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Standard Specification for Structural Steel for Bridges[1]

This standard is issued under the fixed designation A 709/A 709M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers carbon and high-strength low-alloy steel structural shapes, plates, and bars and quenched and tempered alloy steel for structural plates intended for use in bridges. Nine grades are available in four yield strength levels as follows:

Grade U.S. [SI]	Yield Strength, ksi [MPa]
36 [250]	36 [250]
50 [345]	50 [345]
50S [345S]	50 [345]
50W [345W]	50 [345]
HPS 50W [HPS 345W]	50 [345]
HPS 70W [HPS 485W]	70 [485]
100 [690]	100 [690]
100W [690W]	100 [690]
HPS 100W [HPS 690W]	100 [690]

~~1.1.1Grades 36 [250], 50 [345], 50S [345S], 50W [345W], 100 [690], and 100W [690W] are also included in Specifications A36/A 36M, A 572/A 572M, A992/A 992M, A 588/A 588M, and A514/A 514M, respectively. When the supplementary requirements of this specification are specified, they exceed the requirements of Specifications A36/A 36M, A572/A 572M, A992/A 992M, A588/A 588M, and A 514/A 514M~~

1.1.1 Grades 36 [250], 50 [345], 50S [345S], 50W [345W], 100 [690], and 100W [690W] are also included in Specifications A 36/A 36M, A 572/A 572M, A 992/A 992M, A 588/A 588M, A 514/A 514M, and A 514/A 514M, respectively. When the supplementary requirements of this specification are specified, they exceed the requirements of Specifications A 36/A 36M, A 572/A 572M, A 992/A 992M, A 588/A 588M, and A 514/A 514M.

1.1.2 Grades 50W [345W], HPS 50W [HPS 345W], HPS 70W [HPS 485W], 100W [690W], and HPS 100W [HPS 690W] have enhanced atmospheric corrosion resistance (see 14.1.2). Product availability is shown in Table 1.

1.2 Grade HPS 70W [HPS 485W], 100 [690], 100W [690W], or HPS 100W [HPS 690W] shall not be substituted for Grades 36 [250], 50 [345], 50S [345S], 50W [345W], or HPS 50W [HPS 345W]. Grade 50W [345W], or HPS 50W [HPS 345W] shall not be substituted for Grades 36 [250], 50 [345] or 50S [345S] without agreement between the purchaser and the supplier.

1.3 When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized. See Appendix X3 of Specification A 6/A 6M~~/A6M~~ for information on weldability.

1.4 For structural products to be used as tension components requiring notch toughness testing, standardized requirements are provided in this standard, and they are based upon American Association of State Highway and Transportation Officials (AASHTO) requirements for both fracture critical and non-fracture critical members.

1.5 Supplementary requirements are available but shall apply only if specified in the purchase order.

1.6 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system is to be used independently of the ~~other, without combining~~ other. Combining values from the two systems may result in ~~any way.~~ non-conformance with the standard.

1.7 For structural products produced from coil and furnished without heat treatment or with stress relieving only, the additional requirements, including additional testing requirements and the reporting of additional test results, of Specification A 6/A 6M~~/A6M~~ apply.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock and Ships.

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***A Summary of Changes section appears at the end of this standard.**

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
A 36/A 36M Specification for Carbon Structural Steel
A 370 Test Methods and Definitions for Mechanical Testing of Steel Products
A 514/A 514M Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
A 572/A 572M Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A 588/A 588M Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
A 673/A 673M Specification for Sampling Procedure for Impact Testing of Structural Steel
A 992/A 992M Specification for Structural Steel Shapes
G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *fracture critical member*—a main load-carrying tension member or tension component of a bending member whose failure would be expected to cause collapse of a structure or bridge without multiple, redundant load paths.

3.1.2 *main load-carrying member*—a steel member designed to carry primary design loads, including dead, live, impact, and other loads.

3.1.3 *non-fracture critical member*—a main load-carrying member whose failure would not be expected to cause collapse of a structure or bridge with multiple, redundant load paths.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Tensile and Hardness Requirements[A]

NOTE 1— Where ". . ." appears in this table, there is no requirement.

