

NAVISTAR, INC.		
Material, Parts, and Process Specifications (MPAPS)		NUMBER: MPAPS C-5
		Former Designation: CEMS C-5
TITLE: Bearing and Bushing Alloys		CURRENT REV No.: 1510
		DATE: OCT 2015
WRITTEN/EDITED BY: J. Goldschmidt	APPROVED BY: R. Goluch	SUPERSEDES: April 2012
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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: Reformatted to MPAPS and added the information from the appendix document.		

1.0 APPLICATION

This specification applies to bearings, bushings and thrust washers that are lubricated hydro-dynamically with oil and used in engines, reciprocating pumps and compressors, transmissions, transaxles turbochargers, electric motors and other reciprocating and/or rotating machines and assemblies. Specifically it applies to multi- layer connecting rod and crankshaft bearings, and multi-layer and single material full round bushings and thrust washers. It also applies to oil- impregnated, sintered, powder-metal bearings and bushings made from alloys covered under MPIF Standard 35

2.0 SCOPE

This specification covers chemistry requirements for selected materials used for bearings in the Corporation's products. It also covers mechanical property and microstructural requirements of certain solid single alloy bronze bearing materials and sintered powder metal materials. Requirements for similar materials may be found in the following specifications:

Brass and Bronze Castings	MPAPS C-2
Wrought Copper Base Alloys	CEMS C-3
Aluminum Castings	MPAPS C-8
Wrought Aluminum Alloys	MPAPS C-10
Powdered Metal Iron and Steel Structural Parts	MPAPS H-1

For the use of polymer coatings as bearing materials, see CEMS G-15.

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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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 E 18	SAE J460
CFR Title 29, Part 1910	ASTM B 328	SAE J461
NAVISTAR Manufacturing Std. MS-D-13	ASTM B 438	SAE J462
NAVISTAR Engineering Design Std A-16	ASTM B 439	SAE J463
NAVISTAR MPAPS B-50	ASTM B 487	SAE J471
NAVISTAR MPAPS A-6 Part I	ASTM B 612	SAE J993
NAVISTAR CEMS G-15		SAE J452
NAVISTAR CEMS HT-1		SAE J454
NAVISTAR MPAPS D-28		SAE J459
MPIF Standard 35		

4.0 REQUIREMENTS

4.1 Chemical Composition

4.1.1 Solid, Bimetal and Trimetal Alloys

Bearings and bushings purchased to this specification will meet the requirements of chemical composition shown in Table I. Materials which are not shown in Table I, but for which the Aluminum Association (see SAE J993 Aluminum Classification, SAE J452 Casting Alloys, or SAE J454 Wrought Alloys) or the Copper Development Association (see SAE J461 Copper Alloy Classification, SAE J462 Cast Alloys, or SAE J463 Wrought Alloys) have published designations and composition limits, will be specified using those designations. All bimetal and trimetal bearings and bushings will be provided with steel (Grade 1, MPAPS A-6, Part I) backing unless otherwise specified on the drawing.

4.1.2 Powdered Metal Alloys

Bearings and bushings purchased to this specification will meet the requirements of chemical composition shown in Table I. Other materials not shown in Table I may be used. Refer to SAE J471 and Metal Powder Industries Federation (MPIF) Standard 35. P/M alloys which are not shown in Table I will be supplied to the chemical composition as specified on the drawing or to the chemical composition of the MPIF code/classification as shown in MPIF Standard 35.

4.1.3 Nonmetallic Materials

A variety of plastic bearing materials exist today, although at present there are no accepted rules for classification. General nonmetallic bearing materials include Nylon, Phenolics, Polyacetals, PTFE, Polyamides, and composites. In addition, various filler media are often added to improve material properties. Compositional requirements for all nonmetallic bearings will be specified by the material designation on the drawing. Refer to MPAPS D-28 and MPAPS G-15. The designation should include base material and filler media if added.

4.2 Classification

Although the selection of materials is dependent upon their physical and mechanical properties, the classification of bearing and bushing alloys has traditionally been based upon their chemical composition. The chemical compositions of current and commonly used alloys are listed in Table I. If none of the alloys listed include the characteristics required for a particular application, other materials

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may be used. Refer to SAE J459 and SAE J460 for other bushing and bearing alloys and/or to SAE J471 for other ferrous powder metal alloys.

