

NAVISTAR, INC.		
Material, Parts, and Process Specifications (MPAPS)	NUMBER: MPAPS A-6 Part I	
	Former Designation: CEMS A-6 Part I	
TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	CURRENT REV No.: 1406	DATE: June 2014
WRITTEN/EDITED BY: Materials Engineering	APPROVED BY: Materials Engineering	SUPERSEDES: Rev. 1402 – Feb. 2014
PRINTED COPIES OF THIS DOCUMENT MUST BE VERIFIED FOR CURRENT REVISION		
<i>This specification may involve hazardous materials, equipment, and procedures. This specification does not purport to address all of the safety issues associated with its use. The user is responsible to consult appropriate safety and health practices and to determine the applicability of regulatory limits prior to use.</i>		
Change Notice: Revised footnote C in Table 5 for HSLA steel grades; editorial changes.		

1.0 APPLICATION

This specification applies to cold-rolled (CR) and hot-rolled (HR) Low Carbon Steel, as well as Dent-Resistant, Structural (SS), High Strength Low Alloy (HSLA), Ultra-High Strength (UHSS), and other high-strength steel types, in the form of flat-rolled sheet/plate/bar and structural shapes. **(Note that HSLA and UHSS product forms having thickness of 0.25 in. or greater are covered in MPAPS A-43.)** MPAPS A-6 is divided into three parts, as follows:

- Part I - covers uncoated base metal requirements for low carbon steel products
- Part II - Metallic Coated Low Carbon Steel Sheet/Strip (including galvanized and aluminized)
- Part III - Organic Coated Low Carbon Steel Sheet/Strip

2.0 SCOPE

This specification defines a system for specifying hot and cold rolled low carbon steel products in flat rolled and structural shapes, including bar size flats and shapes. Bar shapes include channels, angles, tees and zees with their greatest sectional dimension less than 3 inches (75 mm). Shapes with dimensions over 3 inches (75 mm) are classified as structural shapes. The NAVISTAR system is based upon the Engineering designation of material type based on design requirements and is specified by a general grade classification on the engineering drawing. Manufacturing can specify on the purchase order a specific material within the specified design grade based upon manufacturing process requirements (for example, engineering drawing specifies Grade 1 or 2 per MPAPS A-6, Part I; purchase order may specify Steel Sheet, Grade 1, DS Type A, per MPAPS A-6, Part I). Considerable freedom of material selection is permitted at the manufacturing level. For description of the various products and material variations, see “Appendix - General Information.”

CEMS A-0, Part II, includes requirements for higher carbon steel used in bar size flats and shapes. It also includes requirements for bar size flats where special quality killed steel is needed for case hardening and other special applications. CEMS A-2 covers requirements for cold finished carbon and alloy steel bars; CEMS A-44 describes requirements for high-strength heat-treated constructional or wear-resistant steels.

2.1 Restricted Chemical Substances

Effective January 1, 2007, all product supplied to the requirements of this specification must comply with the requirements of the MPAPS B-50 specification.

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JUNE 2014



Documents

Page 1 of 20

Document Sharing Hub

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

3.0 REFERENCE DOCUMENTS

Unless otherwise specified, the latest issue of all referenced standards shall apply. The following Specifications, Standards, and Regulations are referenced in this specification.

Quality System Standard ISO 9001 or TS-16949	ASTM A 6	ASTM A 1018
NAVISTAR Manufacturing Standard MS-D-13	ASTM A 36	ASTM A 749
NAVISTAR MPAPS A-0, Part II	ASTM A 109	ASTM E 517
NAVISTAR MPAPS A-6, Part II	ASTM A 283	ASTM E 646
NAVISTAR CEMS A-2	ASTM A 370	SAE J911
NAVISTAR MPAPS A-43	ASTM A 635	SAE J2340
NAVISTAR CEMS A-44	ASTM A 1008	ASTM A 568
NAVISTAR MPAPS B-50	ASTM A 1011	SAE J1392
	ASTM A 653	SAE J810

NOTE: ALL REFERENCED TABLES ARE GROUPED AT THE END OF THIS DOCUMENT (STARTING ON PAGE 8).