Grade	Plate Thickness, in. [mm]	Structural Shape Flange or Leg Thickness, in. [mm]	Yield Point or Yield Strength,[B] ksi [MPa]	Tensile Strength, ksi [MPa]	Minimum Elongation, %				Reduction of Area[C,D] min, %	Brinell Hardness Number
					Plates and Bars[C,E]		Shapes[E]			
					8 in. or 200 mm	2 in. or 50 mm	8 in. or 200 mm	2 in. or 50 mm		
36 [250]	to 4 [100], incl	to 3 in. [75 mm], incl	36 [250] min	58–80 [400–550]	20	23	20	21	...	...
		over 3 in. [75 mm]	36 [250] min	58 [400] min	...	..	20	19	...	...
50 [345]	to 4 [100], incl	all	50 [345] min	65 [450] min	18	21	18	21[F]	...	...
50S [345S]	[G]	all	50–65 [345–450][HI]	65 [450][H] min	...	...	18	21	...	...
50W [345W] and HPS 50W [HPS 345W]	to 4 [100], incl	all	50 [345] min	70 [485] min	18	21	18	21[J]	...	...
HPS 70W [HPS 485 W]	to 4 [100], incl	[G]	70 [485] min[B]	85–110 [585–760]	. . .	19[K]	. . .	. . .	. . .	...
100 [690] , 100W [690W], and HPS 100W [HPS 690W]	to 2½ [65], incl	[G]	100 [690] min[B]	110–130 [760–895]	...	18[K]	...	...	[L]	235–293[M]
100 [690] and 100W [690 W]	over 2½ to 4 [65 to 100]	[G]	90 [620] min[B]	100–130 [690–895]	...	16[K]	...	...	[L]	...

[A] See specimen orientation and preparation subsection in the Tension Tests section of Specification A 6/A 6M.
[B] Measured at 0.2 % offset or 0.5 % extension under load as described in Section 13 of Test Methods A 370.
[C] Elongation and reduction of area not required to be determined for floor plates.
[D] For plates wider than 24 in. [600 mm], the reduction of area requirement, where applicable, is reduced by five percentage points.
[E] For plates wider than 24 in. [600 mm], the elongation requirement is reduced by two percentage points. See elongation requirement adjustments in the Tension Tests section of Specification A 6/A 6M.
[F] Elongation in 2 in. or 50 mm: 19 % for shapes with flange thickness over 3 in. [75 mm].
[G] Not applicable.
[H] The yield to tensile ratio shall be 0.87 or less for shapes that are tested from the web location; for all other shapes, the requirement is 0.85.
[I] A maximum yield strength of 70 ksi [480 MPa] is permitted for structural shapes that are required to be tested from the web location.
[J] For wide flange shapes with flange thickness over 3 in. [75 mm], elongation in 2 in. or 50 mm. of 18 % minimum applies.
[K] If measured on the Fig. 3 (Test Methods A 370) 1½ –in. [40–mm] wide specimen, the elongation is determined in a 2-in. or 50-mm. gage length that includes the fracture and shows the greatest elongation.
[L] 40 % minimum applies if measured on the Fig 3 (Test Methods A 370) 1 ½ –in. [40-mm] wide specimen; 50 % minimum applies if measured on the Fig. 4 (Test Methods A 370)) ½ –in. [12.5-mm] round specimen.
[M] Applies only to Grades 100 [690] and 100W [690W] plates that are ⅜ in. [10 mm] or less in thickness and are not tension tested (Ssee 8.1).

TABLE 2 Grade 36 [250] Chemical Requirements (Heat Analysis)

NOTE 1— Where ". . ." appears in this table there is no requirement. The heat analysis for manganese shall be determined and reported as described in the Heat Analysis section of Specification A 6/A 6M..

