Designation: A414/A414M – 14

# Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy for Pressure Vessels[1]

This standard is issued under the fixed designation A414/A414M; 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[2] covers hot-rolled carbon steel sheet for pressure vessels involving fusion welding or brazing. Welding and brazing technique is of fundamental importance and shall be in accordance with commercial practices.

1.2 The following grades are included in this specification:

Mechanical Requirements

| Grade | Yield Strength, min | | Tensile Strength, min | |
|---|---|---|---|---|
| | ksi | MPa | ksi | MPa |
| A | 25 | 170 | 45 | 310 |
| B | 30 | 205 | 50 | 345 |
| C | 33 | 230 | 55 | 380 |
| D | 35 | 240 | 60 | 415 |
| E | 38 | 260 | 65 | 450 |
| F | 42 | 290 | 70 | 485 |
| G | 45 | 310 | 75 | 515 |
| H | 45 | 310 | 75 | 515 |

1.3 Hot-rolled carbon steel sheet is generally furnished in cut lengths and to decimal thickness only. Coils may be furnished, provided tension test specimens are taken to represent the middle of the slab as required by 6.1.3. The purchaser should recognize this may require cutting the coils to obtain test samples and results in half-size coils. The sheet is furnished to the following size limits:

| | Width, in. [mm] |
|---|---|
| Thickness, in. [mm] | Over 12 [Over 300] |
| 0.270 to 0.230 [7.0 to 6.0] | sheet (coils only) |
| Under 0.230 to 0.057 [6.0 to 1.5] | sheet |

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

1.5 Tolerances are found in General Requirements Specifications A568/A568M and A635/A635M. The appropriate General Requirements specification is applied based on the thickness and width of the product ordered.

## 2. Referenced Documents

2.1 *ASTM Standards:*[3]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A568/A568M Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for

A635/A635M Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

## 3. Terminology

3.1 *Definitions*—For definitions of other terms used in this specification refer to Terminology A941.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lot, n*—all coils of one thickness and width combination from one heat and one rolling on the hot mill, up to 100 tons [90 tonnes] total mass.

## 4. Ordering Information

4.1 Orders for material under this specification shall include the following information, as required, to describe the material adequately:

4.1.1 Designation or specification number, date of issue, and grade,

[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 A01.19 on Steel Sheet and Strip.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-414 in Section 11 of that Code.

[3] 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**

4.1.1.1 Grade H may be substituted for Grade G upon agreement between the purchaser and producer,

4.1.2 Copper bearing steel, when required,

4.1.3 Special requirements, if required,

4.1.3.1 Charpy impact properties may be specified for Grade H at the time of order,

4.1.3.2 Strength levels at other than room temperature may be specified for Grade H at the time of order,

4.1.4 Condition—pickled (or blast cleaned), if required (material so ordered will be oiled unless ordered dry), and

4.1.5 Dimensions, including type of edges.

4.1.5.1 When the purchaser requires thickness tolerances for 3⁄8 in. [10 mm] minimum edge distance (see Supplementary Requirement in Specifications A568/A568M or A635/A635M, as applicable), this requirement shall be specified in the purchase order or contract.

NOTE 1—Not all producers are capable of meeting all of the limitations of the thickness tolerance tables in Specification A568/A568M or Specification A635/A635M. The purchaser should contact the producer regarding possible limitations prior to placing an order.

4.1.6 Cast or heat analysis, or test report request, or both, if required.

NOTE 2—A typical ordering description is as follows: "ASTM A414, Grade A, Hot-Rolled Sheet, 0.100 in. [2.54 mm] by 36 in. [914.4 mm] by 96 in. [2438 mm], cut edges."

## 5. Chemical Requirements

5.1 *Cast or Heat Analysis*—The analysis of the steel shall conform to the requirements prescribed in Table 1.

5.1.1 Each of the elements listed in Table 2 shall be included in the report of the heat analysis. When the amount of an element present is less than 0.02 %, the analysis may be reported as "<0.02 %."

5.2 *Product, Check, or Verification Analysis*—Analyses may be made by the purchaser from finished material representing each heat.

**TABLE 2 Limits on Unspecified Elements (See 5.1.1)**

| | | |
|---|---|---|
| Copper, max %[A] | Heat analysis | 0.40 |
| | Product analysis | 0.43 |
| Nickel, max %[A] | Heat analysis | 0.40 |
| | Product analysis | 0.43 |
| Chromium, max %[A,B] | Heat analysis | 0.30 |
| | Product analysis | 0.34 |
| Molybdenum, max %[A,B] | Heat analysis | 0.12 |
| | Product analysis | 0.13 |
| Vanadium, max %[C] | Heat analysis | 0.03 |
| | Product analysis | 0.04 |
| Columbium, max %[C] | Heat analysis | 0.02 |
| | Product analysis | 0.03 |

[A] The sum of copper, nickel, chromium, and molybdenum shall not exceed 1.00 % on heat analysis. When one or more of these elements are specified, the sum does not apply, in which case, only the individual limits on the remaining unspecified elements will apply.
[B] The sum of chromium and molybdenum shall not exceed 0.32 % on heat analysis. When one or more of these elements are specified, the sum does not apply, in which case, only the individual limits on the remaining unspecified elements will apply.
[C] By agreement, the heat analysis limits for vanadium or columbium, or both, may be increased up to 0.10 % and 0.05 %, respectively.

