Designation: A913/A913M – 15

Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)[1]

This standard is issued under the fixed designation A913/A913M; 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 high-strength low-alloy structural steel shapes in Grades 50 [345], 60 [415], 65 [450] and 70 [485], produced by the quenching and self-tempering process (QST). The shapes are intended for riveted, bolted or welded construction of bridges, buildings and other structures.

1.2 The QST process consists of in line heat treatment and cooling rate controls which result in mechanical properties in the finished condition that are equivalent to those attained using heat treating processes which entail reheating after rolling. A description of the QST process is given in Appendix X1.

1.3 Due to the inherent characteristics of the QST process, the shapes shall not be formed and post weld heat treated at temperatures exceeding 1100°F [600°C].

1.4 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 A6/A6M for information on weldability.

1.5 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 this specification.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

A673/A673M Specification for Sampling Procedure for Impact Testing of Structural Steel

A898/A898M Specification for Straight Beam Ultrasonic Examination of Rolled Steel Structural Shapes

3. General Requirements for Delivery

3.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A6/A6M.

4. Materials and Manufacture

4.1 The shapes shall be produced by the quenching and self-tempering process (QST). Following rapid quenching to achieve a surface temperature below the martensite start temperature, Ms, the shapes shall be allowed to auto-temper to a self-tempering temperature (STT) that shall be 1100°F [595°C] minimum and 1300°F [705°C] maximum. The STT shall be reported on the mill test report.

4.2 For grades 60 [415], 65 [450], and 70 [485], the requirements for fine austenitic grain size in Specification A6/A6M shall be met.

5. Chemical Composition

5.1 The chemical analysis of the heat shall conform to the requirements prescribed in Table 1.

5.2 The steel shall conform on product analysis to the requirements prescribed in Table 1 subject to the product analysis tolerances in Specification A6/A6M.

6. Mechanical Properties

6.1 *Tensile Properties*—The material as represented by the test specimens shall conform to the tensile properties given in Table 2.

6.2 Charpy V-notch tests shall be made in accordance with Specification A673/A673M, Frequency H:

6.2.1 The test results of full-size specimens shall meet an average value of 40 ft-lbf [54 J] at 70°F [21°C].

6.2.1.1 Test reports for every heat supplied are required.

6.2.2 Charpy V-notch test requirements exceeding the value specified in 6.2.1 or lower test temperatures are subject to agreement between the purchaser and the producer.

[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.

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

TABLE 1 Chemical Requirements (Heat Analysis)

NOTE 1—Boron shall not be intentionally added. See Specification A6/A6M, Section 7.1.2 for additional guidance regarding boron.

Element	Maximum content in %			
	Grade 50 [345]	Grade 60 [415]	Grade 65 [450]	Grade 70 [485]
Carbon	0.12	0.12	0.12	0.12
Manganese	1.60	1.60	1.60	1.60
Phosphorus	0.030	0.030	0.030	0.030
Sulfur	0.030	0.030	0.030	0.030
Silicon	0.40	0.40	0.40	0.40
Copper	0.45	0.35	0.35	0.45
Nickel	0.25	0.25	0.25	0.25
Chromium	0.25	0.25	0.25	0.25
Molybdenum	0.07	0.07	0.07	0.07
Columbium	0.05	0.05	0.05	0.05
Vanadium	0.06	0.06	0.08	0.09

TABLE 2 Tensile Requirements

Grade		Yield Point, min.		Tensile Strength, min.		Elongation, min	
		ksi	[MPa]	ksi	[MPa]	8 in. [200 mm], %	2 in. [50 mm], %
50	[345]	50	[345]	65	[450]	18	21
60	[415]	60	[415]	75	[520]	16	18
65	[450]	65	[450]	80	[550]	15	17
70	[485]	70	[485]	90	[620]	14	16

Carbon equivalent limits
Grade 50 [345]: 0.38 %
Grade 60 [415]: 0.40 %
Grade 65 [450]: 0.43 %
Grade 70 [485]: 0.45 %

7. Maximum Carbon Equivalent Requirement

7.1 The carbon equivalent on heat analysis shall not exceed the limits listed in this section. The chemical analysis (heat analysis) of the elements that appear in the carbon equivalent formula and the actual carbon equivalent shall be reported.