Product Thickness, in. (mm)	Shapes[A] All	Plates[B]				Bars[B]		
		To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 2½ [40 to 65], incl	Over 2½ to 4 [65 to 100], incl	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 4 [100], incl
Carbon, max, %	0.26	0.25	0.25	0.26	0.27	0.26	0.27	0.28
Manganese, %	...	...	0.80–1.20	0.80–1.20	0.85–1.20	...	0.60–0.90	0.60–0.90
Phosphorus, max, %	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max, %	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Silicon, %	0.40 max	0.40 max	0.40 max	0.15–0.40	0.15–0.40	0.40 max	0.40 max	0.40 max
Copper, min, % when copper steel is specified	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

[A] Manganese content of 0.85 to 1.35 % and silicon content of 0.15 to 0.40 % is required for shapes with flange thickness over 3 in. [75 mm].
[B] For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

TABLE 3 Grade 50 [345] Chemical Requirements[A] (Heat Analysis)

Maximum Diameter, Thickness, or Distance Between Parallel Faces, in. [mm]	Carbon, max, %	Manganese,[B] max, %	Phosphorus, max, %	Sulfur, max, %	Silicon[C]		Columbium, Vanadium and Nitrogen
					Plates to 1½-in. [40–mm] Thick, Shapes with flange or leg thickness to 3 in. [75 mm] inclusive, Sheet Piling, Bars, Zees, and Rolled Tees, max, %[D]	Plates Over 1½ –in. [40-mm] Thick and Shapes with flange thickness over 3 in. [75 mm], %	
4 [100]	0.23	1.35	0.04	0.05	0.40	0.15–0.40	[E]

~~[A] Copper when specified shall have a minimum content of 0.20 % by heat analysis (0.18 % by product analysis).~~
[A] Copper when specified shall have a minimum content of 0.20 % by heat analysis (0.18 % by product analysis).
~~[B] Manganese, minimum by heat analysis of 0.80 % (0.75 % by product analysis) shall be required for all plates over ⅜ in. [10 mm] in thickness; a minimum of 0.50 % (0.45 % by product analysis) shall be required for plates ⅜ in. [10 mm] and less in thickness, and for all other products. The manganese to carbon ratio shall not be less than 2 to 1. For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum is permitted, up to a maximum of 1.60 %.~~
[B] Manganese, minimum by heat analysis of 0.80 % (0.75 % by product analysis) shall be required for all plates over ⅜ in. [10 mm] in thickness; a minimum of 0.50 % (0.45 % by product analysis) shall be required for plates ⅜ in. [10 mm] and less in thickness, and for all other products. The manganese to carbon ratio shall not be less than 2 to 1. For each reduction of 0.01 percentage point below the specified carbon maximum, an increase of 0.06 percentage point manganese above the specified maximum is permitted, up to a maximum of 1.60 %.
~~[C] Silicon content in excess of 0.40 % by heat analysis must be negotiated.~~
[C] Silicon content in excess of 0.40 % by heat analysis must be negotiated.
~~[D] Bars over 1½ in. [40 mm] in diameter, thickness, or distance between parallel faces, shall be made by a killed steel practice.~~
[D] Bars over 1½ in. [40 mm] in diameter, thickness, or distance between parallel faces, shall be made by a killed steel practice.
~~[E] Alloy content shall be in accordance with Type 1, 2, 3, or 5 and the contents of the applicable elements shall be reported on the test report.~~
[E] Alloy content shall be in accordance with Type 1, 2, 3, or 5 and the contents of the applicable elements shall be reported on the test report.

Type	Elements	Heat Analysis, %
1	Columbium[A]	0.005–0.05[B]
2	Vanadium	0.01–0.15
3	Columbium[A]	0.005–0.05[B]
	Vanadium	0.01–0.15
	Columbium plus vanadium	0.02–0.15[C]
5	Titanium	0.006–0.04
	Nitrogen	0.003–0.015
	Vanadium	0.06 max

[A] Columbium shall be restricted to Grade 50 [345] plate, bar, zee, and rolled tee thickness of ¾ in. [20 mm] max, and to shapes with flange or leg thickness to 1½ in. [40 mm] inclusive unless killed steel is furnished. Killed steel shall be confirmed by a statement of killed steel on the test report, or by a report of the presence of a sufficient quantity of a strong deoxidizing element, such as silicon at 0.10 % or higher, or aluminum at 0.015 % or higher.
[B] Product analysis limits = 0.004 to 0.06 %.
[C] Product analysis limits = 0.01 to 0.16 %.

3.1.4 *non-tension component* —a steel member that is not in tension under any design loading.