5.3 *Deoxidation*—For all grades, killed steel is required. See Table 1 and footnote B.

## 6. Mechanical Property Requirements

6.1 *Tensile Strength:*

6.1.1 *Requirements*—Material as represented by the test specimen shall conform to the tensile requirements specified in Table 3. One coil per lot shall have test specimens taken from locations representing the front end, middle, and back end of the coil. If all tensile results conform to the requirements, other coils of that lot may be tested only at the middle position.

6.1.2 *Location and Orientation* (see Fig. 1):

6.1.2.1 Tensile test samples shall be taken from the full thickness of the sheet as rolled.

6.1.2.2 Tensile test specimens shall be taken from a location approximately halfway between the center of the sheet and the edge of the material as-rolled.

**TABLE 1 Chemical Requirements**

| | % Heat Analysis, Element Maximum Unless Otherwise Shown | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade | C | Mn[A] | P | S | Al[B] | Si[B] | $Cu_D^{C,}$ | Ni[D] | Cr[D, E] | Mo[D, E] | V | Cb | Ti[F] | N | B |
| A | 0.15 | 0.90 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| B | 0.22 | 0.90 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| C | 0.25 | 0.90 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| D | 0.25 | 1.20 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| E | 0.27 | 1.20 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| F | 0.31 | 1.20 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| G | 0.31 | 1.35 | 0.035 | 0.035 | 0.02–0.08 | 0.30 | 0.40 | 0.40 | 0.30 | 0.12 | 0.03 | 0.02 | 0.025 | . . . | . . . |
| H[A, G] | 0.14 | 1.25 | 0.020 | 0.015 | 0.02–0.08 | 0.30 | 0.20 | 0.20 | 0.15 | 0.06 | 0.05 min | 0.005/ 0.05 | 0.005 min | 0.009 | . . . |

[A] For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum wll be permitted up to a maximum of 1.50 %.
[B] The steel shall be considered aluminum-silicon killed when the silicon is between 0.15 % and 0.30 %, otherwise it shall be considered aluminum killed.
[C] When copper is specified, a minimum of 0.20 % is required. When copper is not specified, the copper limit is a maximum requirement.
[D] The sum of copper, nickel, chromium, and molybdenum shall not exceed 1.00 % on heat analysis. When one or more of these elements are specified, the sum does not apply, in which case, only the individual limits on the remaining unspecified elements will apply.
[E] The sum of chromium and molybdenum shall not exceed 0.32 % on heat analysis. When one or more of these elements are specified, the sum does not apply, in which case, only the individual limits on the remaining unspecified elements will apply.
[F] Titanium is permitted for Grades A through G, at the producer's option, to the lesser of 3.4N + 1.5S or 0.025 %.
[G] Grade H contains the strengthening elements columbium (niobium), vanadium, titanium and molybdenum added singly or in combination. The minimum requirements only apply to the microalloy elements selected for strengthening of the steel.

**TABLE 3 Tensile Requirements**

| Designation | Yield Strength[A] | Tensile Strength | | Elongation in 2 in. [50 mm] min. % for Thickness | | | Elongation in 8 in. [200 mm], min. % |
|---|---|---|---|---|---|---|---|
| | | Minimum | Maximum | Under 0.270 in. [7.0 mm] to 0.145 in. [3.8 mm] | Under 0.145 in. [3.8 mm] to 0.089 in. [2.2 mm] | Under 0.089 in. [2.2 mm] to 0.057 in. [1.5 mm] | |
| | ksi [MPa] | ksi [MPa] | ksi [MPa] | - | - | - | - |
| Grade A | 25 [170] | 45 [310] | 60 [415] | 26 | 24 | 23 | 20 |
| Grade B | 30 [205] | 50 [345] | 65 [450] | 24 | 22 | 21 | 18 |
| Grade C | 33 [230] | 55 [380] | 70 [485] | 22 | 20 | 19 | 16 |
| Grade D | 35 [240] | 60 [415] | 75 [515] | 20 | 18 | 17 | 14 |
| Grade E | 38 [260] | 65 [450] | 85 [585] | 18 | 16 | 15 | 12 |
| Grade F | 42 [290] | 70 [485] | 90 [620] | 16 | 14 | 13 | 10 |
| Grade G | 45 [310] | 75 [515] | 95 [655] | 16 | 14 | 13 | 10 |
| Grade H | 45 [310] | 75 [515] | 90 [620] | 25 | 24 | 23 | 20 |

[A] Yield strength determined by the 0.2 % offset or 0.5 % extension under load methods.

