

NAVISTAR, INC.		
Material, Parts, and Process Specifications (MPAPS)		NUMBER: MPAPS E-2
		Former Designation: CEMS E-2, CEMS E-2 APPX
TITLE: Steel Castings		CURRENT REV No.: 1602
		DATE: Feb. 2016
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<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: Updated to MPAPS format, added Charpy reference ASTM E23, combined with appendix, and editorial changes.		

1.0 APPLICATION

Cast steels offer a wide range of properties, achievable by heat treatment, and are readily weldable at most strength levels. They offer good impact resistance but are less castable and more expensive than the gray cast irons.

2.0 SCOPE

This specification covers the Company's requirements for steel castings.

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.

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
CFR Title 29, Part 1910
NAVISTAR Engineering Design Std. A-16
NAVISTAR Manufacturing Std. MS-D-13
NAVISTAR MPAPS B-50
NAVISTAR MPAPS AT-2
NAVISTAR EPS-91

NAVISTAR EPS-143
ASTM A370
ASTM E10
ASTM E23
ASTM E94
ASTM E112

ASTM E125
ASTM E140
ASTM E208
ASTM E446
ASTM E709
SAE J435

4.0 CLASSIFICATION OR DESIGNATION

Steel castings are classified on the basis of strength and heat treatment process.

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FEBRUARY 2016



Documents

Page 1 of 20
Document Sharing Hub

NUMBER: MPAPS E-2	TITLE: Steel Castings	REVISION: 1602
-----------------------------	---------------------------------	--------------------------

5.0 REQUIREMENTS

5.1 Mechanical Properties

The primary intent of this specification is to obtain castings with controlled mechanical properties. (Refer to Section 5.2 for chemical requirements.)

All castings purchased to this specification will be supplied heat treated and have mechanical properties conforming to Tables I, IA and II. Other required heat treatments and/or properties will be specified on the drawing. All heat treat agreements and specifications will remain in effect until mutually changed or terminated.

5.1.1 Castings - Normalized Or Normalized And Tempered

Grades SC-0, SC-1, SC-2, and SC-3 will be either normalized or normalized and tempered, unless otherwise specified. Normalizing and tempering is required for Grades SC-4, SC-5, SC-6 SC-2R and SC-6R but these grades may be supplied quenched and tempered with approval of the controlling design engineering department, after consultation with the materials engineer. After quenching and tempering, they will meet the mechanical properties required for normalized and tempered castings, unless otherwise specified on the drawing. Grades SC-2 and SC-6 will be assigned an 'R' suffix designation when impact requirements are specified. Example SC-2R, SC-6R.

5.1.2 Castings - Quenched And Tempered

Where quenching and tempering is required for Grades SC-3 through SC-6 the appropriate suffix letter shown in Tables I and IA (suffix letters A, B, C, or D) indicating the required mechanical properties will be added: Example: SC-6B. Note: A suffix letter need not be added to those castings which are quenched and tempered to meet normalized and tempered mechanical properties. See "Castings - Normalized or Normalized and Tempered" above.

5.1.2.1 Quenched castings will be tempered at 425°C (800°F) minimum, except those used in abrasion resistant applications. Castings must be in a homogeneous state, achieved by either a normalizing operation or a longer austenitizing time, prior to quenching and tempering, unless otherwise specified. However, when castings are specified quenched and tempered, they are not required to meet the mechanical properties specified for normalized or normalized and tempered castings, prior to quenching and tempering. The purchaser and supplier will agree upon the necessary process and material to assure mechanical properties, machinability and weldability requirements are achieved.

5.1.3 Tensile Requirements

The tensile requirements specified for test bars pertain to standard tensile test specimens machined from keel blocks or test coupons having a thickness of 25 mm (1 inch). Casting tensile requirements will be determined on tensile test specimens taken from the center of sections up to 25 mm (1 inch) thick, inclusive and from the mid-radius of sections over 25 mm (1 inch) thick. See "Methods of Test", Section 7.0.

5.1.3.1 If the foundry anticipates or finds that it cannot meet the strength requirements throughout the casting as determined above, the foundry will request the controlling engineering department to identify significant sections on the drawing. When sections of a casting are deemed significant for reasons of stress, function or reliability, the controlling design engineering department must designate the location of the significant section or sections on the drawing. The purpose of this procedure is to clearly establish that strength (or corresponding hardness) determinations be made in those required areas.

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FEBRUARY 2016



Documents

Page 2 of 20
Document Sharing Hub

NUMBER: MPAPS E-2	TITLE: Steel Castings	REVISION: 1602
-----------------------------	---------------------------------	--------------------------

5.1.4 Hardness

Hardness requirements for casting will be met on finished machined surfaces. Therefore, it may be necessary to control hardness at or near the casting surfaces to a range different than specified herein, to compensate for stock removal. Navistar Engineering and supplier will agree upon the different hardness ranges. The conversion of hardness to tensile strength will be according to the Hardness Conversion Chart in ASTM E-140.