TABLE 4 Grade 50W [345 W] Chemical Requirements (Heat Analysis)

NOTE 1—Types A, B, and C are equivalent to Specification A 588/A 588M Grades A, B, and C, respectively. Grades A, B, and C, respectively.

Element	Composition, %[A]		
	Type A	Type B	Type C
Carbon[B]	0.19 max	0.20 max	0.15 max
Manganese[B]	0.80–1.25	0.75–1.35	0.80–1.35
Phosphorus	0.04 max	0.04 max	0.04 max
Sulfur	0.05 max	0.05 max	0.05 max
Silicon	0.30–0.65	0.15–0.50	0.15–0.40
Nickel	0.40 max	0.50 max	0.25–0.50
Chromium	0.40–0.65	0.40–0.70	0.30–0.50
Copper	0.25–0.40	0.20–0.40	0.20–0.50
Vanadium	0.02–0.10	0.01–0.10	0.01–0.10

[A] Weldability data for these types have been qualified by FHWA for use in bridge construction.
[B] For each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage point above the specified maximum for manganese is permitted, up to a maximum of 1.50 %.

TABLE 5 Grade 100 [690] and 100W [690W] Chemical Requirements (Heat Analysis)

NOTE 1— Where ". . ." appears in this table there is no requirement.
NOTE 2—Types A, B, C, E, F, H, J, M, P, and Q are equivalent to Specification A 514/A 514M Grades A, B, C, E, F, H, J, M, P, and Q, respectively. Grades A, B, C, E, F, H, J, M, P, and Q, respectively.

	Type A, %	Type B, %	Type C, %	Type E[A], %	Type F[A], %	Type H, %	Type J, %	Type M, %	Type P[A], %	Type Q[A], %
Maximum Thickness, in. [mm]	1¼ [32]	1¼ [32]	1¼ [32]	4 [100]	2½ [65]	2 [50]	1¼ [32]	2 [50]	4 [100]	4 [100]
Carbon	0.15–0.21	0.12–0.21	0.10–0.20	0.12–0.20	0.10–0.20	0.12–0.21	0.12–0.21	0.12–0.21	0.12–0.21	0.14–0.21
Manganese	0.80–1.10	0.70–1.00	1.10–1.50	0.40–0.70	0.60–1.00	0.95–1.30	0.45–0.70	0.45–0.70	0.45–0.70	0.95–1.30
Phosphorus, max	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Silicon	0.40–0.80	0.20–0.35	0.15–0.30	0.20–0.40	0.15–0.35	0.20–0.35	0.20–0.35	0.20–0.35	0.20–0.35	0.15–0.35
Nickel	...	...	...	...	0.70–1.00	0.30–0.70	...	1.20–1.50	1.20–1.50	1.20–1.50
Chromium	0.50–0.80	0.40–0.65	...	1.40–2.00	0.40–0.65	0.40–0.65	...	...	0.85–1.20	1.00–1.50
Molybdenum	0.18–0.28	0.15–0.25	0.15–0.30	0.40–0.60	0.40–0.60	0.20–0.30	0.50–0.65	0.45–0.60	0.45–0.60	0.40–0.60
Vanadium	...	0.03–0.08	...	[B]	0.03–0.08	0.03–0.08	...	...	...	0.03–0.08
Titanium	...	0.01–0.03	...	0.01–0.10	...	...	...	...	...	. ..
Zirconium	0.05–0.15[C]	...	...	...	...	...	...	...	...	...
Copper	...	...	...	...	0.15–0.50	...	...	...	...	...
Boron	0.0025–max	0.0005–0.005	0.001–0.005	0.001–0.005	0.0005–0.006	0.0005–0.005	0.001–0.005	0.001–0.005	0.001–0.005	...

[A] Types E, F, P, and Q meet the requirements of atmospheric corrosion resistance in accordance with 1~~1~~4.1.2.
[B] May be substituted for part or all of titanium content on a one for one basis.
[C] Zirconium may be replaced by cerium. When cerium is added, the cerium/sulfur ratio should be approximately 1.5 to 1, based upon heat analysis.

3.1.5 *secondary member* —a steel member used for aligning and bracing of main load-carrying members, or for attaching utilities, signs, or other items to them, but not to directly support primary design loads

3.1.6 *tension component* —a part or element of a fracture critical or non-fracture critical member that is in tension under various design loadings.

