MIL-S-8840B(ASG)
5 OCTOBER 1965
Superseding
MIL-S-8840A(ASG)
30 September 1963

MILITARY SPECIFICATION

# STEEL SHEET AND STRIP, CORROSION-RESISTANT, PRECIPITATION HARDENING (AM350 and AM355), PREMIUM QUALITY

This specification has been approved by the Department of the Air Force and by the Bureau of Naval Weapons.

## 1. SCOPE

1.1 Scope.- This specification covers corrosion-resistant, heat treatable steel in sheet and strip form (see 6.3), of the compositions and conditions indicated.

1.2 Classification.- Materials shall be supplied in the following compositions, forms, and conditions, as specified (see 6.2):

| | | |
|---|---|---|
| Composition - AM350 - | Sheet: | Hot or cold rolled, annealed and descaled (No. 2D finish, or equivalent). |
| | Strip: | Cold rolled, annealed, and descaled (No. 1 Strip Finish). |
| Composition - AM355 - | Sheet and strip: | Hardened to CRT 150 (see table 3)<br>Hardened to CRT 180 (see table 3)<br>Hardened to CRT 210 (see table 3) |

## 2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

STANDARDS

Federal

| | |
|---|---|
| FED. TEST METHOD STD. NO. 151 | Metals; Test Methods |
| FEDERAL STANDARD NO. 183 | Continuous Identification Marking of Iron and Steel Products |

Military

| | |
|---|---|
| MIL-STD-163 | Steel Mill Products Preparation for Shipment and Storage |
| MS33520 | Tolerances, Corrosion Resistant Steel Plate, Sheet and Strip |

FSC 9515

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Material.- The steel shall be manufactured by the electric furnace process.

3.2 Chemical composition.- The chemical composition shall be as specified in table I.

TABLE I. Chemical composition

| Element | Composition | | Check analysis | |
|---|---|---|---|---|
| | AM350 | AM355 | Under min. | Over max. |
| Carbon | 0.07 to 0.11 | 0.10 to 0.15 | 0.01 | 0.01 |
| Manganese | .50 to 1.25 | .50 to 1.25 | .04 | .04 |
| Silicon | .50 (max) | .50 (max) | .... | .05 |
| Phosphorus | .040 (max) | .040 (max) | .... | .005 |
| Sulfur | .030 (max) | .030 (max) | .... | .005 |
| Chromium | 16.00 to 17.00 | 15.00 to 16.00 | .20 | .20 |
| Nickel | 4.00 to 5.00 | 4.00 to 5.00 | .07 | .07 |
| Molybdenum | 2.50 to 3.25 | 2.50 to 3.25 | .10 | .10 |
| Nitrogen | 0.07 to 0.13 | 0.07 to 0.13 | .01 | .01 |

3.3 Condition.-

3.3.1 AM350 (annealed).- Composition AM350 material shall be in the annealed condition, obtained by heating to 1,950° ±25° F and holding at temperature for 45 minutes per inch of thickness, followed by water quenching.

3.3.1.1 Hardness in the annealed condition.- The annealed hardness of the AM350 material shall be not higher than Rockwell C30, or equivalent.

3.3.1.2 Bending.- As-received AM350 material shall withstand, without cracking, bending at room temperature through an angle of 180 degrees (free bend) or 135° (guided bend) with the axis of bend parallel to the direction of rolling. The radius of bend shall be not greater than two times the nominal thickness.

3.3.2 AM355 cold rolled and tempered.- Composition AM355 material shall be supplied by the producer in the cold rolled and tempered condition obtained by tempering at 850° to 950° F subsequent to final cold rolling to conform to the requirements of 3.5.

3.4 Response to heat treatment.-

3.4.1 AM350.- As-received material, when heat treated as specified in 4.6.2, shall develop the respective mechanical properties specified in table II.

3.4.2 AM355 (Reheat treatment).- AM355 material supplied in the CRT (see 6.3.3) condition is not normally heat treated by the customer. However, if the formability is not adequate for some parts, the material may be reheat treated as indicated in 4.6.2 and may be expected to develop the respective nominal properties indicated by table II.

TABLE II. Mechanical properties (heat treated)

| Properties | AM350 | | AM355 (nominal properties) |
|---|---|---|---|
| | SCT850 | SCT1000 | Reheat treated SCT1000 |
| Yield strength at 0.2 percent, offset, psi | 160,000 | 150,000 | 150,000 |
| Tensile strength, psi | 185,000 | 165,000 | 170,000 |
| Elongation, percent in 2 inches, Nominal thickness, inch: | | | |
| 0.0005 to 0.0015, incl. | 2 (min) | 2 (min) | 2 |
| Over 0.0015 to 0.0020, incl. | 4 | 4 | 3 |
| Over .0020 to .0050, incl. | 6 | 6 | 5 |
| Over .0050 to .020, incl. | 8 | 8 | 7 |
| Over .020 to .1875, excl. | 8 | 10 | 8 |

3.5 Properties of AM355 (as received).- The properties of AM355 shall equal or exceed the minimum requirements of table III for the respective condition.