TABLE I – CHEMICAL COMPOSITION

BABBITT ALLOYS ^{(1)*}

Designation		Composition, % max (except where shown otherwise)									
MPAPS C-5 ALLOY	APPROX. SAE NO. (J460)	Copper	Tin	Lead	Antimony	Zinc	Iron	Bismuth	Aluminum	Arsenic	Other
TBL – 1	--	2.5-3.5	88.0 min	0.50 ⁽²⁾	7.0-8.0	0.005	0.08	0.08	0.005	0.10	0.20
TBL – 2	11	5.0-6.5	86.0 min	0.50 ⁽²⁾	6.0-7.5	0.005	0.08	0.08	0.005	0.10	0.20
TBL – 3	14	.050 0.7	9.25-10.75 9.0 – 11.0	bal.	14.0-16.0	0.005	-- 0.10	0.10	0.005	0.60	cadmium- 0.05 0.08/0.020
TBL – 4	15	.050 0.7	0.90-1.25 0.9 – 1.7	bal.	14.0-15.5 13.5 – 15.5	0.005	-- 0.10	0.10	0.005	0.80-1.20	cadmium- 0.02 0.08/0.020

LEADED BRONZE ALLOY ^{(3)*}

Designation		Composition, % max (except where shown otherwise)									
MPAPS C-5 ALLOY	APPROX. SAE NO. (J460)	Copper	Tin	Lead	Antimony	Zinc	Iron	Bismuth	Nickel	Silver	Other
BL-26-08 ⁽⁴⁾	798	83.0 min	3.5-4.5	7.0-9.0	0.50	4.0	0.50	--	0.50	--	0.30
BL-26-10 ⁽⁴⁾	797	77.0 min	9.0-11.0	9.0-11.0	0.50	0.75	0.08	--	0.50	--	0.40
BL-26-16	--	79.0-78.0	9.0-11.0	13.0-18.0	0.50	0.50	0.50	--	0.50	--	0.40
BL-26-25 ⁽⁴⁾	799	68.5-75.5	3.0-4.0	21.0-25.0	0.50	3.0	0.50	--	0.50	--	0.40

COPPER LEAD ALLOYS *

Designation		Composition, % max (except where shown otherwise)									
MPAPS C-5 ALLOY	APPROX. SAE NO. (J460)	Copper	Tin	Lead	Antimony	Zinc	Iron	Bismuth	Nickel	Silver	Other
BGB – 1	--	36-49.5	0.5-1.5	50.0-62.0	--	0.05	0.25	0.10	0.05	--	0.20/Arsenic 0.05
CL – 1 ^(3,5)	480	60.0-70.0	0.50	30.0-40.0	--	--	0.50	--	--	1.5	0.30
CL – 2 ^(3,5)	48	67.0-74.0	0.25	25.0-32.0	--	0.10	0.50	--	--	1.5	0.15/Phosphorus 0.025

OVERPLATED COPPER LEAD ALLOYS ^{(3,6)*}

Designation		Composition, % max (except where shown otherwise)									
MPAPS C-5 ALLOY	SAE NO. (J460)	Copper	Tin	Lead	Silicon	Zinc	Iron	Aluminum	Cadmium	Nickel	Other
CL-3	49	73.0-79.0	0.50 ⁽⁷⁾	21.0-27.0	--	--	0.50	--	--	--	0.45
CL-4		70.0-75.0	2.0-3.5	22.0-26.0	--	--	0.50	--	--	--	--
CL-5		86.0-90.0	1.5-2.5	--	--	--	0.50	--	--	9.5-10.5	--
CL-6		79.0 min	9.0-11.0	9.0-11.0	--	--	0.50	--	--	--	--
CL-7		78.5-84.5	3.0-4.0	12.5-16.5	--	--	0.50	--	--	--	0.45

*See footnotes at end of table

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TABLE I – CHEMICAL COMPOSITION (cont'd)

