

NAVISTAR, INC.		
Material, Parts, and Process Specifications (MPAPS)		NUMBER: MPAPS D-22
		Former Designation: CEMS D-22
TITLE: Fiber Glass Reinforced Polymer Materials		CURRENT REV No.: 1402
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WRITTEN/EDITED BY: Materials Engineering	APPROVED BY: Materials Engineering	SUPERSEDES: CEMS D-22 - April 2004
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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: Changes to Table 4 tensile strength test method description; editorial changes.		

1.0 SCOPE

This specification covers requirements for molded plastics based on fiberglass reinforced polymer (FRP) materials used in the Corporation's products.

2.0 CONTENTS

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3.0 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.

4.0 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 D 638
CFR Title 29, Part 1910	ASTM G 53
NAVISTAR Manufacturing Standard D-13	ASTM D 790
NAVISTAR CEMS DT-2 and DT-8	ASTM D 792
	ASTM D 150
	ASTM D 2132

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NAVISTAR CEMS G-5

ASTM D 495

ASTM D 570

NAVISTAR TMS-7095

ASTM D 618

ASTM D 2583

Federal Motor Vehicle Safety Std. FMVSS-302

5.0 CLASSIFICATION OF COMPOUNDS

Molded fiberglass reinforced polymer (FRP) materials are designated by Type and Grade. The Type defines a particular molding process. The Grade designates the physical properties required within the Type. Suffixes are used to specify additional requirements dictated by the application. See “Appendix – General Information” for a more complete discussion of materials.

5.1 Types

5.1.1 Type I - Light duty nonstructural parts made of premix or bulk molding compound (BMC) by matched die compression or injection molding.

5.1.2 Type II -Decorative and/or Structural parts made by compression molded sheet molding compound (SMC).

5.1.3 Type III -Decorative and/or Structural parts made by an “open mold” process, such as hand-layup, spray-up or bag molding.

5.1.4 Type IV -Decorative and/or Structural parts made from low pressure closed mold systems, such as cold molding or resin transfer molding (RTM).

5.1.5 Type V -Special purpose moldings constructed with high-performance resins and/or oriented glass or specialty reinforcements.

5.1.6 Type VI- Thermoplastic composites (GMT) made from low pressure compression mold systems, such as Azdel[®], Quadrant or StaMax[®].

5.2 Grades

5.2.1 Grade A – Light Duty

5.2.2 Grade B – Medium strength, general purpose

5.2.3 Grade C – High Strength

5.2.4 Grade D – Extra High Strength

5.2.5 Grade E – Special purpose – moldings constructed with high performance resins and/or oriented glass or specialty reinforcements – grade requirements will be shown on the part drawing.

5.3 Suffix letters

Suffix letters indicate materials or molded part requirements in addition to those shown in Table 2 – Basic Property Requirements. Specific limitations are shown in Table 3 – Suffix Requirements; for a discussion of suffix requirements, see “Appendix – General Information”. The following suffix letters will be used to indicate the additional properties required:

5.3.1 A - Surface Finish Quality

5.3.2 B - Surface Finish Compatibility

5.3.3 C - Weather and Sunlight Resistance

5.3.4 D - High Temperature Resistance

5.3.5 E - Oil, Fuel or Solvent Resistance

5.3.6 F - High Temperature Properties

5.3.7 G - Matrix Crazing

5.3.8 K - Adhesion Properties

5.3.9 L - Water or Coolant Resistance

5.3.10 M - Flame Resistance

5.3.11 N - Chemical Resistance

5.3.12 P - Impact Resistance

5.3.13 R - Resin Control

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5.3.14 S - Electrical Properties

5.3.15 T - Translucency or Light Transmission

5.3.16 Z - Special Requirements

TABLE 1 CROSS REFERENCE TO OBSOLETE CLASSIFICATIONS

OBSOLETE INTERNATIONAL CLASSIFICATION	NEW NAVISTAR CLASSIFICATION
Type – Grade	Type – Grade
Type 2 – Grade A	Type IV – Grade A
Type 2 – Grade B	Type IV – Grade B
Type 2 – Grade BB	Type II – Grade B
Type 2 – Grade C	Type IV – Grade C
Type 2 – Grade CC	Type II – Grade C
Type 2 – Grade D	Type IV – Grade D
Type 2 – Grade DD	Type II – Grade D
Type 4 – Grade A (Centrifugally Cast)	Deleted – No Usage of Centrifugally Cast Parts in International Systems

6.0 PROPERTY REQUIREMENTS

Material purchased to this specification will meet the basic property requirements shown in Table 2, and the applicable suffix requirements shown in Table 3. Evaluation criteria are defined in “Methods of Test”, Section 8 and Table 4.