TABLE III. Mechanical properties cold rolled and tempered AM355 (as received)

| Properties | CRT 150 | CRT 180 | CRT 210 |
|---|---|---|---|
| Yield strength, min., 0.2% offset | 150,000 psi | 180,000 psi | 210,000 psi |
| Elongation, % in 2 inches, (min) Thickness | | | |
| 0.0005 - 0.002, excl. | 10 | 5 | 3 |
| .002 - .005, incl. | 12 | 6 | 4 |
| Over .005 - .010, incl. | 15 | 8 | 5 |
| Over .010 - .015, incl. | 15 | 10 | 6 |
| Over .015 - .020, incl. | 20 | 15 | 8 |
| Over .020 - .125, incl. | 20 | 15 | 10 |

3.6 Dimensional tolerances.- Permissible variations from nominal dimensions shall be within the limits of MS33520.

3.7 Identification of product.- The material shall be marked in accordance with Federal Standard No. 183. The marking shall include this specification number, composition designator, condition, and the heat number.

3.8 Workmanship.- Material shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any other commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Quality conformance inspection.- Inspection of the steel sheet and strip is classified as quality conformance inspection.

4.3 Examinations.-

4.3.1 Examination of product.- Sample units shall be randomly selected to represent each respective thickness, of a number not less than indicated by table IV, and examined to determine conformance to this specification with respect to surface finish (1.2), identification of product (3.7), dimensions (3.6), and workmanship (3.8). Inspection for thickness and crown shall consist of measurements distributed along, and 1/2 inch from a longitudinal (with respect to rolling direction) edge, plus measurements near the center (as rolled).

TABLE IV. Sampling

| Lot size | Sample size | Acceptance number |
|---|---|---|
| 1 - 65 | 4 | 0 |
| 66 - 110 | 5 | 0 |
| 111 - 300 | 7 | 0 |
| 301 - 500 | 10 | 0 |
| 501 - 800 | 15 | 0 |
| Over 800 | 25 | 0 |

4.3.2 Preservation, packaging, packing, and marking.- Preparation for delivery shall be examined for conformance to section 5.

4.4 Chemical analysis.-

4.4.1 Sampling.- Samples for chemical analysis shall be selected to represent each heat in the shipment.

4.4.1.1 Samples for chemical analysis may be waived at the discretion of the procuring activity, provided that all of the material under inspection can be identified as being made from a heat previously analyzed and found to be in accordance with the chemical composition specified herein.

4.4.2 Method.- Analysis shall be made in accordance with Method 111 or 112 of Federal Test Method Standard No. 151, or other appropriate analytical methods. In the even of dispute, analysis shall be by Federal Test Method Standard No. 151.

4.5 Tensile strength of AM355 (as received).-

4.5.1 Sampling.- Two tensile test samples shall be selected to represent each 200 sheets or each coil of steel from each heat, of the same thickness and condition.

4.5.2 Preparation of specimens.- Two or more tensile test specimens of 2-inch gage length conforming to F1 or F2 of Method 211 of Federal Test Method Standard No. 151 shall be cut from each sample and heat treated in accordance with 3.4.1. For widths 9 inches and over, tensile test specimens shall be taken with the axis perpendicular to the direction of rolling. For widths less than 9 inches, tensile test specimen shall be taken with the axis parallel to the direction of rolling. Prior to testing, specimens shall be heat treated in accordance with 3.4.

4.5.3 Method.- Tensile tests shall be conducted in accordance with applicable requirements of Method 211 of Federal Test Method Standard No. 151. The properties shall be equal to or exceed the minimum requirements of table II.

4.6 Response to heat treatment.-

4.6.1 Sampling.- Two samples shall be selected to represent each heat of steel from which materials are supplied in the annealed condition.

4.6.2 Processing.- Transverse specimens conforming to types F1 or F2, Method 211 of Federal Test Method Standard No. 151 shall be austenite conditioned by heating to 1,710° ±25° F, held at heat for not less than 45 minutes per inch of thickness, quenched in water or otherwise quenched very rapidly to room temperature, cooled to -100° F or lower, held at this temperature for not less than 3 hours, warmed to room temperature, heated to either 1,000° F or 850° ±10° F, held at temperature for not less than 3 hours nor more than 4 hours, and air cooled to room temperature.

4.6.3 Method.- Tensile tests shall be conducted in accordance with Method 211 of Federal Test Method Standard No. 151.

4.7 Hardness.- Hardness tests shall be conducted in accordance with Method 243 of Federal Test Method Standard No. 151 on each material and condition of material in the "as-received" condition.

4.8 Bend test.-

4.8.1 Sampling.- Two or more bend test samples shall be selected from each 200 sheets or from each coil of steel from each heat, of the same thickness and condition.

