Designation: A 710/A 710M – 02 (Reapproved 2007)

Standard Specification for Precipitation–Strengthened Low-Carbon Nickel-Copper-Chromium-Molybdenum-Columbium Alloy Structural Steel Plates[1]

This standard is issued under the fixed designation A 710/A 710M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers low-carbon precipitation—strengthened nickel - copper - chromium - molybdenum - columbium alloy steel plates for general applications. The alloys in this specification are strengthened by precipitation in various temperature ranges. Precipitation strengthening can occur upon air cooling after hot rolling, during normalizing, and by another heat treatment. These grades are not intended for use in applications above 900°F [540°C].

1.2 Two grades, each with three classes, are provided as follows:

Grade and Class	Condition
Grade A, Class 1	as-rolled and precipitation heat treated
Grade A, Class 2	normalized and precipitation heat treated
Grade A, Class 3	quenched and precipitation heat treated
Grade B, Class 1	as-rolled
Grade B, Class 2	normalized
Grade B, Class 3	normalized and precipitation heat treated

1.3 Grade A provides minimum yield strength levels ranging from 50 to 85 ksi [345 to 585 MPa], depending on thickness and condition.

1.4 Grade A, Class 1, plates are limited to a maximum thickness of ¾ in. [20 mm]. The maximum thickness of Grade A, Classes 2 and 3, is limited only by the capacity of the composition to meet the specified mechanical property requirements; however, current practice normally limits the maximum thickness to 8 in. [200 mm].

1.5 Mandatory notch toughness requirements are specified for Grade A, Class 1.

1.6 Grade B provides minimum yield strength levels ranging from 70 to 75 ksi [480 to 515 MPa], depending on thickness and condition.

1.7 Grade B plates are limited to a maximum thickness of 2 in. [50 mm].

1.8 Mandatory notch toughness requirements are specified for the three classes of Grade B.

1.9 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 for information on weldability.

1.10 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 must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

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 673/A 673M Specification for Sampling Procedure for Impact Testing of Structural Steel

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *precipitation heat treatment*—a sub-critical temperature thermal treatment performed to cause precipitation of submicroscopical constituents, etc., so as to result in enhancement of some desirable property.

3.1.2 *precipitation strengthening*—the precipitation of submicroscopic and/or microscopic constituents of an alloy at various temperatures, which results in the alteration of certain properties.

3.1.3 *soak*—to hold at temperature after the material has attained the temperature throughout.

[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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[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.

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4. General Requirements for Delivery

4.1 Material furnished under this specification shall conform to the requirements of the current edition of Specification A 6/A 6M, for the ordered material, unless a conflict exists in which case this specification shall prevail.

5. Materials and Manufacture

5.1 The steel shall be made to fine grain practice.

6. Heat Treatment

6.1 Grade A, Class 1 material shall be precipitation heat treated in the temperature range from 1000 to 1300°F [540 to 705°C] for a time to be determined by the material manufacturer.

6.2 Grade A, Class 2 material shall be normalized at a temperature in the range from 1600 to 1700°F [870 to 925°C] and then precipitation heat treated at a temperature in the range from 1000 to 1300°F [540 to 705°C] for a time to be determined by the material manufacturer.

6.3 Grade A, Class 3 material shall be quenched in water or oil from a temperature in the range from 1600 to 1700°F [870 to 925°C] and then precipitation heat treated at a temperature in the range from 1000 to 1300°F [540 to 705°C] for a time to be determined by the material manufacturer.

6.4 Grade B, Class 1 shall be hot-rolled.

6.5 Grade B, Class 2 shall be normalized after hot rolling by reheating to 1600 to 1700°F [870 to 925°C], and then cooled in still air.

6.6 Grade B, Class 3, shall be normalized at 1600 to 1700°F [870 to 925°C], and then precipitation heat treated at 1000 to 1300°F [540 to 705°C] for a time to be determined by the material manufacturer. One hour at a specified temperature is generally considered as a maximum.