4.0 REQUIREMENTS

Steel supplied will meet the property requirements for the indicated NAVISTAR Grade as shown in Table 1. When a Type designation is added to the NAVISTAR Grade designation, material supplied will meet the additional requirements of Tables 3 and 4, or 5 and 6, as applicable. Material supplied to the requirements of this specification will meet the general requirements of ASTM A6 (Rolled Structural Steel Bar/Plates), ASTM A109 (Cold Rolled Steel Strip), ASTM A568 (Steel Sheet), or ASTM A635 (Hot Rolled Steel Sheet/Strip in Heavy-Thickness Coils), as applicable.

4.1 Flat Bars and Bar Shapes

Flat bars and bar size structurals are classified on the basis of yield strength and composition. Flat bars and bar shapes will be specified on engineering drawings using the NAVISTAR Grade classification shown in Table 1. Product supplied will meet requirements specified for the Class indicated and the applicable general product requirements of ASTM A6.

4.2 Plate and Structural Shapes

Steel plates are classified based on composition, unless structural grades or a specific strength level is specified. Shapes are classified by composition and yield strength. Plate and structural shapes will be specified on engineering drawings using the NAVISTAR Grade classification as shown in Table 1. It is anticipated that plate product supplied will be processed from heavy coils. Therefore, plate products covered by this specification will meet the applicable product requirements of ASTM A6, and all requirements specified herein for the Class and Type as indicated.

4.3 Sheet And Strip

Low carbon steel sheet is classified on the basis of chemistry, yield strength, and formability parameters. Structural Steel Sheet is classified on the basis of chemistry and tensile strength. Cold rolled strip is classified on the basis of chemistry and temper designation. Hot rolled strip is classified on the basis of chemistry and yield strength. Sheet and strip will be specified on engineering drawings using the NAVISTAR Grade classification as shown in Table 1. Steel sheet or strip specified as Grade 1, Grade 1C, Grade 2, and Grade 6 shall meet applicable requirements of ASTM A568, ASTM A109, or ASTM A749, and all requirements specified herein for the Grade classification indicated. When a Type designation is added to the NAVISTAR Grade designation, material supplied will meet the additional requirements of Tables 3 and 4, or 5 and 6 as applicable to the Type specified. Steel sheet or strip

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JUNE 2014

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

specified as Grade 3, Grade 4B, or Grade 5 shall meet the applicable requirements of ASTM A568, ASTM A635, and the requirements specified herein for the Class (and Type) as indicated.

4.3.1 Structural Sheet and Strip – Grade 6

Several steel types with strengths varying from 180-1500 MPa (25-220 ksi) are available as Grade 6 steels. In general, formability decreases with increasing strength; this is especially true with some of the higher strength materials in this class. However, several of the lower strength steels (180-550 MPa) in this Grade classification exhibit good formability.

4.3.2 Edge Condition: Unless otherwise specified,

4.3.2.1 Hot rolled strip and sheet - will be supplied with mill edge or cut edge.

4.3.2.2 Cold rolled sheet - will be supplied with cut edges.

4.3.2.3 Cold rolled strip - will be supplied with a No. 3 cut edge.

4.3.2.4 Other edge conditions shall be specified on the Engineering drawing, purchase order, or in the purchasing contract. See “Appendix – General Information” for information on specifying other edge conditions.

4.3.3 Surface Condition

Engineering design using sheet and strip products may indicate on the drawing whether the part is for an exposed (E) or unexposed (U) application. Exposed is intended for the most critical applications where painted surface appearance is of primary importance (surface condition of sheet will have controlled surface texture, quality, and flatness). Surface condition should be free from coil breaks, fluting, stretcher strain and other common surface imperfections as described and defined by SAE J810. Unexposed is intended for applications where appearance is not a significant issue; surface condition may exhibit coil breaks, fluting, stretcher strains, and surface imperfections, and standard flatness and texture tolerances are not applicable. Manufacturing must indicate on the Purchase order whether the steel being ordered is for an exposed or an unexposed application (see Section 9.4).

4.3.3.1 Hot rolled – will normally have an oxide/scale. The scaled surface is generally removed for press work and/or welding. It can be removed by blast cleaning or pickling in an acid bath. The descaled surface is subject to rusting and, unless otherwise specified, will be oiled. The hot rolled product is not normally used for exposed applications where appearance is a primary concern.