4. Ordering Requirements

4.1 In addition to the items listed in the ordering information section of Specification A 6/A 6M, the following items should be considered if applicable:

4.1.1 Type of component (tension or non-tension, fracture critical or non-fracture critical) (see Section 10).

4.2 Impact testing temperature zone (see Table 8).

5. General Requirements for Delivery

5.1 Structural products furnished under this specification shall conform to the requirements of the current edition of Specification ~~A6~~A 6/A 6M~~/A6M,~~, for the specific structural product ordered, unless a conflict exists in which case this specification shall prevail.

TABLE 6 Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485 W], and HPS 100W [HPS 690W] Chemical Requirements (Heat Analysis)

NOTE 1— Where ". . ." appears in this table, there is no requirement.

Element	Composition, %	
	Grades HPS 50W [HPS 345W], HPS 70W [HPS 485W]	Grade HPS 100W [HPS 690W]
Carbon	0.11 max	0.08 max
Manganese		
2.5 in. [65 mm] and under	1.10–1.35	0.95–1.50
Over 2.5 in. [65 mm]	1.10–1.50	[A]
Phosphorus	0.020 max	0.015 max
Sulfur[B]	0.006 max	0.006 max
Silicon	0.30–0.50	0.15–0.35
Copper	0.25–0.40	0.90–1.20
Nickel	0.25–0.40	0.65–0.90
Chromium	0.45–0.70	0.40–0.65
Molybdenum	0.02–0.08	0.40–0.65
Vanadium	0.04–0.08	0.04–0.08
Columbium (Niobium)	. . .	0.01–0.03
Aluminum	0.010–0.040	0.020–0.050
Nitrogen	0.015 max	0.015 max

[A] Not applicable.
[B] The steel shall be calcium treated for sulfide shape control.

TABLE 7 Grade 50S [345S] Chemical Requirements (Heat Analysis)

Element	Composition, %
Carbon, max	0.23
Manganese	0.50 to 1.60[A]
Silicon, max	0.40
Vanadium, max	0.15[B]
Columbium, max	0.05[B]
Phosphorus, max	0.035
Sulfur, max	0.045
Copper, max	0.60
Nickel, max	0.45
Chromium, max	0.35
Molybdenum, max	0.15

[A] Provided that the ratio of manganese to sulfur is not less than 20 to 1, the minimum limit for manganese for shapes with flange or leg thickness not exceeding 1 in. [25 mm] shall be 0.30 %.
[B] The sum of columbium and vanadium shall not exceed 0.15 %.

TABLE 8 Relationship Between Impact Testing Temperature Zones and Minimum Service Temperature

Zone	Minimum Service Temperature, °F [°C]
1	0 [–18]
2	below 0 to –30 [–18 to –34]
3	below –30 to –60 [–34 to –51]

5.2 Coils are excluded from qualification to this specification until they are processed into a finished structural product. Structural products produced from coil means structural products that have been cut to individual lengths from a coil. The processor directly controls, or is responsible for, the operations involved in the processing of a coil into a finished structural product. Such operations include decoiling, leveling or straightening, hot-forming or cold-forming (if applicable), cutting to length, testing, inspection, conditioning, heat treatment (if applicable), packaging, marking, loading for shipment, and certification.

NOTE 1—For structural products produced from coil and furnished without heat treatment or with stress relieving only, two test results are to be reported for each qualifying coil. Additional requirements regarding structural products produced from coil are described in Specification A 6/A 6M~~/A6M~~.

6. Materials and Manufacture

6.1 For Grades 36 [250] and 50 [345], the steel shall be semi-killed or killed.
6.2 For Grades 50W [345W], HPS 50W [HPS 345W], and HPS 70W [HPS 485W], the steel shall be made to fine grain practice.

6.3 For Grade 50S [345S], the steel shall be killed and such shall be affirmed in the test report by a statement of *killed steel*, a value of 0.10 % or more for the silicon content, or a value of 0.015 % or more for the total aluminum content.