6.7 If the purchaser elects to perform the thermal (heat) treatment, the material shall be accepted on the basis of mill tests from test coupons heat treated in accordance with the purchase order requirements. If the test coupon heat treatment requirements are not indicated on the purchase order, the manufacturer shall heat treat the test coupons under conditions he considers appropriate. The manufacturer shall inform the purchaser of the procedure followed in thermally treating the test coupons at the mill.

7. Chemical Composition

7.1 The heat analysis shall conform to the requirements as to chemical composition prescribed in Table 1.

7.2 The steel shall conform on product analysis to the requirements prescribed in Table 1, subject to the product analysis tolerance in Specification A 6/A 6M for alloy steels.

8. Tension Test

8.1 The material, as represented by the test specimens, shall conform to the requirements specified in Table 2.

8.2 *Number of Tests*—One tension test shall be taken from a corner of each plate as heat treated for each class of material. For plates ⅜ in. [10 mm] and under in thickness, a tension test shall be made 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 [13.6 Mg] in weight. Plates wider than 24 in. [610 mm] shall be tested in the transverse direction and are subject to the modifications for elongation contained in footnote[D] of Table 2.

9. Notch Toughness Requirements

9.1 *Notch Toughness Tests—Grade A, Class 1*:

9.1.1 Notch toughness tests shall be made in accordance with Test Frequency H of Specification A 673/A 673M. Upon agreement, transverse tests may be specified instead of the longitudinal tests specified in Specification A 673/A 673M (plates only).

9.1.2 The test results shall meet a minimum average value of 20 ft·lbf [27 J] at −50°F [−45°C] for longitudinal specimens. For transverse specimens, the test results shall meet a minimum average value of 15 ft·lbf [20 J] at −50°F [−45°C]. By agreement, a test temperature lower than −50°F [−45°C] may be used.

9.2 *Notch Toughness Tests—Grade B*:

9.3 Notch toughness tests shall be made in accordance with Test Frequency H of Specification A 673 / A 673M.

9.4 The test results for Grade B, Class 1, and Grade B, Class 3, shall have a minimum average notch toughness of 35 ft·lbf [47 J] at -10°F [-23°C] in the longitudinal direction of the plate. For Grade B, Class 2, test results shall have a minumum

TABLE 1 Chemical Requirements

Element	Composition, %	
	Grade A	Grade B
Carbon	0.07 max	0.03–0.09
Manganese	0.40–0.70	0.45–1.30
Phosphorus, max	0.025	0.025
Sulfur, max	0.025	0.025
Silicon	0.40 max	0.30–0.50
Nickel	0.70–1.00	0.80–1.00
Chromium	0.60–0.90	0.30 max
Molybdenum	0.15–0.25	0.25 max
Copper	1.00–1.30	1.25–1.50
Columbium	0.02 min	0.02–0.06
Titanium	...	0.01–0.03

NOTE: Where an ellipsis (...) appears in the table, there is no requirement.

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TABLE 2 Tensile Requirements[A]