4.3.3.2 Cold rolled sheet/strip - will be supplied with standard matte finish suitable for exterior (exposed) applications. When required, other cold rolled surfaces, regular/commercial bright, and/or best-bright/luster, may be specified on the engineering drawing or purchase order.

4.3.3.3 Surface Roughness - Cold-rolled steel ordered for exposed applications will exhibit an R_a surface roughness of 0.5-1.6 μm and a peak count greater than 40 peaks per cm, as measured in accordance with SAE J911, using a 1.25 μm bandwidth for determining peaks per cm and an appropriate traverse as per SAE J911.

4.3.4 Bend Test Requirements

4.3.4.1 Grade 1: Both hot and cold rolled Grade 1 material will be capable of being bent at room temperature in any direction through 180 degree flat on itself without cracking on the outside of the bend portion. (Cracks at sheared edges of the specimen will be disregarded).

4.3.4.2 Grade 1C: Cold rolled strip is usually produced to any of five temper designations. Material specified to one of these tempers will meet requirements for hardness and bending as shown in Table 2.

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JUNE 2014



Documents

Page 3 of 20

Document Sharing Hub

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

Cold rolled sheet will meet the bend requirements of Grade 1. (Cracks at sheared edges of the specimen will be disregarded).

4.3.4.3 Grade 6 Bend Radii: See Appendix- General Information

4.4 Dimensional Tolerances

The dimensional tolerances of the basic/general ASTM specification applicable to the product will apply unless otherwise specified. All tolerances are taken as equal plus and minus increments about the specified nominal value. The nominal values for preferred thickness and associated tolerances are shown in the tables. Preferred thickness should be used in all designs. The tolerances for “inch [and soft metric conversion] design” are not the same as the tolerances shown herein for “hard metric design”. The tolerances for each design practice are different and they should not be interchanged. Further discussion on tolerances is available in “Appendix – General Information”.

4.4.1 Plate (Including Heavy Thickness Coil) Products – Dimensional Tolerances

Unless otherwise specified, plate products (including plate made from coil) will meet the tolerance requirements of ASTM A6 (ASTM A635). Preferred thickness and plate thickness tolerances are shown in Table 8 for inch design (and soft metric conversion), and in Table 9 for metric design.

4.4.1.1 Designation of Preferred Thickness and Preferred Thickness Tolerances on Drawings: When thickness is shown as a single value on the drawing and the value shown corresponds to a thickness shown in Table 8 or 9, then the thickness tolerance shown in Table 8 or 9 is applicable. Closer tolerances may be available at increased cost or by negotiation. When closer tolerances are required, they should be shown on the drawing and purchase order as a thickness range.

4.4.2 Sheet and Strip – Dimensional Tolerances Unless otherwise specified, sheet products shall meet the dimensional tolerances of ASTM A568 and strip products will meet the dimensional tolerances of ASTM A109 or ASTM A749. Preferred sheet thickness and sheet thickness tolerances are shown in Table 11 for inch design (and soft metric conversion), and in Table 12 for metric design.

4.4.2.1 Designation of Preferred Thickness and Preferred Thickness Tolerances on Drawings: When the thickness is shown as a single value on the drawing and the value shown corresponds to a thickness value shown in Table 11 or 12, then the thickness tolerance shown in Table 11 or 12 is applicable. Closer tolerances may be available by negotiation or at an increased cost. When closer tolerances are required, they should be shown as a thickness range on the drawing and purchase order.

4.5 Test Methods

4.5.1 Hardness Test

Determine the Rockwell hardness at a point, except for sheet, midway between the side edges on a single thickness only. Determine hardness on sheet 3 inches (76 mm) from the sheet edge. The recommended hardness scales for different thicknesses are shown in Table 10. Conversion between scales should be made using ASTM A370. For base metal hardness of coated samples, all coating must be removed.

4.5.2 Bend Test

Remove all burrs from the edges of the test piece by filing or grinding, then perform bend test in accordance with ASTM A370.

4.5.3 Tensile Test

Perform standard tensile tests in accordance with ASTM A370. Tensile samples should be flat and free of defects such as scores, wrinkles, die marks, etc. EDM machining is the preferred method of sample preparation. If samples are machined, care must be exercised to avoid cold working the sample edges.