TABLE 2 – BASIC PROPERTY REQUIREMENTS

Property			TYPE I			TYPE II			
			Grade			Grade			
			A	B	C	B	C	D	
Water Absorption, % max, average			1.5	1.0	0.6	0.5	0.5	0.5	
Specific Gravity, g/cc, max			2.2	2.2	2.0	2.0	2.0	2.0	
Tensile Strength, min	average	psi	-	-	5000	8000	10500	13500	
		Mpa	-	-	34.5	55.2	72.4	93.1	
	single value*	psi	-	-	3500	5600	7350	9450	
		Mpa	0	0	24.1	38.6	50.7	65.2	
Tensile Modulus, min, average	10 ³ psi		-	-	-	1200	1500	1750	
	Gpa		-	-	-	8.3	10.3	12.0	
Flexural Strength, min	average	psi	6000	8000	14000	20000	24000	28000	
		Mpa	41.4	55.2	96.5	137.9	165.5	193.1	
	single value*	psi	4200	5600	9800	14000	16800	19600	
		Mpa	29.0	38.6	67.6	96.5	115.8	135.1	
Flexural Modulus of Elasticity, min, average		10 ³ psi	800	900	1200	1200	1400	1600	
		Gpa	5.52	6.31	8.27	8.27	9.65	11.03	
Flexural Strength Retention, min, average		psi	-	-	-	14000	16800	19600	
		Mpa	-	-	-	96.5	115.8	135.1	
Flexural Modulus of Elasticity Retention, min, average		10 ³ psi	-	-	-	840	980	1120	
		Gpa	-	-	-	5.79	6.76	7.72	
Hardness, Barcol, min, average			40	45	45	45	45	45	
Reverse Impact, drop height, min	tested as received and conditioned	room temp	In-lbs	-	-	-	6	6	6
			mm	-	-	-	150	150	150
		-20°F (-29°C)	In-lbs	-	-	-	6	6	6
			mm	-	-	-	150	150	150
	tested after aging	room temp	In-lbs	-	-	-	6	6	6
			mm	-	-	-	150	150	150

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TABLE 2 – BASIC PROPERTY REQUIREMENTS (Continued)

Property				TYPE III			TYPE IV				TYPE V	TYPE VI		
				Grade			Grade				Grade	Grade		
				A	B	C **	A	B	C	D	A	A	B	C**
Water Absorption, % max, average				0.5	0.5	0.5	0.5	0.5	0.5	0.5	As specified on part drawing. Contact Materials Engineering for further information	0.5		
Specific Gravity, g/cc, max				1.5	1.6	1.7	1.8	1.8	1.7	1.7		1.5		
Tensile Strength, min	average	psi	7000	10000	14000	7000	10000	13500	15000	7000				
		Mpa	48.3	68.9	96.5	48.3	68.9	93.1	103.4	48.2				
	single value*	psi	4900	7000	9800	4900	7000	9450	10500	4900				
		Mpa	33.8	48.3	67.6	33.8	48.3	65.2	72.4	33.8				
Tensile Modulus, min, average	10 ³ psi			800	1000	1200	800	1000	1200	1500		700		
	Gpa			5.5	6.9	8.3	5.5	6.9	8.3	10.3		4.8		
Flexural Strength, min	average	psi	12000	18000	25000	12000	18000	25000	28000	12000				
		Mpa	82.7	124.1	172.4	82.7	124.1	172.4	193.1	82.7				
	single value*	psi	8400	12600	17500	8400	12600	17500	19600	8000				
		Mpa	57.9	86.9	120.7	57.9	86.9	120.7	135.1	55.2				
Flexural Modulus of Elasticity, min, average			10 ³ psi	600	800	1100	600	800	1100	1300		600		
			Gpa	4.14	5.52	7.58	4.14	5.52	7.58	8.96		4.14		
Flexural Strength Retention, min, average			psi	8400	12600	17500	8400	12600	17500	19600		8000		
			Mpa	57.9	86.9	120.7	57.9	86.9	120.7	135.1		55.2		
Flexural Modulus of Elasticity Retention, min, average			10 ³ psi	420	560	770	420	560	770	1120		420		
			Gpa	2.90	3.86	5.31	2.90	3.8	5.31	7.72		2.90		
Hardness, Barcol, min, average				45	45	45	45	45	45	45				
Reverse Impact, drop height, min	tested as received and conditioned	room temp	In-lbs	7	8	8	6	7	7	8		36		
			mm	180	200	200	150	180	180	200		914		
		-20°F (-29°C)	In-lbs	5	6	6	5	6	6	6		30		
			mm	130	150	150	130	150	150	150		762		
	tested after aging	room temp	In-lbs	7	8	8	6	7	7	8		30		
			mm	180	200	200	150	180	180	200		762		