TABLE I - MECHANICAL PROPERTIES*

Designation			Required Heat Treatment	Tensile Strength, min ksi		Yield Strength, 0.2% offset, min ksi		Elongation in 2 inches, % min		Reduction of Area, % min		Brinell Hardness Number HBW
Navistar Grade	Suffix Letter	Obsolete Navistar Grade		test bars	castings	test bars	castings	test bars	castings	test bars	castings	test bars and castings
SC-0	none	—	normalized or normalized and tempered	—	—	—	—	—	—	—	—	187 max
SC-1		—		65	52	35	28	24	19	35	28	131-187
SC-2		—		75	60	45	36	20	16	20	24	156-207
SC-3		—		85	68	45	36	16	13	24	19	170-229
SC-4		—	normalized and tempered **	90	72	60	48	16	13	35	28	187-241
SC-5		—		75	60	45	36	20	16	30	24	156-207
SC-6		SC-7		90	72	60	48	16	13	35	28	187-241
SC-2R		—		100	80	70	56	10	8	15	12	207-255
SC-6R		SC-R		105	84	85	68	17	14	35	28	217-269
SC-3	A	—	quenched and tempered ***	120	96	95	76	14	11	30	24	255-302
SC-4	B	—		150	120	125	100	9	7	22	18	302-363
SC-5		—										
SC-6	C	SC-7										
SC-4		—										
SC-5	D	—										
SC-6		SC-7										
SC-4	D	—										
SC-5		—										

* See “Appendix - General Information” for mechanical properties design criteria.

** These grades may be quenched and tempered with approval of the controlling design engineering department. In such cases, the materials engineer should be consulted.

*** When castings and test bars are quenched and tempered, they do not have to meet the mechanical properties specified for normalized or normalized and tempered castings and test bars prior to quenching and tempering.

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FEBRUARY 2016



Documents

Page 3 of 20

Document Sharing Hub

NUMBER: MPAPS E-2	TITLE: Steel Castings	REVISION: 1602
-----------------------------	---------------------------------	--------------------------

TABLE I A - METRIC EQUIVALENT OF TABLE I*

Designation			Required Heat Treatment	Tensile Strength MPa, min		Yield Strength, 0.2% offset MPa, min		Elongation in 50 mm % min		Reduction of Area, % min		Brinell Hardness Number HBW
Navistar Grade	Suffix Letter	Obsolete Navistar Grade		test bars	castings	test bars	castings	test bars	castings	test bars	castings	test bars and castings
SC-0	none	—	normalized or normalized and tempered	—	—	—	—	—	—	—	—	187 max
SC-1		—		448	359	241	193	24	19	35	28	131-187
SC-2		—		517	414	310	248	20	16	20	24	156-207
SC-3		—		586	469	310	248	16	13	24	19	170-229
SC-4		—	normalized and tempered **	620	496	414	331	16	13	35	28	187-241
SC-5		—		517	414	310	248	20	16	30	24	156-207
SC-6		SC-7		620	496	414	331	16	13	35	28	187-241
SC-2R		—		620	496	414	331	16	13	35	28	187-241
SC-6R		SC-R		689	552	483	386	10	8	15	12	207-255
SC-3	A	—	quenched and tempered ***	724	579	586	469	17	14	35	28	217-269
SC-4	B	—		827	662	655	524	14	11	30	24	255-302
SC-5		—		1034	827	862	689	9	7	22	18	302-363
SC-6	C	—										
SC-6		SC-7										
SC-4	D	—										
SC-5		—										

*, **, *** See footnotes for Table I

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FEBRUARY 2016



Documents
Page 4 of 20

NUMBER: MPAPS E-2	TITLE: Steel Castings	REVISION: 1602
-----------------------------	---------------------------------	--------------------------

5.1.5 Impact Test Requirements (Grade SC-2R and SC-6R)

These grades of steel castings purchased to this specification will meet the following impact test requirements unless otherwise specified. See “Methods of Test”, Section 7.0.

5.1.5.1 The requirements for standard and sub-size Charpy V-Notch specimens are shown in Table II. The standard size specimen will be used except where the section thickness does not permit machining a 10 mm by 10 mm specimen. In such cases, sub-size specimens as listed will be used. The sub-size specimen selected will be as large as the particular section thickness permits.