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JUNE 2014

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

The plastic strain ratio 'r' is determined per ASTM E517 using longitudinal, transverse and 45° samples. The strain hardening exponent 'n' is determined as per ASTM E646.

5.0 QUALITY

The quality designations listed in Table 7 are economical, readily available, and suitable for most applications. A quality designation/description for the steel must be selected **when the steel is ordered**. In most applications, the specific quality designation [such as Merchant Quality, Commercial Steel (CS), Drawing Steel (DS), Deep Drawing Steel (DDS), or Extra Deep Drawing Steel (EDDS)] to be used, will be specified by manufacturing or by the supplier on the purchase order and **should not be specified** on the engineering drawing. In special applications, other sheet designations/descriptions required by engineering, will be specified on the engineering drawings.

5.1 Other Quality Designations

When other sheet designations/qualities are indicated on engineering drawings, purchase orders, or in contracts, referring to this specification, the product supplied will meet the chemical, process, and mechanical property requirements shown in Tables 1 or 2, or 3 and 4, or 5 and 6, as applicable to the product and to the Type designation which is added to the Grade designation.

6.0 SOURCE APPROVAL AND QUALITY CONTROL

6.1 Supplier Requirements

All suppliers to NAVISTAR are required to be registered to ISO 9001 Quality System Requirements. NAVISTAR will also accept TS-16949 registration as long as the supplier can also fulfill all AIAG PPAP (Production Part Approval Process) documentation and approval requirements. Suppliers must maintain their certification with an accredited registrar and must furnish copies of registration certificates to their Corporate Buyer upon request.

6.2 Approval

Parts supplied against contracts or purchase orders citing this specification shall be equivalent in all respects to those samples which were approved by the purchaser. No changes in formulation or processing practices are permitted without approval. In the event that changes in material, properties, processing practices, construction, color, or labeling of the product are required, the supplier shall notify NAVISTAR Materials Engineering and Purchasing and Supplier Development of the proposed change(s). Test data indicating conformance to all requirements of this specification, test samples, and new or amended or updated Material Safety Data Sheet(s) (MSDS), in accordance with CFR Title 29, Part 1910 shall be submitted with the request for change.

6.3 Process Control

The supplier shall either perform and report results of tests on specific lots of parts produced using ISO 9001 or TS-16949 guidelines, or provide statistical evidence of the lot having been produced in a state of statistical control and with a process capable of providing all required properties. The part supplier and the quality control manager of the using NAVISTAR plant may determine testing and reporting requirements on specific products.

7.0 SHIPPING AND HANDLING

Shipping and identification shall be in accordance with NAVISTAR Manufacturing Standard MS-D-13. Parts shall be packaged so as to avoid any damage in shipment detrimental to the appearance of the part.

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JUNE 2014

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

8.0 DESIGNATION ON DRAWINGS

8.1 Ordering Steel By NAVISTAR Classification

The successful operation of the NAVISTAR classification system depends upon: first, the creation of a group or class of steels which will guarantee satisfactory engineering performance; and, second, the selection of a single steel from within this group which will best respond to all manufacturing operations, such as forming, machining, and welding. In order to effect Company-wide standardization of materials, steel should be selected from the "Recommended Steels" column within the NAVISTAR grade whenever practicable.

8.1.1 The selection of an individual steel from within the Grade classification should be made by the Quality Control Manager or Planning Department of the plant ordering the steel. It is assumed that the Planning Department will consult with the various departments involved from the standpoint of cost, inventory, processing and so forth, to determine which steel within the class can be used to best advantage. The drawings and engineering specifications for individual parts should show only the general NAVISTAR Grade of steel as indicated in Table 1 (e.g., Steel, Grade 1, MPAPS A-6, Part I).

8.1.2 When more than one plant is involved in the production of a part, it is the responsibility of the Planning Department of the originating plant to obtain the approval of the Planning Departments from other fabricating plants on the selection of material. In general, it should be the plant having the most critical operation (usually forming or welding) who should decide upon the material that is most suitable for production of the part.

8.1.3 The Quality Control Manager or Planning Department is responsible for specifying the steel to be purchased. In no case should other steels be substituted without the approval of the Plant Planning Department, since different types of steel, although satisfactory from the engineering performance standpoint, may respond differently in the manufacturing operations.