7.2 Calculate the carbon equivalent using the following equation:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Cu + Ni)/15$$

8. Keywords

8.1 high-strength low-alloy steel; QST; quenching and self-tempering process; steel shapes; structural shapes; 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 A6/A6M. Those that are considered suitable for use with this specification are listed by title:

S1. Vacuum Treatment.
S2. Product Analysis.
S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons.
S5. Charpy V-Notch Impact Test.
S18. Maximum Tensile Strength.
S30. Charpy V-Notch Impact Test for Structural Shapes: Alternate Core Location.

ADDITIONAL SUPPLEMENTARY REQUIREMENTS

In addition, the following special supplementary requirements are also suitable for use with this specification:

S4. *Additional Tension Test:*

S4.1 One tension test shall be made per ingot or per bloom. The results obtained and the actual self-tempering temperature for the ingot or bloom represented shall be reported on the mill test report when such tests are required by the order.

S8. *Ultrasonic Examination:*

S8.1 Ultrasonic Examination in accordance with Specification A898/A898M.

S32. *Single Heat Bundles:*

S32.1 Bundles containing shapes or bars shall be from a single heat of steel.

S59. On purchaser's request and after contract, the manufacturer shall provide weldability data from tests on previous production. Base material tested shall be representative of material furnished (similar composition, melting and rolling practice). The type of test, test variables and acceptance criteria shall be as agreed between the manufacturer and the purchaser. Weldability tests shall be provided to verify preheat temperature requirements, adjusted for thickness, if a prequalified welding procedure specification according to AWS D1.1-10, Table 3.2, Category D, or a similar provision in another welding standard, is to be applied. The weldability data shall include a complete joint penetration groove weld according to AWS D1.1 and an oblique Y groove test according to AWS B4.0.

S75. *Maximum Yield Point to Tensile Strength Ratio—Grade 50 [345]:*

S75.1 The maximum yield point shall be 65 ksi. [450].

S75.2 The maximum yield to tensile strength ratio shall be 0.85.

S77. *Reduced Sulfur:*

S77.1 The Grade 65 [450] shall be furnished with a maximum sulfur of 0.010 %. Sulfur of 0.010 % or less can be desirable in material subjected to high through-thickness stresses.

S77.2 The Grade 70 [485] shall be furnished with a maximum sulfur of 0.010 %. Sulfur of 0.010 % or less can be desirable in material subjected to high through-thickness stresses.

APPENDIX

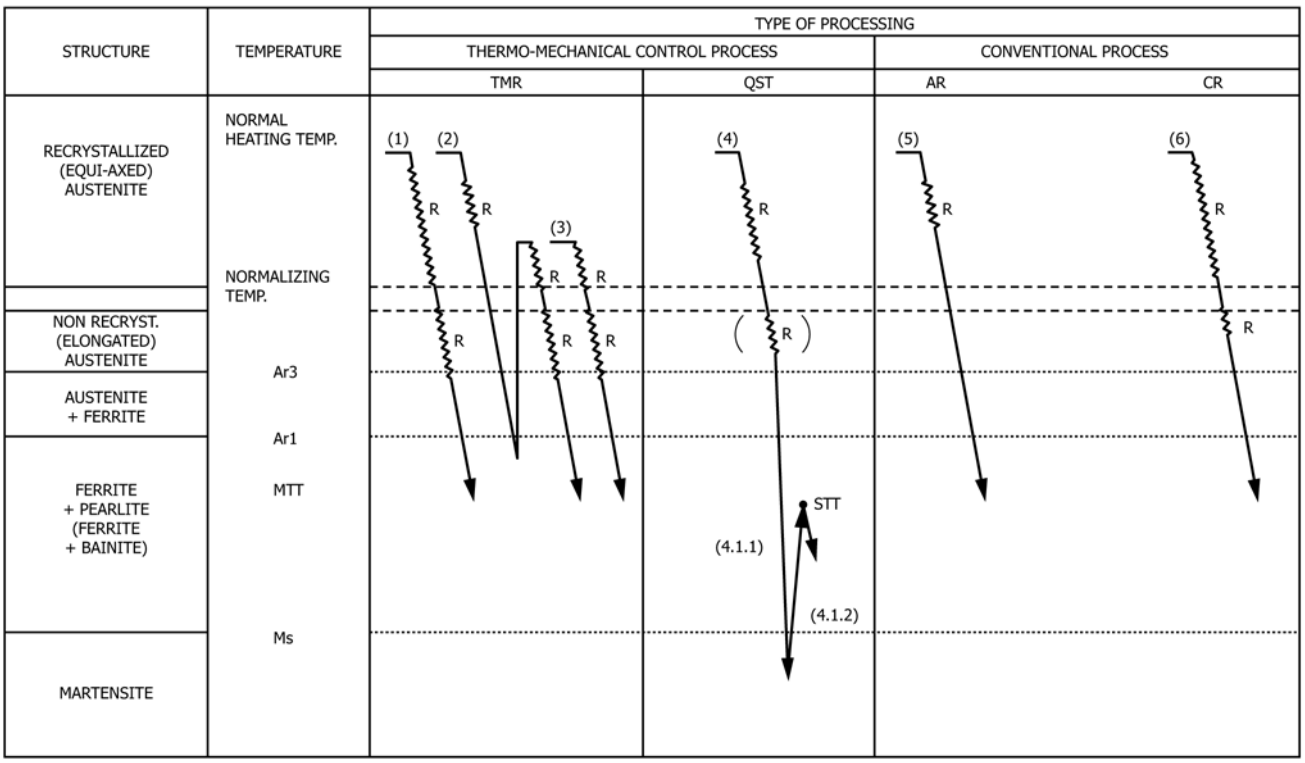
(Nonmandatory Information)