6.4 For Grade 50S [345S], the steelmaking practice used shall be one that produces steel having a nitrogen content not greater than 0.015 % and includes the addition of one or more nitrogen-binding elements, or one that produces steel having a nitrogen content of not greater than 0.012 % (with or without the addition of nitrogen-binding elements). The nitrogen content need not be reported, regardless of which steelmaking practice was used.

6.5 For Grades HPS 50W [HPS 345W], HPS 70W [HPS 485W], and HPS 100W [HPS 690W], the steel shall be made using a low-hydrogen practice, such as vacuum degassing during steel making; controlled soaking of the ingots, slabs; controlled slow cooling of the ingots, slabs, or plates, or a combination thereof.

6.6 For Grades 100 [690], 100W [690W],and HPS 100W [HPS 690W], the requirements for fine austenitic grain size in Specification ~~A6~~A 6/A 6M~~/A6M~~ shall be met.

6.7 Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485W] shall be furnished in one of the following conditions: as-rolled, control-rolled, thermo-mechanical control processed (TMCP) with or without accelerated cooling, or quenched and tempered.

7. Heat Treatment

7.1 For quenched and tempered Grades HPS 50W [HPS 345W] and HPS 70W [HPS 485W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to not less than 1650°F [900°C], quenching it in water or oil, and tempering it at not less than 1100°F [590°C]. The heat-treating temperatures shall be reported on the test certificates.

7.2 For Grades 100 [690] and 100W [690W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to not less than 1650°F [900°C], quenching it in water or oil, and tempering it at not less than 1150°F [620°C]. The heat-treating temperatures shall be reported on the test certificates.

7.3 For Grade HPS 100W [HPS 690W], the heat treatment shall be performed by the manufacturer and shall consist of heating the steel to a temperature in the range from 1600 to 1700°F [870 to 925°C], quenching it in water, and tempering it at not less than 1050°F [565°C] for a time to be determined by the manufacturer. The heat-treating temperatures shall be reported on the test certificates.

8. Chemical Requirements

8.1 The heat analysis shall conform to the requirements for the specified grade, as given in Tables 2-7.

8.2 For Grade 50S [345S], in addition to the elements listed in Table 7, test reports shall include, for information, the chemical analysis for tin. Where the amount of tin is less than 0.02 %, it shall be permissible for the analysis to be reported as <0.02 %.

8.3 For Grade 50S [345S], the maximum permissible carbon equivalent value shall be 0.47 % for structural shapes with flange thickness over 2 in. [50 mm], and 0.45 % for other structural shapes. The carbon equivalent shall be based on heat analysis. The required chemical analysis as well as the carbon equivalent shall be reported. The carbon equivalent shall be calculated using the following formula:

$$CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15} \quad (1)$$

9. Tensile Requirements

9.1 The material as represented by test specimens, except as specified in 9.2, shall conform to the requirements for tensile properties given in Table 1.

9.2 For Grade 36 [250], shapes less than 1 in.^{2} [645 mm^2] in cross section and bars, other than flats, less than ½ in. [12.5 mm] in thickness or diameter need not be subjected to tension tests by the manufacturer.

10. Impact Testing Requirements

10.1 *Non-Fracture-Critical, T, Tension Components* —Structural products ordered for use as tension components of non-fracture-critical members shall be impact tested in accordance with Specification A 673/A 673Mand as given in Table 9. The test results shall meet the requirements given in Table 9.

10.2 *Fracture-Critical, F, Tension Components*—Structural products ordered for use as tension components of fracture-critical members shall be impact tested in accordance with Specification A 673/A 673M and as given in Table 10. The test results shall meet the requirements given in Table 10.

10.3 Steel grades ordered for use without suffix T or F as listed in 10.1 and 10.2 do not require impact testing and shall be used as non-tension components or secondary members only.

11. Brinell Hardness Requirements for Grades 100 [690] and 100W [690W]

11.1 For plates ⅜ in. [10 mm] and under in thickness, a Brinell hardness test may be used instead of tension testing each plate, in which case a tension test specimen shall be taken from a corner of each of two plates per lot. A lot shall consist of plates from the same heat and thickness, same prior condition and scheduled heat treatment and shall not exceed 15 tons [15 Mg] in weight [mass]. A Brinell hardness test shall be made on each plate not tension tested and shall meet the requirements given in Table 1.