4.8.2 Preparation of specimens.- Where dimensions permit, strip specimens shall be cut from each sample with the longitudinal axis transverse to the direction of rolling.

4.8.3 Method.-

4.8.3.1 Free bend test.- Specimens shall be bent cold, either by pressure or by blows; however, in case of dispute, tests shall be made by pressure.

4.8.3.2 Controlled bend (V-block) test.- Specimens shall be bent cold by means of V-blocks or mating punch and die having an included angle of 45 degrees, and with proper curvature of surfaces at the bend areas to impart the desired shape and diameter of bend to the specimen.

4.9 Rejection.- When the failure of one or more specimens indicate that the test sample fails to meet the specified requirement, the entire lot shall be rejected.

4.9.1 Retest.- At the discretion of the supplier, retest will be permitted. A retest sample of five specimens shall be tested to replace each failed specimen of the initial sample. If one or more of the retest specimens fail, the lot shall be rejected with no further retesting permitted.

4.9.2 Resubmittal.- If the defectives in a lot previously rejected can be identified and removed from the lot, resampling at the frequency of the initial sampling will be acceptable.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packaging, packing, and marking.- Preservation, packaging, packing, and marking shall be in accordance with MIL-STD-163. The marking shall include the following nomenclature:

Specification number
Heat treated condition
Surface finish
Size(s)
Thickness(es)
Heat number

6. NOTES

6.1 Intended use.- The steel sheet and strip is intended for use in the fabrication of structural parts requiring corrosion resistance, formability, and high strength at operating temperatures up to 800° F, and where such parts may require welding during fabrication.

6.1.1 Weldability.- The steel is weldable by standard welding processes.

6.2 Ordering data.- Procurement documents should specify:

(a) Title, number, and date of this specification.
(b) Composition (see 1.2 and table I).
(c) Condition (see 1.2 and table II).
(d) Length, width, and thickness desired.
(e) Whether materials should be supplied as cut sheets or in coils.

6.3 Definitions.-

6.3.1 Sheet.- Sheet will be interpreted as material which is 0.1875 inch or less in thickness and 24 inches or more in width.

6.3.2 Strip.- Strip will be interpreted as material which is 0.1875 inch or less in thickness and less than 24 inches in width.

6.3.3 CRT condition.- A material obtained by appropriate cold rolling and tempering by the producer.

6.4 Properties.-

6.4.1 Forming AM355 cold rolled and tempered.- If the formability of AM355 in the CRT (cold rolled and tempered) condition is not adequate for some parts, the material can be annealed and warm-formed at 300° F or higher. Anneal at 1,850° F and rapidly cool directly to forming temperature and hold at the forming temperature by means of an oil bath or external resistance heaters. This cycle may be repeated as necessary. The AM355 material is then hardened by heat treatment specified in 4.6.2.

6.4.2 Forming AM350.- The formability of annealed AM350 may be improved by warm-forming at 300° F or higher. Additional cycles of heating to 1,950° F and rapid cooling directly to the forming temperature can be used as required.

6.4.3 Stress corrosion resistance.- The stress corrosion resistance of martensitic high strength stainless steels increases as the steels are tempered to lower strength levels. By tempering AM350 at 1,000° F, its resistance to stress corrosion will be improved compared to material tempered at 850° F. The higher strength alloy AM355 should only be used in the 1,000° F tempered condition if resistance to stress corrosion is required. The maximum resistance to both general and stress corrosion can be obtained by using a carbide solution heat treatment to improve the metallurgical structure of consumable electrode melted AM355. This treatment consists of solution treating at 1,900° F, water quenching, cooling to -100° F, warming in air to room temperature, austenite conditioning at 1,750° F, water quenching, cooling to -100° F, warming in air to room temperature, and tempering at 1,000° F.

6.4.4 Fracture toughness.- Sharp edge-notched 0.025 inch thick sheet tensile specimens with a notch severity factor of $K_t$ greater than 17 have been used to evaluate the fracture toughness of AM350 and AM355 sheet and strip. Sheet and strip specimens from both the heat treated (SCT) and the cold rolled (CRT) conditions with yield strengths from 150,000 to 210,000 psi indicate a ratio of notched to unnotched tensile strengths of 0.95 to 1.05. Similar tests, employing transverse specimens conforming to the ASTM Fracture Committee recommendations, should be conducted for record purposes on each heat of material.

6.4.4.1 References.- NASA Technical Note D-1798, May 1963, "Progress Report of NASA Special Committee on Materials Research for Supersonic Transport", is available from the Defense Documentation Center.

Allegheny Ludlum Report SS432, "Fracture Toughness Evaluation of Cold Rolled AM350 and AM355 Alloys," available on application to the Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh, Pennsylvania.

Custodians:
Navy - WP
Air Force - (11)

Reviewer activities:
Navy - WP
Air Force - (11), (69)

User activities:
Navy -
Air Force -

Preparing activity:
Navy - WP