

NAVISTAR, INC.		
Material, Parts, and Process Specifications (MPAPS)		NUMBER: MPAPS C-10
		Former Designation: CEMS C-10
TITLE:	Wrought Aluminum Alloys	CURRENT REV No.: 1703
		DATE: Mar. 2017
WRITTEN/REVISED BY: W. Cook	APPROVED BY: R. Goluch	SUPERSEDES ISSUE OF: Rev. 1510 – Oct. 2015
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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 note for alloy 5754-H22 in table II		

1.0 SCOPE

This specification covers the most frequently specified grades and product forms of wrought aluminum alloys used in the Corporation's products. Refer to MPAPS C-1059 for aluminum tubing requirements used primarily for engine air/fluid systems, such as air intake, charge air coolers, etc.

2.0 INTRODUCTION

This specification is generally based upon the Aluminum Association "Aluminum Standards and Data" (ASD) handbook. Aluminum alloy compositions listed herein are based upon their Aluminum Association (AA) designations.

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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4.0 REFERENCE DOCUMENTS

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

Quality System Standard ISO 9001 or TS-16949	Alum. Assn. ASD Manual
NAVISTAR Supplier Packing and Shipping Std. D-13	ASTM E 34
CFR Title 29, Part 1910	ASTM B 557
NAVISTAR MPAPS B-50	NAVISTAR MPAPS C-1059
NAVISTAR MPAPS G-21	

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5.0 CLASSIFICATION

Aluminum alloys are classified by alloy composition and temper. All of the alloys, tempers and product forms covered in the Aluminum Association “Aluminum Standards and Data” (ASD) Manual are a part of and will be specified through MPAPS C-10. The ASD manual contains detailed information on standard wrought alloys and the mill products normally produced from these alloys. Single copies of this document are available on request from the Aluminum Association (www.aluminum.org or by phone at 480-779-6259).

6.0 MATERIAL REQUIREMENTS

6.1 Chemical Composition

Refer to Table I for requirements. For Aluminum Association registered alloys not listed in Table I refer to Aluminum Association Aluminum Standards and Data Manual for chemical composition requirements.

6.2 Mechanical Properties

Refer to Table II for requirements. For informational purposes, MPAPS C-10 Appendix also provides typical mechanical properties in Table A-III(a) and variation of tensile properties with temperature in Table A-III(b) (Appendix). For specified Aluminum Association registered alloys not listed in Table II that are supplied in sheet or plate form subject to Aluminum Association Property Limits, refer to refer to Aluminum Association Aluminum Standards and Data Manual for mechanical property requirements.

6.3 Permissible Alternates

When a particular type of aluminum alloy is specified on a drawing, it may be desirable or advantageous to permit the manufacturing plant or supplier to use an alternate aluminum alloy. Permissible alternates for certain specific aluminum alloys are described in this section. The manufacturer/supplier is responsible to ensure that the alternate alloy selected has adequate formability, weldability, surface quality or other necessary properties to successfully fabricate the part.

6.3.1 AA 6005/6105

When alloy 6005 or 6105 is specified on a drawing, the use of either alloy is optional.

6.3.2 AA 2008-T4/6022-T4

When alloy 2008-T4 or 6022-T4 is specified on a drawing, the use of either alloy is optional. Note that there may be slight differences in formability in some manufacturing processes.

6.3.3 AA 6005-T5/6061-T6/6351-T5

When alloy 6005-T5 or 6061-T6 or 6351-T5 is specified on a drawing, the use of any one of these alloys and tempers is optional.

6.3.4 AA 6463/6463A

When alloy 6463 is specified on a drawing, alloy 6463A may be substituted.

6.3.5 AA 5052 H32, H34/ 5754 H22

When Alloy 5052 H32 or H34 is specified on a drawing, alloy 5754 H22 may be substituted

6.4 Surface Finishes

All materials will be supplied in the mill finish unless otherwise specified. If another mechanical or chemical surface finish is desired (e.g., M21 for high gloss mechanical polish), the finish should be specified on the engineering drawing using the standard Aluminum Association finish designations as shown in Table III of this specification. For some exterior or exposed applications, aluminum parts may

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require anodizing to enhance corrosion resistance (or prevent galvanic corrosion), wear resistance, or for decorative purposes. Generally, anodizing is more cost effective than chrome plating of aluminum. Refer to MPAPS G-21 for anodizing requirements.

6.5 Preferred Sheet/Plate Thicknesses and Tolerances

Refer to Table IV for preferred aluminum thicknesses and Table V for thickness tolerances. Values given in Table IV should be used on engineering drawings when specifying such aluminum products.