ALUMINUM BASE ALLOYS*

Designation		Composition, % max (except where shown otherwise)									
MPAPS C-5 ALLOY	SAE NO. (J460)	Copper	Tin	Lead	Silicon	Iron	Zinc	Aluminum	Cadmium	Nickel	Other
AL – 1 ⁽⁸⁾											
AL – 2 ⁽⁶⁾		0.7-1.3	--	0.3	--	Balance	--	1.0-3.5	0.75-1.25	0.7	--
AL – 3	780	0.7-1.3	5.5-7.0	--	1.0-2.0	0.7	--	Balance	0.5-1.5	0.25-0.75	0.15
AL – 4		0.75-1.25	5.5-7.0	--	--	0.70	--	Balance	--	0.75-1.25	--
AL – 5	783	0.7-1.3	--	--	--	0.5	--	Balance	--	0.10	0.15
AL – 6	781	0.05-.15	--	--	--	0.35	--	Balance	0.8-1.4	--	0.25
AL – 7		0.25-0.75	1.0-2.0	6.5-10.5	--	3.5-4.5	--	Balance	--		--
AL – 8 ⁽⁶⁾	782	1.0-1.5	--	--	--	0.30	--	Balance	2.7-3.5	0.7-1.3	0.15

PLATED OVERLAY ALLOYS *

Designation		Composition, % max (except where shown otherwise)									
MPAPS C-5 ALLOY	SAE NO. (J460)	Copper	Tin	Lead	Antimony	Indium	Iron	Aluminum	Cadmium	Nickel	Other
PL – 1	19	1.0-3.0	8.0-12.0	Balance	--	--	--	--	--	--	--
PL – 2		--	3.0-5.0	Balance	3.0-4.0	--	--	--	--	--	--
PL – 3		3.0-5.0	Balance		7.0-8.0	--	--	--	--	--	--
PL – 4		--	--	Balance	--	5-10	--	--	--	--	--
PL – 5		--	8.0-12.0	Balance	--	12-16	--	--	--	--	Alumina 0.5-1.5

WROUGHT BRONZE ALLOYS *

Designation		Composition, % max (except where shown otherwise)										
MPAPS C-5 ALLOY	OBSOLETE CEMS C-5	CDA NO.	Copper	Tin	Lead	Silicon	Zinc	Iron	Aluminum	Phosphorus	Nickel	Other
WB411	BS-21-10	C41100	88.0-91.5	0.25-0.75	--	--	Balance	0.05	--	--	--	0.2
WB544	BS-26-04	C54400	88.0-91.5	3.5-4.5	3.5-4.5	--	1.5-4.5	0.1	--	0.01-0.15	--	0.2
WB624	BR-33-10	C62400	88.0-91.5	0.20	--	0.25	--	2.0-4.0	10.0-11.5	--	--	Manganese 0.30

CAST BRONZE ALLOYS *

Designation		Composition, % max (except where shown otherwise)										
MPAPS C-5 ALLOY	OBSOLETE CEMS C-5	CDA NO.	Copper	Tin	Lead	Silicon	Zinc	Iron	Aluminum	Phosphorus	Nickel	Other
CB836	BC-26-05	C83600	84.0-86.0	4.0-6.0	4.0-6.0	0.005	4.0-6.0	2.0-4.0	0.005	0.05	1.0	--
CB863	BC-41-30	C86300	60.0-68.0	0.20	0.20	--	Balance	0.4-2.0	3.0-7.5	--	--	Manganese 2.5-5.0
CB865	BC-41-40	C86500	55.0-60.0	1.0	0.40	--	Balance	0.15	0.50-1.50	--	0.5	Manganese 1.5
CB937	BC-26-10	C93700	78.0-82.0	9.0-11.0	8.0-11.0	0.005	0.75	2.5-4.0	0.005	0.25	0.5	Antimony 1.5
CB952	BC-33-09	C95200	86.0 min	--	--	--	--	2.5-4.0	8.5-9.5	--	--	1.0
CB953	BC-33-11	C95300	86.0 min	--	--	--	--	0.8-1.5	9.0-11.0	--	--	1.0

*See footnotes at end of table

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TABLE I - CHEMICAL COMPOSITION (cont'd)