* NOTE: In certain cases, due to part configuration, the vendor will not be able to totally avoid knit lines or severe flow. This will result in limited areas of lower single value strength. Such areas will not be allowed where they may detract from the performance of the component. Therefore, the vendor will request and receive permission for such deviations from the Appropriate International engineering department prior to qualification of the molded part. Such request will detail the location(s), extent of orientation and minimum strength value of all such deviations.

** Type III and VI, C normally cannot be achieved by spray-up process.

TABLE 3 – SUFFIX REQUIREMENTS

Property	Suffix	Requirements
Surface Finish Quality	A1 A1n	Best surface on parts to be painted. Surface quality will be such that, after painting, the finish is equivalent to that of painted sheet metal normal to the using International plant. There will be no visible fiber pattern, pinholing, cratering, waviness or other defects. Type II and Type IV will be made using “low-profile” resin systems. Type I and III will use gel coat and/or “low-profile” resin systems. Achievement of the A1 surface finish requirement may necessitate the use of in-mold coatings. Where the use on in-mold coatings is required by Engineering it will be specified on the engineering drawing by means of a “Z” suffix requirement. Control of production parts will be accomplished through comparison with master samples retained from the initial qualification of molded parts or by means of written acceptance standards for the individual part. When a second suffix numeral is shown, this designates a maximum surface finish of 100 times the second digit in microinches. [A15 requires a finish of 500 μin (13μm).]

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TABLE 3 – SUFFIX REQUIREMENTS (continued)

Property	Suffix	Requirements										
Surface Finish Quality	A2	Good surface on parts to be painted. After painting, surface will exhibit a finish approaching that of painted sheet metal. However, a very faint fiber pattern will not be cause for rejection.										
	A3	Minimum surface on parts to be painted. Surface preparation need only be sufficient to meet paint compatibility requirements. Fiber pattern and/or slight pinholing will not be cause for rejection.										
	A4	Best surface on parts not to be painted. Parts will be free from fiber pattern (color or roughness), waviness or other defects when viewed with the unaided eye. Type I & II will be made of “low-profile” resin systems.										
	A4n	Type III material will use gel coat and/or “low-profile” resin systems. When a second suffix numeral is shown, this designates a maximum surface finish of 100 times the second digit in microinches. Parts will meet any 60° glossmeter requirement stated on the drawing.										
	A5	Good surface on parts not to be painted. Parts will exhibit a uniformly attractive surface with no more than a faint fiber pattern. Such parts may be made of BMC or SMC, highly filled but not necessarily “low-profile” , or by use of surface veil on “wet-system”, Types II, III and IV parts. Parts will meet any 60° glossmeter requirement stated on the drawing.										
	A7	Minimum surface on parts not to be painted. Surface will be uniformly attractive; Prominent fiber pattern will be allowable.										
	A9	Special finish; requirements will be stated on the part drawing.										
Surface Finish Compatibility	B1n	Parts will be compatible with paint finishing operations employed by the using Navistar plant. Surface preparation will be sufficient to allow finishing paint top coat to meet dry film requirements, as well as the finish requirements of Suffix A. The suffix B1n indicates priming is not specifically required. However, priming is not precluded where necessary to meet the above requirements. After being subjected to standard NAVISTAR finishing operations wherein paint baking temperatures do not exceed the temperature designated by the second suffix numeral as shown below, parts will not delaminate, blister, shrink, warp or sag to the extent that function or appearance is impaired. The finish paint will not exhibit craters or pinholes. There will be no failure in adhesive bonded joints. The second suffix numerals indicate paint bake temperatures as follows: <table><tr><td>0 – as stated on drawing</td><td>5 - 310°F (154°C)</td></tr><tr><td>1 - 190°F (88°C)</td><td>6 - 340°F (171°C)</td></tr><tr><td>2 - 220°F (104°C)</td><td>7 - 370°F (188°C)</td></tr><tr><td>3 – 250°F (121°C)</td><td>8 - 400°F (204°C)</td></tr><tr><td>4 – 280°F (138°C)</td><td></td></tr></table> Example: B13 indicates a paint bake not exceeding 250°F (121°C).	0 – as stated on drawing	5 - 310°F (154°C)	1 - 190°F (88°C)	6 - 340°F (171°C)	2 - 220°F (104°C)	7 - 370°F (188°C)	3 – 250°F (121°C)	8 - 400°F (204°C)	4 – 280°F (138°C)	
	0 – as stated on drawing	5 - 310°F (154°C)										
	1 - 190°F (88°C)	6 - 340°F (171°C)										
	2 - 220°F (104°C)	7 - 370°F (188°C)										
	3 – 250°F (121°C)	8 - 400°F (204°C)										
	4 – 280°F (138°C)											
	B2n	Same as B1n except that priming is specifically required. Dry film properties will meet the requirements of CEMS G-5, Grade – 52, or other stated requirements.										
B3n	Same as B2n except that primed surface will be electrically conductive as necessary for electrostatic painting.											
B4n	Same as B2n except that top coat of primer system will have a 60° gloss of 85 minimum for use as an inspection aid.											
B5n	Same as B1n except that primed surface will be electrically conductive as required for electrostatic painting.											
B8n	Same as B1n except that surface preparation will be as specially detailed on the drawing or in referenced documents.											
B9n	Parts will be finish painted by the vendor to match color or colors specified on the drawing. Dry film properties will meet the requirements of the specified Grade per CEMS G-5 or other stated requirements.											