8.2 Steel Ordered By Outside Suppliers

Outside suppliers furnishing finished parts may use any steel covered by the "Recommended Steels" column in Table 1, for the Grade shown on the drawing. The use of "Permissible Alternate Materials" requires approval of the NAVISTAR Plant Planning Department of the purchasing plant.

8.2.1 Outside suppliers of semi-finished parts requiring welding, heat treating, forming or machining in NAVISTAR plants must obtain approval for the specific steel they are using from the Planning Department of the purchasing NAVISTAR Plant.

8.3 Designation on Drawings

Material designation on engineering drawings will consist of the Grade designation and any other special requirements determined to be necessary to the function and/or appearance of the part.

- Examples:
- (1) Steel, Grade 1, MPAPS A-6, Pt. I
 - (2) Steel, Grade 1 or 2, MPAPS A-6, Pt. I
 - (3) Steel, Grade 1C, Temper No.3, MPAPS A-6, Pt. I
 - (4) Steel, Grade 4B, MPAPS A-6, Pt. I
 - (5) Steel, Grade 6, Type 340X, MPAPS A-6, Pt. I
 - (6) Steel, Grade 6, Type 230SS, MPAPS A-6, Pt. I
 - (7) Steel, Grade 6, Type 550XF, MPAPS A-6, Pt. I

In using this specification, Design Engineering should specify the Grade from Table 1 meeting the minimum requirements necessary to the function and appearance of the part. It is the responsibility of the Manufacturing Plant Planning Department to select one of the appropriate standard steels and to

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JUNE 2014



Documents

Page 6 of 20

Document Sharing Hub

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

determine such other requirements as are necessary for the successful fabrication of the part. Manufacturing will determine the type of product [such as, sheet, strip, flat bar, or plate, coiled or cut lengths,] steel quality [such as Commercial Steel (CS), Drawing Steel (DS), etc.,] special surface, heat treatment, oiling, pickling and so forth. This method of specifying flat rolled steel will eliminate the Engineering specification of unnecessary “cost-extras”, reduce the need for stocking several grades of steel, provide for Company standardization of steel grades and sizes, and permit maximum freedom of selection at the manufacturing level.

8.4 Designation on Purchase Orders

Material designation on purchase orders will consist of the product type, the Engineering specified steel Grade, the Manufacturing selected steel (quality) designation [as Merchant Quality-MQ, CS, DS, and Type, etc.,] and any other additional special requirements which Manufacturing determines to be necessary for proper fabrication of the part. See “Appendix.”

- Examples:
- (1) Steel Sheet, Grade 1, CS Type B, per MPAPS A-6, Part I
0.067 x 40 x coil, HR P&O*, Cut Edge, Unexposed
 - (2) Steel Sheet, Grade 1, DS Type A, per MPAPS A-6, Part I
0.8mm x 1000 x coil, CR - oiled, Cut Edge, Exposed
 - (3) Steel Strip, Grade 1, DS Type A, per MPAPS A-6, Part I
(0.78-0.82mm) x 420 x coil, CR - oiled, Cut Edge, Exposed
 - (4) Steel Sheet, Grade 6, Type 340XF, per MPAPS A-6, Part I
(0.056-0.060) x 28 x 74 HR P&O*, Mill Edge, Unexposed
 - (5) Steel Flat Bar, Grade 3, per MPAPS A-6, Part I
¼ x 4 x 90 M1020 HR
 - (6) Steel Plate, Grade 5, per MPAPS A-6, Part I
3/8 x 40 x 80 SAE 1018
 - (7) Steel Structural Angle, 4 x 3 x 1/4, Grade 4B, per MPAPS A-6, Part I

9.0 CONTACT INFORMATION

For further information related to the technical content of this specification, contact:	Suppliers may purchase controlled copies of this specification by contacting:
Materials Engineering and Technology Dept. 10400 W. North Avenue Melrose Park, IL 60160 E-mail: MaterialsEngineering@Navistar.com	IHS Global Inc. 15 Inverness Way East Englewood CO 80112-5776 Phone: 1-800-854-7179 E-mail: Automotive@IHS.com Website: http://global.ihs.com

