

(R) Carbon Fiber Fabric Repair Prepreg, 120 °C (250 °F) Vacuum Curing
Part 2 - Qualification Program for Fiber, Fabric, Carbon Prepreg, Film Adhesive and
Non-Structural Glass Prepreg

RATIONALE

AMS3970/2 is revised to include PRI rules to manage the qualification program through the CACRC-Qualified Product Group (QPG). The qualification testing scope has been updated.

FOREWORD

AMS3970/2 belongs to the Technical Specification system explained in AMS3970.

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1. SCOPE

AMS3970/2 gives specific information about the qualification program for carbon fiber reinforced epoxy structural repair prepreg systems, applicable for 120 °C (250 °F) vacuum curing. The prepreg system may include an epoxy film adhesive to be applied in a co-curing process with the prepreg for joint and sandwich bonding. The need for a film adhesive shall be established during screening tests.

1.1 Field of Application

This specification is only applicable to carbon fiber fabric epoxy prepreg and if necessary, associated epoxy film adhesive.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS3970	Carbon Fiber Fabric Repair Prepreg, 120 °C (250 °F) Vacuum Curing - Part 0 - Introduction
AMS3970/1	Carbon Fiber Fabric Repair Prepreg, 120 °C (250 °F) Vacuum Curing - Part 1 - General Requirements
AMS3970/6	Carbon Fiber Fabric Repair Prepreg, 120 °C (250 °F) Vacuum Curing - Part 6 - Carbon Fiber Fabric Reinforced Epoxy Prepreg for Repair, Plain Weave, 193 gm/m ² , Adhesive Film for Repair, Non-Structural Glass Fiber fabric Reinforced Epoxy Prepreg, 105 gm/m ²

2.2 Other Publications

See the Applicable Documents Section of AMS3970/1 for reference to all other documents listed within this part specification.

3. DEFINITIONS

Refer to AMS3970/1.

4. REQUIREMENTS

Refer to AMS3970/1 and the relevant MS (AMS3970/6). The number of specimens per test condition is specified in Table 18. Refer to Table 17 for abbreviations used.

5. QUALIFICATION

Refer to AMS3970/1. The qualification program is given in:

TABLE 1	Material Qualification Program for Carbon Fiber
TABLE 2	Material Qualification Program for Carbon Fabric
TABLE 3	Composite Batch Combinations for the Qualification Program
TABLE 4 and TABLE 5	Material Qualification Program for Uncured Carbon or Glass Prepregs and Film Adhesive
TABLE 6 through TABLE 8	Material Qualification Program for Cured Carbon or Glass Composites and Film Adhesive - Physical Properties
TABLE 9 through TABLE 15	Material Qualification Program for Composite and Bonded Joints

6. NOTES

- 6.1 A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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TABLE 1 - MATERIAL QUALIFICATION PROGRAM FOR CARBON FIBER

id	Property	Number of Batches Tested ¹	Test Method
1.1	Tensile Impregnated Yarn (σ_f , E_f , ϵ_f)	-	ISO 10618.2/B ²
1.2	Fiber Density (ρ_f)	-	ISO 10119/A
1.3	Filament Count	-	according to manufacturer
1.4	Sizing Content	-	ISO 10548/C
1.5	Linear Density	-	ISO 10120
1.6	Twist	-	ISO 1890
1.7	Filament Diameter	-	according to manufacturer
¹ No qualification tests are required. The fiber shall be a qualified material in a prepreg used by an OEM, reference AMS3970/1. Substantiating qualification data shall be provided. ² Normalize to 100% fiber volume.			

TABLE 2 - MATERIAL QUALIFICATION PROGRAM FOR CARBON FABRIC

id	Property	Number of Batches Tested ¹
2.1	Weaving Style and Yarn Count	w
2.2	Fabric Areal Mass	w
¹ No qualification tests are required. Data from batches used in the qualification program shall be provided by the fabric manufacturer. NOTE: Test methods per AMS3970/1.		

TABLE 3 - COMPOSITE BATCH COMBINATIONS FOR QUALIFICATION PROGRAM

	Base Material Batches and Batch Combinations Tested		
Prepreg Batch	1	2	3
Fiber Batch ¹	Fi1	Fi2	Fi2
Fabric Batch ²	F1	F2	F2
Prepreg Resin Batch	R1	R2	R1
Film Adhesive Batch ³	A1	A1	A1
¹ It is sufficient to test one fiber batch. ² Preferably two fabric batches (F1, F2) shall be qualification tested Fabric batch F1 is an acceptable replacement for fabric batch F2. ³ For cocure specimens manufactured using a film adhesive. One film adhesive batch shall be used.			