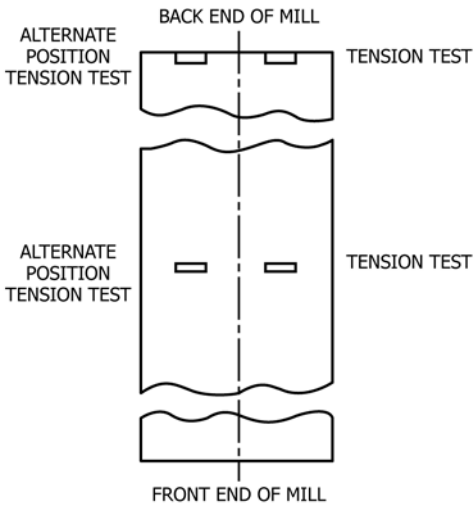


**FIG. 1 Location of Test Specimens**

6.1.2.3 Tensile test specimens shall be taken with the axis of the test specimen perpendicular to the rolling direction (transverse test).

6.1.3 *Test Method*—Yield strength shall be determined by either the 0.2 % offset method or by the 0.5 % extension under load method, unless otherwise specified per Test Method A370.

6.2 *Impact Properties:*

6.2.1 *Requirements*—At the time of order, Charpy impact properties may be specified by the purchaser for Grade H only.

6.2.1.1 Impact energy minimums and testing temperatures shall be agreed upon between the producer and the purchaser.

6.2.2 *Number of Tests*—Three samples taken in the transverse direction shall be taken at mid-length (middle) of each coil to be certified.

6.2.3 Testing shall be in accordance with Test Method A370.

## 7. General Requirements for Delivery

7.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A568/A568M or Specification A635/A635M unless otherwise provided herein.

## 8. Workmanship

8.1 The material shall be free from injurious defects (see Specifications A568/A568M or A635/A635M, as appropriate due to thickness).

## 9. Finish and Appearance

9.1 *Surface Finish:*

9.1.1 Unless otherwise specified, the material shall be furnished without removing the hot-rolled oxide or scale.

9.1.2 When required, the material may be specified to be pickled or blast cleaned.

9.2 *Oiling:*

9.2.1 Unless otherwise specified, the material shall be furnished not oiled.

9.2.2 When specified to be pickled or blast cleaned, the material shall be furnished oiled. When required, pickled or blast-cleaned material may be specified to be furnished dry.

9.3 *Edges*—Unless otherwise specified, mill edges shall be furnished on material that has not had the hot-rolled oxide or scale removed and cut edges shall be furnished on material that has had the hot-rolled oxide or scale removed.

## 10. Certification and Reports

10.1 The manufacturer or processor shall furnish copies of a test report showing the results of the heat analysis and mechanical property tests made to determine compliance with this specification.

10.2 The report shall include the purchase order number, the specification number and year date, product designation, grade, the heat number, and heat analysis and mechanical properties as indicated by the tension test.

10.2.1 All the mechanical properties from the coil used to qualify the lot and the middle test from the particular coil shall be reported along with the coil identification for that coil. If the source of the material is the coil used to qualify the lot, the middle test shall be reported as the second middle test on the report. The test report shall contain the results of four tensile tests and all must meet the requirements tensile requirements table.

10.3 A signature is not required on the test report. However, the document shall clearly identify the organization submitting the report. Notwithstanding the absence of a signature, the organization submitting the report is responsible for the content of the report.

10.4 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked ASTM standard and the purchaser and supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

## 11. Product Marking

11.1 The name or brand of the manufacturer, heat and slab number, specification designation number, and grade shall be legibly and durably marked on each cut length sheet in two places not less than 12 in. [300 mm] from the edges. Cut length sheets, the maximum lengthwise and crosswise, dimensions of which do not exceed 72 in. [1800 mm], shall be legibly and durably marked in one place approximately midway between the center and a side edge. The manufacturer's test identification number shall be legibly and durably marked on each test specimen. Steel-die marking of sheets is prohibited on material < 0.250 in. [6 mm].

11.2 For coil product, the information required in 11.1 shall be legibly and durably marked both on each coil and on a tag affixed to each coil.

## 12. Keywords

12.1 carbon steel sheet; pressure vessel steels; steel sheet

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A414/A414M – 13) that may impact the use of this standard. (Approved May 1, 2014.)

*(1)* Deleted old Footnote F in Table 1.