	Grade A Class 1	Grade A Class 2	Grade A Class 3	Grade B Class 1	Grade B Class 2	Grade B Class 3
Yield strength,[B] min, ksi [MPa]						
¼ in. [6.5 mm] and under	85 [585]	65 [450]	80 [550]	70 [485]	70 [485]	70 [515]
Over ¼ in. to 5⁄16 in. [6.5 to 8 mm], incl	85 [585]	65 [450]	80 [550]	70 [485]	70 [485]	70 [515]
Over 5⁄16 in. to ⅜ in. [8 to 10 mm], incl	80 [550]	65 [450]	80 [550]	70 [485]	70 [485]	70 [515]
Over ⅜ in. to ½ in. [10 to 12.5 mm], incl	80 [550]	65 [450]	80 [550]	70 [485]	70 [485]	70 [515]
Over ½ in. to ¾ in. [12.5 to 20 mm], incl	80 [550]	65 [450]	80 [550]	70 [485]	70 [485]	70 [515]
Over ¾ in. to 1 in. [20 to 25 mm], incl	...	65 [450]	80 [550]	70 [485]	70 [485]	70 [485]
Over 1 in. to 1¼ in. [25 to 30 mm], incl	...	60 [415]	80 [550]	...	70 [485]	70 [485]
Over 1¼ in. to 2 in. [30 to 50 mm], incl	...	60 [415]	75 [515]	...	70 [485]	70 [485]
Over 2 in. to 4 in. [50 to 100 mm], incl	...	55 [380]	65 [450]	...	...	...
Over 4 in. [100 mm]	...	50 [345]	60 [415]	...	...	...
Tensile strength, min, ksi [MPa]						
¼ in. [6.5 mm] and under	90 [620]	72 [495]	85 [585]	80 [550]	80 [550]	80 [585]
Over ¼ in. to 5⁄16 in. [6.5 to 8 mm], incl	90 [620]	72 [495]	85 [585]	80 [550]	80 [550]	80 [585]
Over 5⁄16 in. to ⅜ in. [8 to 10 mm], incl	90 [620]	72 [495]	85 [585]	80 [550]	80 [550]	80 [585]
Over ⅜ in. to ½ in. [10 to 12.5 mm], incl	90 [620]	72 [495]	85 [585]	80 [550]	80 [550]	80 [585]
Over ½ in. to ¾ in. [12.5 to 20 mm], incl	90 [620]	72 [495]	85 [585]	80 [550]	80 [550]	80 [585]
Over ¾ in. to 1 in. [20 to 25 mm], incl	...	72 [495]	85 [585]	80 [550]	80 [550]	80 [550]
Over 1 in. to 1¼ in. [25 to 30 mm], incl	...	72 [495]	85 [585]	...	80 [550]	80 [550]
Over 1¼ in. to 2 in. [30 to 50 mm], incl	...	72 [495]	85 [585]	...	80 [550]	80 [550]
Over 2 in. to 4 in. [50 to 100 mm], incl	...	65 [450]	75 [515]	...	...	...
Over 4 in. [100 mm]	...	60 [415]	70 [485]	...	...	...
Elongation in 2 in. or 50 mm, min, %[C,D]	20	20	20	20	20	20

NOTE: Where ellipses (...) appear in the table, there is no requirement.

[A] For plates wider than 24 in. [600 mm], the test specimen is taken in the transverse direction. See Specification A 6/A 6M, Tension Tests requirements.
[B] 0.2 % offset or 0.5 % extension-under-load.
[C] For thickness of ¾ in. [20 mm] and under, measured on 1½ in. [40 mm] wide full thickness rectangular specimen as shown in Fig. 4 of Test Methods and Definitions A 370. The elongation is measured in a 2-in. [50-mm] gage length which includes the fracture and which shows the greatest elongation.
[D] For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points.

average notch toughness of 20 ft·lbf [27 J] at -50°F [-45°C] in the longitudinal direction of the plate.

10. Retreatment

10.1 Thermally treated material that fails to meet the mechanical property requirements may be reheat-treated. All required tests shall be repeated when material is resubmitted for inspection.

11. Keywords

11.1 alloy; carbon; chromium; columbium; copper; general applications; low carbon; manganese; molybdenum; nickel; plates; precipitation heat treatment; precipitation strengthening; steel; structural steel

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall not apply unless specified in the purchase order or contract. Standardized supplementary requirements for use at the option of the purchaser are listed in Specification A 6/A 6M. In addition, the following supplementary requirement is also suitable for use with this specification:

S94. Notch Toughness—Grade A, Classes 2 and 3

S94.1 Notch toughness tests on longitudinal specimens shall be made in accordance with Test Frequency H of Specification A 673/A 673M.

S94.2 *Grade A, Class 2*—The test results shall meet a minimum average value of 50 ft·lbf [69 J] at −50°F [−45°C].

S94.3 *Grade A, Class 3*—The test results shall meet a minimum average value of 50 ft·lbf [69 J] at −80°F [−60°C].

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