TABLE 4 - MATERIAL QUALIFICATION PROGRAM FOR UNCURED CARBON OR GLASS PREPREG PHYSICAL AND PHYSICO/CHEMICAL PROPERTIES

id	Properties	Number of Batches	Test Method ¹
4.1	Mass per Unit Area	q3, s, r, p	EN 2557 ⁵ , EN 2329 ⁶ or ASTM D 3776
4.2	Resin Density	q1, r	ISO 1183 Method A
4.3	Volatile Content	q3, s, r, p	EN 2558 ⁵ , EN 2330 ⁶ or ASTM D 3530
4.4	Resin Content	q3, s, r, p	EN 2559 ⁵ , EN 2331 ⁶ or ASTM D 3529/ASTM D 3529M
4.5	Mass per Unit Area Dry Fabric	q3, s, r, p	EN 2559 ⁵ , EN 2331 ⁶
4.6	Resin Flow	q3	EN 2560 or ASTM D 3531
4.7	Tack	q1	To be agreed between Manufacturer and CACRC - QPG
4.8	Viscosity Profile ²	q3, s, r, p	ASTM D 4440 or EN 6043
4.9	Gel Time	q3, s, r, p	ASTM D 3532 or EN 6043
4.10	DSC - uncured	q3, r, p	EN 6041 or ISO 11357-2 and -5
4.11	DSC - uncured Storage Life ³	q1	EN 6041 or ISO 11357-2 and -5
4.12	DSC - uncured Work Life ⁴	q1	EN 6041 or ISO 11357-2 and -5
4.13	HPLC	q3, r, p	EN 6040 or SACMA SRM 20R-94
4.14	Infrared	q3, r, p	ASTM E 1252 or EN 6042
¹ Method for id 4.3, 4.4 and 4.6 to be agreed between Manufacturer and CACRC - QPG. ² Viscosity profile not required for non-structural glass prepreg. ³ Requirement for qualification is in AMS3970/6 (Storage life $\geq$ 12 months from the date of shipment). ⁴ Requirement for qualification is in AMS3970/6 (Work life $\geq$ 10 days). ⁵ EN Method is for carbon fiber fabric prepregs. ⁶ EN Method is for glass fiber fabric prepregs. NOTE: Reference Table 17 for nomenclature.			

TABLE 5 - MATERIAL QUALIFICATION PROGRAM FOR UNCURED FILM ADHESIVE
PHYSICAL AND PHYSICO/CHEMICAL PROPERTIES

id	Properties	Number of Batches ¹	Test Method ²
5.1	Mass per Unit Area	q1, s, a	EN 2557
5.2	Resin Density	q1, a	ISO 1183 Method A
5.3	Volatile Content	q1, a	EN 2558
5.4	Resin Flow	q1	To be defined during qualification and recorded in the Appendix of PRI QPL AMS3970
5.5	Tack	q1	To be agreed between Manufacturer and CACRC - QPG
5.6	Viscosity Profile	q1, s, a	ASTM D 4440 or EN 6043
5.7	Gel Time	q1, s, a	ASTM D 3532 or EN 6043
5.8	DSC - uncured	q1, a	EN 6041 or ISO 11357-2 and -5
5.9	DSC - uncured Storage Life ³	q1, a	EN 6041 or ISO 11357-2 and -5
5.10	DSC - uncured Working Life ⁴	q1, a	EN 6041 or ISO 11357-2 and -5
5.11	HPLC	q1, a	EN 6040 or SACMA SRM 20R-94
5.12	Infrared	q1, a	ASTM E 1252 or EN 6042
¹ Test only to be performed if film adhesive is part of the prepreg system. ² Method for id 5.4 and 4.6 to be agreed between Manufacturer and CACRC - QPG. ³ Requirement for qualification is in AMS3970/6 (Storage life $\geq$ 12 months from the date of shipment). ⁴ Requirement for qualification is in AMS3970/6 (Work life $\geq$ 10 days). NOTE: Reference Table 17 for nomenclature.			