5.1.5.2 Nil Ductility Transition Temperature - Optional Method

SC-2R and SC-6R Grades steel castings will have a maximum nil ductility transition temperature (NDTT) of -34°C (-30°F). This requirement may be used in lieu of the Charpy V-Notch impact requirement for material with section thickness 15.9 mm (0.625 inch) and greater.

TABLE II - GRADES SC-2R & SC-6R CHARPY V-NOTCH IMPACT TEST REQUIREMENTS

Type of Specimen	Specimen Size, mm	Test Temperature		Impact Value, min			
				castings		test bars*	
		°F	°C	ft lbf	J	ft lbf	J
Standard	10 x 10	-20	-29	8.0	11.0	11.0	15.0
sub-size	10 x 9	-20	-29	7.5	10.0	N/A	N/A
sub-size	10 x 8	-20	-29	7.0	9.5	N/A	N/A
sub-size	10 x 7.5	-20	-29	7.0	9.5	N/A	N/A
sub-size	10 x 7	-20	-29	6.5	9.0	N/A	N/A
sub-size	10 x 6.7	-20	-29	6.5	8.5	N/A	N/A
sub-size	10 x 6	-20	-29	6.0	8.0	N/A	N/A
sub-size	10 x 5	-20	-29	5.5	7.5	N/A	N/A
sub-size	10 x 4	-20	-29	5.0	7.0	N/A	N/A
sub-size	10 x 3.3	-20	-29	4.5	6.0	N/A	N/A
sub-size	10 x 3	-20	-29	4.5	6.0	N/A	N/A
sub-size	10 x 2.5	-20	-29	4.0	5.5	N/A	N/A

N/A = Not applicable

* Machined from keel block or test coupons having a thickness of 25 mm (1 inch).

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FEBRUARY 2016



Documents

Page 5 of 20
Document Sharing Hub

NUMBER: MPAPS E-2	TITLE: Steel Castings	REVISION: 1602
-----------------------------	---------------------------------	--------------------------

5.2 Chemical Composition

Steel castings purchased to this specification will have compositions as shown in Table III.

TABLE III - CHEMICAL COMPOSITION

Designation			Chemical Composition, percent maximum (unless otherwise specified)					
Navistar Grade	Obsolete Navistar Grade	Approximate SAE Grade	Carbon	Manganese	Silicon	Phosphorus	Sulfur	Alloys *
SC-0	—	J435,0000 (0022)	0.12	0.50-0.90	0.60	0.040	0.045	—
SC-1	—	J435, 450 (0030)	0.30 **	0.70	0.80	0.040	0.045	—
SC-2	—	—	0.35 **	0.80	0.80	0.040	0.045	optional
SC-3	—	J435,585 (0050A)	0.40-0.50	0.50-0.90	0.80	0.040	0.045	optional
SC-4	—	J435,620 (090)	0.45	optional	0.80	0.040	0.045	optional
SC-5	—		0.32	optional	0.80	0.040	0.045	optional
SC-6	SC-7		0.25	optional	0.80	0.040	0.045	optional
SC-2R	—	J1119	0.30	optional	0.80	0.040	0.030	optional ***
SC-6R	SC-R	J1119	0.30	optional ***	0.80	0.040	0.030	optional ***

- * ALLOY OPTIONS - For all grades which specify alloys as optional, the supplier and the plant metallurgist will agree upon the alloying elements necessary to meet the mechanical properties, weldability, machinability or other requirements, unless specified on the drawing.
- ** For each reduction of 0.01% carbon below the maximum specified, an increase of 0.04% manganese above the maximum specified will be permitted up to a maximum of 1.40% for Grade SC-2 and 1.00% maximum for Grades SC-0 and SC-1.
- *** Alloy additions are permitted as above but are limited to the extent that they do not increase the carbon equivalency (C.E.) of 0.55 for weldability as calculated from the formula (ref: Stout & Doty, "Weldability of Steel", AWS).

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Ni}{20} + \frac{\%Cr}{10} + \frac{\%Mo}{10} + \frac{\%Cu}{40}$$

5.2.1 Flame And Induction Hardened Castings

If flame or induction hardening of a casting is involved, the carbon content range will be specified on the drawing. The plant metallurgist or the Quality Manager of the using NAVISTAR Plant and the supplier will agree upon the necessary carbon content.

5.3 Austenitic Grain Size

Austenitic grain size will be No. 5 or finer. See "Methods of Test", Section 7.5.

5.4 Dimensional Tolerances

Unless otherwise specified, the total dimensional tolerance for unmachined surfaces will be as per Table IV below. The same tolerance will apply to bores, cored openings, all such relations between dimensions and includes dimensions across parting line. It does not include material added for draft angles which will be 1.5 degrees, unless otherwise specified. See "Appendix - General Information".

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FEBRUARY 2016



Documents

Page 6 of 20
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