6.6 Aluminum Tubing

Mechanical properties for aluminum tubing are included in Table II. Also see Section A.7 in MPAPS C-10 Appendix for more information on tubing. Tubing tolerances are dependent on type of aluminum alloy used, type of tube process, and size; refer to the ASD Manual or contact Materials Engineering for more information.

7.0 QUALITY

Materials purchased to this specification will be of uniform quality and temper and will be free from internal and surface discontinuities detrimental to the fabrication or performance of parts.

8.0 METHODS OF TEST

Chemical analysis as per ASTM E 34 and mechanical properties as per ASTM B 557.

9.0 SOURCE APPROVAL AND QUALITY CONTROL

9.1 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.

9.2 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.

9.3 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 plant may determine testing and reporting requirements on specific products.

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10.0 DESIGNATION ON DRAWINGS AND PURCHASE ORDERS

10.1 Drawings

Designation on drawings will include alloy and temper designation and, when necessary, product shape and/or any special requirements.

Examples: Aluminum, 1100-0, MPAPS C-10

Aluminum Forging Stock, 6151-T6, MPAPS C-10

Aluminum Sheet, 3003-H14, one side bright mill finish, MPAPS C-10

10.2 Purchase Orders

In addition to the drawing designation, it is the responsibility of the Plant Planning Department or Quality Control Manager to add to purchase orders any special requirements which may be necessary for proper fabrication of the final part such as formability tests, restricted properties, etc.

11.0 PACKING AND SHIPPING

Material purchased to this specification will be packed in such a manner as to prevent damage in ordinary handling, transportation and storage. Packing and identification of material shipped to Navistar facilities will be in accordance with Navistar Supplier Packing and Shipping Standard D-13.

12.0 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 Ave. Melrose Park, IL 60160 E-mail: MaterialsEngineering@Navistar.com	IHS Markit 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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TABLE I - CHEMICAL COMPOSITION (% max, unless otherwise indicated)

AA Designation	Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Zinc	Titanium	Others	
									Each	Total
1100*	0.95 Si + Fe		0.05-0.20	0.05	-	-	0.10	-	0.05	0.15
1235*	0.65 Si + Fe		0.05	0.05	0.05	-	0.10		0.03	-
2008	0.50-0.8	0.40	0.7-1.10	0.30	0.25-0.5	0.10	0.25	0.10	0.05	0.15
2011†	0.40	0.7	5.0-6.0	--	--	--	0.30	--	0.05†	0.15
2014	0.50-1.2	0.70	3.9-5.0	0.40-1.2	0.20-0.8	0.10	0.25	0.15	0.05	0.15
2036	0.50	0.50	2.2-3.0	0.10-0.4	0.30-0.6	0.10	0.25	0.15	0.05	0.15
2117	--	--	2.6	--	0.35	--	--	--		
3003	0.60	0.70	0.05-0.20	1.0-1.5	-	-	0.10	-	0.05	0.15
3004	0.30	0.70	0.25	1.0-1.5	0.8-1.3	-	0.25	-	0.05	0.15
5005	0.30	0.70	0.20	0.20	0.50-1.1	0.10	0.25	-	0.05	0.15
5049	0.40	0.50	0.10	0.50-1.1	1.6-2.5	0.30	0.20	0.10	0.05	0.15
5052	0.25	0.40	0.10	0.10	2.2-2.8	0.15-0.35	0.10	-	0.05	0.15
5056	0.30	0.40	0.10	0.05-0.20	4.5-5.6	0.05-0.20	0.10	-	0.05	0.15
5083	0.40	0.40	0.10	0.40-1.0	4.0-4.9	0.05-0.25	0.25	0.15	0.05	0.15
5086	0.40	0.50	0.10	0.20-0.70	3.5-4.5	0.05-0.25	0.25	0.15	0.05	0.15
5154	0.25	0.40	0.10	0.10	3.1-3.9	0.15-0.35	0.20	0.20	0.05	0.15
5182**	0.20	0.35	0.15	0.20-0.50	4.0-5.0	0.10	0.25	0.10	0.05	0.15
5252	0.08	0.10	0.10	0.10	2.2-2.8	-	0.05	-	0.03	0.10
5454	0.40	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	0.25	0.20	0.05	0.15
5657	0.08	0.10	0.10	0.03	0.6-1.0	-	0.05	-	0.02	0.05
5754	0.40	0.40	0.10	0.50	2.6-3.6	0.30	0.20	0.15	0.05	0.15
6005	0.6-0.9	0.35	0.10	0.10	0.40-0.60	0.10	0.10	0.10	0.05	0.15
6009	0.6-1.0	0.50	0.15-0.6	0.20-0.8	0.40-0.80	0.10	0.25	0.10	0.05	0.15
6022	0.8-1.5	0.05-0.2	0.01-0.11	0.02-0.1	0.45-0.70	0.10	0.25	0.15	0.05	0.15
6053	***	0.35	0.10	--	1.1-1.4	0.15-0.35	0.10	--	0.05	0.15
6061	0.40-0.8	0.70	0.15-0.40	0.15	0.8-1.2	0.04-0.35	0.25	0.15	0.05	0.15
6063	0.20-0.6	0.35	0.10	0.10	0.45-0.9	0.10	0.10	0.10	0.05	0.15
6105	0.6-1.0	0.35	0.10	0.15	0.45-0.8	0.10	0.10	0.10	0.05	0.15
6111	0.6-1.1	0.40	0.50-0.9	0.10-0.45	0.50-1.0	0.10	0.15	0.10	0.05	0.15
6351	0.7-1.3	0.50	0.10	0.40-0.8	0.40-0.80	-	0.20	0.20	0.05	0.15
6463	0.20-0.6	0.15	0.20	0.05	0.45-0.9	-	0.05	-	0.05	0.15
6463A††	0.20-0.6	0.15	0.25	0.05	0.30-0.8	-	0.05	-	0.05	0.15
7075	0.40	0.50	1.2-2.0	0.30	2.1-2.9	0.18-0.28	5.1-6.1	0.20	0.05	0.15

