
4330V	oil, polymer	-	-	-	-	1000	800 (3)
4335V	oil, polymer	-	-	-	-	1000	800 (3)
4340 (2)	oil, polymer	-	1200	1100	1025	925	825 (3)
4640	oil, polymer	1200	1100	1000	900	750	-
6150	oil, polymer	-	1200	1100	1000	925	825 (4)
8630 (2)	oil, polymer	1200	1025	925	825	700	-
8630 (2)	water	1200	1025	950	825	700	-
8735 (2)	oil, polymer	1200	1125	1025	800	775	-
8740 (2)	oil, polymer	1275	1175	1075	975	850	725
H-11 (3)	air	-	-	-	-	-	1100
98BV40	oil, polymer	-	1200	1100	1000	900	800
D6AC (3)	oil, polymer	-	-	-	1200	(5)	(6)
9Ni-4Co-0.20C (3)	oil, polymer	-	-	-	-	1025 (7)	-
9Ni-4Co-0.30C (3)	oil, polymer	-	-	-	-	1050 (8)	-

NOTES:

1. Absence of values indicates the respective steel is not recommended for the specified tensile strength range.
2. See Table 4.
3. At least two tempering operations required.
4. Spring temper.
5. 1st temper: 1100 °F min; 2nd temper: 1115 to 1200 °F.
6. 1st temper: 1050 °F min; 2nd temper: 1095 to 1145 °F.
7. 190 ksi min tensile strength.
8. 210 ksi min tensile strength.

(R) TABLE 3B - Suggested Tempering Temperatures, °C

Material Designation	Quenchant	Tensile Strength Range MPa (1) 621 to 862	Tensile Strength Range MPa (1) 862 to 1034	Tensile Strength Range MPa (1) 1034 to 1172	Tensile Strength Range MPa (1) 1172 to 1241	Tensile Strength Range MPa (1) 1241 to 1379	Tensile Strength Range MPa (1) 1379 to 1517
1025	water	371	-	-	-	-	-
1035	water	454	-	-	-	-	-
1035	oil, polymer	371	-	-	-	-	-
1045	water	566	482	371	-	-	-
1045	oil, polymer	538	427	-	-	-	-
1095	oil, polymer	677	621	538	482	427	371
1137	oil, polymer	482	329	-	-	-	-
1137	water	538	482	427	371	316	-
3140	oil, polymer	677	593	524	468	427	-
4037	oil, polymer	593	538	496	440	371	-
4037	water	649	593	538	468	385	-
4130 (2)	oil, polymer	649	566	496	427	-	-
4130 (2)	water	677	593	524	468	371	-
4135 (2)	oil, polymer	677	607	552	482	427	-
4140 (2)	oil, polymer	704	635	579	510	454	385
4150	oil, polymer	-	649	593	524	427	-
4330V	oil, polymer	-	-	-	-	538	427 (3)
4335V	oil, polymer	-	-	-	-	538	427 (3)
4340 (2)	oil, polymer	-	649	593	552	496	441 (3)
4640	oil, polymer	649	593	538	482	399	-
6150	oil, polymer	-	649	593	538	496	441 (4)
8630 (2)	oil, polymer	649	552	496	441	371	-
8630 (2)	water	649	552	510	441	371	-
8735 (2)	oil, polymer	649	607	552	427	413	-
8740 (2)	oil, polymer	691	635	579	524	454	385
H-11 (3)	air	-	-	-	-	-	593
98BV40	oil, polymer	-	649	593	538	482	427
D6AC (3)	oil, polymer	-	-	-	649	(5)	(6)
9Ni-4Co-0.20C (3)	oil, polymer	-	-	-	-	552 (7)	-
9Ni-4Co-0.30C (3)	oil, polymer	-	-	-	-	566 (8)	-

NOTES:

1. Absence of values indicates the respective steel is not recommended for the specified tensile strength range.
2. See Table 4.
3. At least two tempering operations required.
4. Spring temper.
5. 1st temper: 593 °C min; 2nd temper: 602 to 649 °C.
6. 1st temper: 566 °C min; 2nd temper: 591 to 618 °C.
7. 1310 MPa min tensile strength.
8. 1448 MPa min tensile strength.