POWDERED METAL ALLOYS *

Designation			TYPE OF BEARING	Composition, % max (except where shown otherwise)						
MPAPS C-5 ⁽⁹⁾ ALLOY	OBSOLETE CEMS C-5	APPROX SAE (J471)		Antimony	Iron	Lead	Tin	Copper	Carbon	Other
F-0005-K28	FP-61-01	851	porous sintered iron oil-impregnated	--	balance	--	--	--	0.25-0.6	2.0
FC-1000-K40	FP-62-12	862	porous sintered iron copper, oil-impregnated	--	balance	--	--	7.0-11.0	0.3	2.0
FC-2000-K40	--	863		--	balance	--	--	18.0-22.0	0.3	2.0
FC-0208-K40	--	864	porous sintered copper-steel, oil-impregnated	--	balance	--	--	1-3	0.6-1.0	2.0
CT-1000-K26	--	--	Porous sintered bronze, oil- impregnated	--	1.0 max	--	9.5-10.5	balance		1.0 max
FCTG-3604-K22	FP-62-38	--	porous sintered copper-steel, oil-impregnated, w/graphite	--	balance	--	3.5-4.5	34.0-38.0	0.5-1.3	2.0
CTG-1001-K23	BP-22-09	841 [J471b]	porous sintered bronze, w/graphite, oil-impregnated	--	--	--	9.5-10.5	85.7-90.0	0.5-1.8	2.0

* Footnotes for Table I:

- (1) Cast bimetal on steel, bronze or brass back.
- (2) Maximum of 0.60% lead is permissible, providing a lead-tin solder has been used for bonding the bearing alloy to the backing material.
- (3) These materials are available as cast or sintered bearings with identical chemistry. They are used interchangeably unless the suffix "C" (cast) or "S" (sintered) is added to the alloy designation. For example: BL-26-10C, CL-4S.
- (4) Lining will have a Rockwell hardness of 68 HRE minimum, unless otherwise specified.
- (5) Not to be used for new applications.
- (6) These materials are supplied with overplate added to the bimetal material to make trimetal bearings. Overplate designation and thickness must be included on drawing.
- (7) Tin content may be raised to 1.25% maximum upon agreement between purchaser and supplier.
- (8) Obsolete material. Supplier will contact appropriate engineering department when drawing specifies this material.
- (9) Current Navistar spec designation reflects current MPIF STD 35 in which suffix denotes radial crush strength. Previously listed with letter suffix indicated density as: F-0005-N, FC-1000-P, FC-2000-P, FC-0208-P; FCT-3804-R is changed to FCTG-3604-K22 and CT-0010-R is changed to CTG-1001-K23.

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4.3 Mechanical And Physical Property Requirements

4.3.1 Special Requirements For WB 411 and 544

The following Rockwell hardness requirements must be met for the applications listed below:

4.3.1.1 WB 411: Split Bushings - 60 to 70 HRB

4.3.1.2 WB 544: General Bearing Applications- 60 to 70 HRB

4.3.1.3 WB 544: Piston Pin Bushings - 75 HRB min

4.3.1.4 When required, specific hardness values may be specified on the drawing. Materials Engineering and the supplier should be consulted before specifying hardness values on the drawing.

4.3.2 P/M Materials

Unless otherwise designated on the drawing, P/M bearing material properties will meet the minimum values specified in MPIF Standard 35. These values include strength constant, porosity or oil content, and density.

4.3.3 Radial Crushing Force

The theoretical radial crushing force of a bearing is a function of the “K” strength constant and its dimensions. Radial crushing force will be calculated as indicated by the equation below. (NOTE: This equation is not valid when the wall thickness is greater than 30% of outside diameter.)

$$P = \frac{KLT^2}{D-T}$$

where: P = Radial Crushing Force, in Pounds Force

L = Bearing Length, in Inches

D = Outside Diameter of Bearing, in Inches

T = Wall Thickness of Bearing, in Inches

K = Strength Constant, Pounds Force per Square Inch (from MPIF Standard)

4.3.3.1 The actual radial crushing force will be determined by compressing the test bearing between two flat surfaces in accordance with ASTM B 438 or CEMS HT-1. Test bearing will meet the minimum strength requirement determined by the above equation.

4.3.4 Porosity

Porosity is the percentage of void volume in a bearing. It is the complement of density. A bearing which is 85% of theoretical density will have 15% porosity. Porosity is related to the oil content of P/M bearings and will be determined as per MPIF Standard 35 or ASTM B 328.

4.3.5 Density

Unlike P/M structural components in which density is reported on a dry, unimpregnated basis, density of P/M bearing materials is reported on a fully impregnated (wet) basis.

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