Footnotes for Table I:

* Aluminum content will be 99.0% minimum for 1100 and 99.35% minimum for 1235

** Certain limitations should be placed on the amount of cold work and the safe operating temperatures permissible for the 5000 series alloys with higher magnesium content (over about 3.5% for operating temperatures above about 150°F) to avoid susceptibility to stress corrosion.

***Silicon 45-65% of actual magnesium content.

† Alloy 2011 also contains 0.20-0.60% each of lead and bismuth for free-machining qualities.

†† Alloy 6463A may be substituted for alloy 6463 as required; these alloys have a slight variation in chemical composition.

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TABLE II - MECHANICAL PROPERTIES

Alloy Designation	Temper	Product Form* And Thickness	TENSILE STRENGTH MPa (Ksi)		YIELD STRENGTH 0.2% Offset MPa (Ksi)		Elongation (% in 2 in.)
			Minimum	Maximum	Minimum	Maximum	Minimum
1100	O	Sheet	76 (11.0)	107 (15.5)	24 (3.5)	-	25
1235	O	Foil		99 (14)	-		-
1235	H-19	Foil	138 (20.0)	-	-	-	-
2008	T4	Sheet	200 (29.0)	-	103 (15.0)	-	22
2011	T3	Rod 0.125-1.5"	310 (45.0)	-	262 (38.0)	-	10
	"	Rod 1.501-2.0"	296 (43.0)	-	234 (34.0)	-	12
	"	Rod 2.001-3.5"	290 (42.0)	-	207 (30.0)	-	12
2014	T4	Forging to 4"	379 (55.0)	-	207 (30.0)	-	11
	T4	Extrusion (all)	344 (50.0)	-	241 (35.0)	-	12
	T6	Extrusion to .5"	414 (60.0)	-	365 (53.0)	-	7
2117	T4	Rivet wire/rod	260 (37.7)	-	125 (18.0)	-	10
3003	O	Sheet	96 (14.0)	131 (19.0)	34 (5.0)	-	23
	O	Extrusion & Tube	96 (14.0)	131 (19.0)	34 (5.0)	-	25
	H112	Extrusion (all)	90 (13.0)	-	34 (5.0)	-	25
	H14	Sheet (to .249")	138 (20.0)	179 (26.0)	117 (17.0)	-	7
	H14	Tube to .259" wall	138 (20.0)	179 (26.0)	117 (17.0)	-	8
	H16	Tube to .5" wall	165 (24.0)	-	145 (21.0)	-	3
	H22	Bright tread sheet to .188"	117 (17.0)	-	83 (12.0)	-	7
3004	O	Sheet	152 (22.0)	200 (29.0)	58 (8.5)	-	16
	H32	Sheet	193 (28.0)	241 (35.0)	145 (21.0)	-	4
	H34	Sheet	221 (32.0)	262 (38.0)	172 (25.0)	-	3
5005	H32	Sheet	117 (17.0)	158 (23.0)	83 (12.0)	-	5
5049	O	Extrusion	180 (26.1)		80 (11.6)		17
	H32	Extrusion	190 (27.6)	220 (31.9)	115 (16.7)	135 (19.6)	17
5052	O	Sheet	172 (25.0)	214 (31.0)	65 (9.5)	-	18
	H32	Sheet/tread plate	214 (31.0)	262 (38.0)	158 (23.0)	-	5
	H34	Sheet	234 (34.0)	283 (41.0)	179 (26.0)	-	4
5056	H32	Wire/Rod	303 (44.0)	-	-	-	-
5083	O	Sheet	275 (40.0)	351 (51.0)	124 (18.0)	200 (29.0)	16
5086	H32	Sheet	275 (40.0)	324 (47.0)	193 (28.0)	-	8
5154	O	Wire	207 (30.0)	283 (41.0)	76 (11.0)	-	25
5182	O	Sheet	255 (37.0)	-	110 (16.0)	-	18
	O2**	Sheet	248 (36.0)	-	103 (15.0)	-	20
5252	H25	Sheet	214 (31.0)	269 (39.0)	-	-	9
	H351	Sheet	214 (31.0)	-	158 (23.0)	-	9
5454	O	Sheet	214 (31.0)	-	83 (12.0)	-	12
5657	H241	Sheet	124 (18.0)	179 (26.0)	-	-	13
5754†	O/H111	Sheet/tread plate	200 (29.0)	-	83 (12.0)	-	17
	H22	Sheet/tread plate	245 (35.5)	-	185 (26.8)	-	15
6005	T1	Extrusion/tubing to 0.5"	172 (25.0)	-	103 (15.0)	-	16
	T5	Extrusion/tubing to .124"	262 (38.0)	-	241 (35.0)	-	8