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TABLE 3 – SUFFIX REQUIREMENTS (continued)

Property	Suffix	Requirements
Weather and Sunlight Resistance	C1	Exterior parts not to be painted will not show visual color change, loss of translucency, where applicable, or degradation of surface appearance or physical properties after subjection to 500 hours of QUV-B exposure as per ASTM G 53.
	C2	Interior parts, painted or unpainted, which are exposed to sunlight under glass will not show visual color change, loss of translucency, where applicable, or degradation of surface appearance or physical properties after subjection to 200 hours of QUV-A exposure as per ASTM G 53
High Temperature Resistance	D1	After being mounted in the assembly, or fixture simulating the same, and subjected to three hours at 190°F(88°C), parts will not shrink, warp, craze, blister, delaminate, sag or change color to the extent that appearance or function is impaired. No failure in adhesive bonded joints is allowed.
	D2	Same as D1 except temperature will be 220°F(104°C).
	D3	Same as D1 except temperature will be 250°F(121°C).
	D4	Same as D1 except temperature will be 280°F(138°C).
	D5	Same as D1 except temperature will be 310°F(154°C).
	D6	Same as D1 except temperature will be 340°F(171°C).
	D7	Same as D1 except temperature will be 370°F(188°C).
	D8	Same as D1 except temperature will be 400°F(204°C)
Oil, Fuel Or Solvent Resistance	E	Will be resistant to leakage or excessive loss of strength or rigidity upon exposure to fluids and temperatures required by the application. Specific requirements and test methods will be shown on drawing. This resistance may typically be obtained through use of a resin-rich surface, such as surface veil, gel coat or equivalent, on side exposed to fluid.
High Temperature Properties	F1	Flexural strength and flexural modulus, when tested at a temperature of 180° F(82°C), will be a minimum of 70% and 60%, respectively, of the room temperature requirements for the grade of material specified.
	F2	Flexural strength and flexural modulus, when tested at a temperature of 230°F(121°C), will be a minimum of 50% and 40%, respectively of the room temperature requirements for the grade of material specified.
Matrix Crazing	Gn	. The laminate should exhibit a minimum of n% elongation in the mandrel bend test.
Adhesion Properties	K	Silicone release agents or other materials that interfere with subsequent joining or bonding operations will not be used.
	K1	Assembly will be neatly and securely bonded using adhesives and techniques suitable to the thermal requirements stated in Suffix D. Bond line will be free from voids or gaps. Visible joints will be neatly finished and free from irregularities and excess adhesive. Sealed joints will meet any pressure test shown on the drawing. Samples cut from the bonded joint will provide an average strength of 150 lbf/inch (26 N/mm), with a minimum value of 50 lbf/inch (9N/mm).
	K2	Same as K1 except average bond strength will be 500 lbf/inch (88 N/mm), with a minimum value of 300 lbf/inch (52 N/mm). In addition, bond adhesion will be sufficient to cause failure in the base laminate (“pull fibers” at the minimum).
	K3	Same as K2 except average bond strength will be 700 lbf/inch (122 N/mm), with a minimum value of 500 lbf/inch (88 N/mm).
Winter or Coolant Resistance	L	Will be resistant to leakage or excessive loss of strength or rigidity upon exposure to water or coolant fluids at temperatures required by the application. Specific requirements and test methods will be shown on the drawing.

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