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JUNE 2014

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

TABLE 1 - GRADE CLASSIFICATION AND REQUIREMENTS FOR LOW CARBON STEEL

NAVISTAR Grade	Condition	Typical Product Type	Minimum Expected Yield Strength		Recommended ASTM or Standard SAE Steels *	Permissible Alternates *
			ksi	MPa		
1	hot or cold rolled	Sheet/HR strip	24 (22) **	165 (150) **	ASTM A 1008 ASTM A 1011 1006, 1008, 1010, 1012	Any steel meeting minimum expected yield strength with 0.15% C max 0.10% P max 0.04% S max
1C	cold rolled strip (see Table 2)	CR strip	24 (22) **	165 (150) **	ASTM A 109	Any steel meeting Table 2 temper reqmts with 0.15% C max (Temper 4/5) & 0.25% C max (Temper 1-3)
1A	aluminized	sheet, strip	Refer to MPAPS A-6, Part II, for requirements.			
1GALV 6GALV	galvanized					
2	hot rolled	plate, sheet	26	179	ASTM A1011/A1018; 1015, 1016, 1017, 1018, 1020, 1021; ASTM A283 Grade B	Any steel meeting minimum expected yield strength with 0.21 C max 0.10 P & 0.04 S max
3	hot or cold rolled	plate or flat bar, structural shapes, bar shapes, sheet or strip	29	200	ASTM A1008, A1011, A1018; 1018, 1020, 1023; ASTM A283 Grades C & D	Any steel meeting minimum expected yield strength with 0.25 C max 0.04 P & 0.04 S max
4B	hot rolled	structural shapes, plate, flat bar, bar shapes	36	250	ASTM A 36; 1018, 1025	Any steel with 0.26 C max 0.04 P max 0.05 S max
5	hot rolled	plate	-	-	1018, 1025	Any steel with 0.33 C max 0.04 P max 0.04 S max
6	hot or cold rolled	Structural sheet & strip	See Table 5		See Table 5	none

* See Sections 10.1 and 10.2 for selection of steel grades. ** The minimum expected or "aim" yield strength is 24 ksi (165 MPa), however the yield strength of steel supplied for Grade 1 will not fall below 22 ksi (150 MPa), unless otherwise approved by the controlling Engineering Department.

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JUNE 2014



Documents

Page 8 of 20

Document Sharing Hub

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
---	---	---------------------------------

TABLE 2 – COLD ROLLED STRIP REQUIREMENTS (GRADE 1C)

Temper	Rockwell Hardness HRB		Bending Requirements * (Strip only)
	min	max (expected)	
No. 1 (hard)	84 **	-	Not required to make bends in any direction.
No. 2 (half hard)	70	85	Bend 90 degrees across the direction of rolling around a radius equal to the thickness of the specimen. ***
No. 3 (quarter hard)	60	75	Bend 180 degrees across the direction of rolling and 90 degrees parallel to the direction of rolling around a radius equal to the thickness of the specimen.
No. 4 (skin rolled)	-	65	Bend flat upon itself in any direction.
No. 5 (dead soft)		55	

* A bend across the direction of rolling is when the axis of the bend is perpendicular to the direction of rolling.

** For thickness less than 0.070 inch (1.78 mm), will meet minimum 90 HRB.

*** The edge of the forming tool will be slightly beveled to give the equivalent of a radius of 0.010 inch (0.25 mm), which may be considered as “commercially sharp.”

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JUNE 2014



Documents

Page 9 of 20

Document Sharing Hub

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

TABLE 3 – Low Carbon Steel Sheet – Chemical Requirements (max unless otherwise specified)