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Alloy Designation	Temper	Product Form* And Thickness	TENSILE STRENGTH MPa (Ksi)		YIELD STRENGTH 0.2% Offset MPa (Ksi)		Elongation (% in 2 in.)
			Minimum	Maximum	Minimum	Maximum	Minimum
6009	T4	Sheet	186 (27.0)		103 (15.0)		21
6022	T4	Sheet	234 (34.0)		131 (19.0)		
6053	O	Rivet wire to 1"		131 (19.0)	-	-	-
	H13	Rivet wire to 1"	131 (19.0)	179 (26.0)	-	-	-
	T61	Rivet wire	205 (29.7)	-	135 (19.6)	-	12
6061	O	Extrusion (all types)	-	152 (22.0)	-	110(16.0)	16
	T1	Extrusion to .625"	179 (26.0)	-	96 (14.0)	-	16
	T4	Extrusion (all)	179 (26.0)	-	110 (16.0)	-	16
	T6	Extrusion to .25"	262 (38.0)	-	241 (35.0)	-	8
	T6	Sheet & Plate	289 (42.0)	-	241 (35.0)	-	10
	T6	Tread Sheet/Plate to .188"	289 (42.0)	-	241 (35.0)	-	6
6063	O	Extrusion (all)	-	131 (19.0)		-	18
	T1	Extrusion	117 (17.0)	-	62 (9.0)	-	12
	T4	Extr. Wire to 0.5"	131 (19.0)		69 (10.0)		14
	T4	Extr. Wire 0.5-1"	124 (18.0)		62 (9.0)		14
	T5	Extrusion to .5"	152 (22.0)	-	110 (16.0)	-	8
	T6	Extrusion	207 (30.0)	-	172 (25.0)	-	8
6105	T1	Extrusion/tubing to 0.5"	172 (25.0)	-	103 (15.0)	-	16
	T5	"	262 (38.0)	-	241 (35.0)	-	8
6111	T4	Sheet	248 (36.0)	-	138 (20.0)	-	23
	T41	Sheet	269 (39.0)	-	145 (21.0)	-	23
6351	T5	Extrusion	262 (38.0)	-	241 (35.0)	-	8
	T6	Extrusion	290 (42.0)	-	255 (37.0)	-	8
6463	T1	Extrusion	117 (17.0)	-	62 (9.0)	-	12
	T5	Extrusion	152 (22.0)	-	110 (16.0)	-	8
	T6	Extrusion Up thru 0.124 in.	207 (30.0)	-	172 (25.0)	-	8
7075	T6	Sheet Up thru 0.249 in.	552 (80.0)		476 (69.0)		9
	T73	Forging Up thru 3.000 in.	455 (66.0)	-	386 (56.0)	-	7
	T73	Sheet Up thru 0.249 in.	462 (67.0)		386 (56.0)		8

* The data selected for sheet products is based on a thickness range of 0.80 to 1.25mm (0.032 to 0.050 inch). There may be differences for other thickness ranges, especially in heavier sections. Consult the ASD Manual for other thicknesses.

**A variation of the O Temper not susceptible to Luders line formation. See Appendix.

† Alloy 5754 is the European standard similar to alloy 5052 aluminum. Alloy 5754-H22 may be substituted for alloy 5052-H32/H34 as required.

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