X1. QUENCHING AND SELF-TEMPERING PROCESS (QST)

X1.1 *Introduction*—The quenching and self-tempering process, commonly referred to as "QST," has evolved from the "thermo-mechanical control processes" (TMCP) that have been known and used for a number of years. QST, which is a variation of TMCP, produces fine-grained steel by a combination of chemical composition and integrated controls of manufacturing processes from ingot or bloom reheating to in-line interrupted quenching and self-tempering, thereby achieving the specified mechanical properties in the required product thicknesses.

X1.2 *Outline of QST*—Given in Fig. X1.1.

X1.2.1 Quenching and Self-Tempering (QST) steels of fine grain size are manufactured by producing tempered martensite and varying the pearlite or bainite, or both. This is accomplished through interrupted water quenching in which the duration of the quench is controlled after the final reduction pass while still in the temperature region above the Ar3. Rapid quenching is continued until the maximum surface temperature of the steel is below the Ms. Tempering occurs as the core



NOTE TMR: THERMO-MECHANICAL ROLLING
AR: AS ROLLED
MTT: MARTENSITE TEMPERING TEMPERATURE
STT: SELF TEMPERING TEMPERATURE
QST: QUENCHING AND SELF-TEMPERING*
CR: CONTROLLED ROLLING
R: REDUCTION

*EXPLANATION OF TEMPERATURE CURVES
(4.1.1): SURFACE TEMPERATURE DURING QUENCHING
(4.1.2): SURFACE TEMPERATURE DURING SELF-TEMPERING

FIG. X1.1 Schematic Diagrams of Thermo-Mechanical Control and Conventional Process

temperature causes the surface temperature to gradually rebound to a proper temperature, defined as the self-tempering temperature (STT), to achieve desired properties.

X1.2.2 The selection of the rolling process to be used is made by the producer depending upon the chemical composition, the product thickness, and the required properties.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A913/A913M – 14a) that may impact the use of this standard. (Approved July 1, 2015.)

(1) Revised 4.
(2) Revised Table 1.
(3) Added Supplementary Requirement S59.
(4) Revised X1.2.1.

Committee A01 has identified the location of selected changes to this standard since the last issue (A913/A913M – 14) that may impact the use of this standard. (Approved May 15, 2014.)

(1) Revised and expanded Supplementary Requirement S77.

Committee A01 has identified the location of selected changes to this standard since the last issue (A913/A913M – 11) that may impact the use of this standard. (Approved May 1, 2014.)

(1) Deleted footnote from 1.1.