PRODUCT TYPE (Applicable to Grades 1, 2, or 3 only)		Chemical Requirements (Percent)																
		Carbon	Manganese	Phosphorus	Sulfur	Aluminum	Silicon	Copper	Nickel	Chromium	Molybdenum	Vanadium	Columbium	Titanium				
Commercial Steel		0.10	0.60	0.030	0.035	(4)(5)	(4)	(6) 0.20	(6) 0.20	(6) (7) 0.15	(6) 0.06	.008	(8) .008	(8) 0.025				
CS ⁽¹⁾	Type A ^{(2) (3)}																	
	Type B ⁽²⁾⁽⁵⁾														0.02 -0.15	0.60	0.030	0.035
	Type C ^{(2) (3)}														0.08	0.60	0.10	0.035
	Type D ⁽⁵⁾ (HR only)														0.10	0.70	0.030	0.035
Drawing Steel		0.08	0.50	0.020	0.030	.01 Min (exc .02 min CR Type B)	(4)	(6) 0.20	(6) 0.20	(6)(7) 0.15	(6) 0.06	.008	(8) .008	(8) 0.025				
DS ⁽¹⁾	Type A ⁽³⁾																	
	Type B ⁽²⁾														0.02 -0.08			
Deep Drawing Steel (CR)		0.06	0.50	0.020	0.025	.01 min	(4)	(6) 0.20	(6) 0.20	(6) (7) 0.15	0.06	.008	(8) .008	(8) .025				
DDS ⁽³⁾																		
Extra Deep Drawing Steel (CR)															0.02	0.40	0.020	0.020
EDDS ⁽⁹⁾																		

- (1) When Type is not specified for CS or DS products, Type B will be supplied.
- (2) To avoid carbon levels below 0.02% for CS or DS products, specify Type B.
- (3) This Type may be supplied vacuum degassed and/or chemically stabilized at producer's option.
- (4) No requirement is specified, but the content shall be included in the chemical analysis.
- (5) When aluminum deoxidized steel is needed, a min 0.01% aluminum may be ordered.
- (6) The sum of the copper, nickel, chromium, and molybdenum contents shall not exceed 0.5%.
- (7) This limitation does not apply when one or more of these elements is specified.
- (8) For carbon contents of 0.05% or less, chromium may be increased to 0.25% at the producer's option. In such cases, the limitations of footnote (6) do not apply.
- (9) For carbon contents below 0.02%, the steel may be stabilized with columbium or titanium. In such cases, the limits shown do not apply.
- (9) Steel supplied shall be stabilized. Elements used for chemical stabilization shall be reported.

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JUNE 2014

NUMBER: MPAPS A-6 Part I	TITLE: Low Carbon Steel, Flat Rolled and Structural Shapes	REVISION: 1406
------------------------------------	--	--------------------------

TABLE 4 - Low Carbon Steel Sheet – Typical Mechanical Properties (Nonmandatory)

PRODUCT TYPE (Applicable to Grades 1, 2, or 3 only)		Mechanical Properties ⁽¹⁾						
		Tensile Strength (min)		Yield Strength, 0.2 % Offset		Elongation %	Plastic Strain Ratio, r _m value (3)	Strain Hardening Exponent n value (4)
		ksi	MPa	ksi	MPa			
Commercial Steel		40	270	30 – 50	205 – 345	≥ 25	---	----
CS ⁽²⁾	Hot Rolled							
	Cold Rolled	40	270	20 – 40	140 – 275	≥ 30	---	----
Drawing Steel		40	270	30 – 45	205 – 310	≥ 28	tbd	tbd
DS ⁽²⁾	Hot Rolled							
	Cold Rolled	40	270	22 – 35	150 – 240	≥ 36	1.3 – 1.7	0.17 – 0.22
Deep Drawing Steel		40	270	17 – 29 (5)	115 – 200 (5)	≥ 38	1.4 – 1.8	0.20 – 0.25
DDS	Cold Rolled							
Extra Deep Drawing Steel		40	270	15 – 25 (5)	105 – 170 (5)	≥ 40	≥ 1.7	0.23 – 0.27
EDDS	Cold Rolled							

⁽¹⁾ Tensile test properties in accordance with ASTM A 370.

⁽²⁾ When Type is not specified for CS or DS products, Type B will be supplied. Mechanical property requirements apply equally to all Types for CS product and to both Types for DS products.

⁽³⁾ Test per ASTM E 517, parameter r calculated at 17% strain, r_m calculated as (r₀ + r₉₀ + 2r₄₅)/4. The r_m value may be up to 0.2 lower than indicated in the Table for steel thickness greater than 1.4mm (0.055 in) or for galvanneal products.

⁽⁴⁾ Test per ASTM E 646, n value calculated at 10-20% strain, or at 10% to end of uniform elongation, for samples whose uniform elongation is less than 20%.

⁽⁵⁾ Yield strength will be 22 ksi (150 MPa) minimum unless otherwise approved by Engineering.

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Page 11 of 20

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