TABLE 6 - MATERIAL QUALIFICATION PROGRAM FOR CURED CARBON OR GLASS COMPOSITE/PHYSICAL PROPERTIES

id	Properties	Number of Batches	
		Dry Condition	Wet Condition
6.1	Moisture Uptake ¹	-	q1
6.2	Extent of Cure ²	q1, s, r, p	q1, s, r, p
6.3	DMA ³	q3, s, r, p	q3, s, r, p
6.4	DMA ^{3, 4, 6} - cocure with the adhesive	q1, s, a	q1, s, a
6.5	DMA ^{3, 5} - cocure with the non-structural glass prepreg	q1, s, a	q1, s, a
¹ Perform Moisture Uptake in accordance with EN 3615B 85 or ASTM D 5229/D 5229 M (Procedure A, single test at 85%R.H.). ² Perform Extent of Cure testing in accordance with EN 6064 or ISO 11357-5. ³ DMA will measure the "Storage Modulus - Onset" Tg value as defined in EN 6032, Table 1. ⁴ Fabricate specimen using 1 ply of prepreg system and 1 ply of film adhesive. ⁵ Fabricate specimen using 1 ply of carbon prepreg system and 1 ply of glass prepreg system. ⁶ Testing not required for non-structural glass prepreg. NOTES: If the non-structural glass form shares the identical resin system as the structural carbon form then tests listed in this Table 6 are not required to be repeated for the non-structural glass form. Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Test methods per AMS3970/1.			

TABLE 7 - MATERIAL QUALIFICATION PROGRAM FOR CURED NEAT ADHESIVE/PHYSICAL PROPERTIES

id	Properties	Number of Batches ¹	
		Dry Condition	Wet Condition
7.1	Moisture Uptake ²	-	q1, a
7.2	Extent of Cure ³	q1, a	-
7.3	DMA ⁴	q1, a	q1, a
¹ Tests only to be performed if film adhesive is part of the prepreg system. ² Perform Moisture Uptake in accordance with EN 3615B 85 or ASTM D 5229/D 5229 M (Procedure A, single test at 85% R.H.). ³ Perform Extent of Cure testing in accordance with EN 6064 or ISO 11357-5. ⁴ DMA will measure the "Storage Modulus - Onset" Tg value as defined in EN 6032, Table 1. NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Test methods per AMS3970/1.			

id	Properties	Number of Batches	
		Maximum Cure Cycle	Minimum Cure Cycle
8.1	Extent of Cure ¹	q1	q1

¹ Perform Extent of Cure testing in accordance with EN 6064 or ISO 11357-5.

NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Test methods per AMS3970/1.

		Number of Batches						
		Nominal Cure Cycle						
		Dry Condition				Wet Condition		
id	Property	-55 °C	RT	80 °C	120 °C	55 °C	80 °C	120 °C
9.1	Tensile Weft ¹ ($\sigma_x^t, E_x^t, \nu^{12}$)	q3	q3, w, p	q3	q3	q3	q3, p	q3
9.2	Tensile Warp (σ_y^t, E_y^t)	-	q3	-	-	-	-	-
9.3	Compression Weft (σ_x^c, E_x^c)	q3	q3, s w, r, p	q3, w	q3	q3	q3, s w, r, p	q3, s, r
9.4	Compression Warp (σ_y^c, E_y^c)	-	q3	q3	-	-	q3	-
9.5	Tensile In-Plane Shear (τ^{12}, G^{12})	q3	q3, s, r, p	q3	-	q3	q3, r	-
9.6	Interlaminar Shear (ILSS) Warp (τ^{13})	q3	q3, s, r, p	q3	-	-	q3, r	-

¹ ν^{12} to be determined on 1 batch at RT/Dry Condition only.

NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Test methods per AMS3970/1.

TABLE 10 - MATERIAL QUALIFICATION PROGRAM FOR COMPOSITE - FLUID RESISTANCE PROPERTIES

id	Property	Number of Batches			
		MEK Soaked	Fuel Soaked	Hydraulic Fluid Soaked	Mixture (Hydraulic Fluid/Water)
		RT	80 °C	80 °C	80 °C
10.1	Tensile In-Plane Shear (τ^{12} , G^{12})	q1 ¹	q1 ¹	q1 ¹ , s	q1 ¹
10.2	Tensile Single Lap Shear ³ (τ^{13}) Film Adhesive Adherent Material A	q1 ²	q1 ² , a	q1 ² , s, a	q1 ² , a

¹ Strength, shear modulus and stress strain curve shall not significantly differ from that of the test in id 9.5 at the test conditions RT/Dry and 80 °C/Wet respectively. CACRC - QPG shall evaluate test results and decide if additional tests are required.

² Test results shall not differ significantly from that of test id 12.3 at the test conditions RT/Dry and 80 °C/Wet respectively. CACRC - QPG shall evaluate test results and decide if additional tests are required.

³ Tests only to be performed if film adhesive is part of the prepreg system.

NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Reference Table 20 for Adherent Material A. Test methods per AMS3970/1.

TABLE 11 - MATERIAL QUALIFICATION PROGRAM FOR COMPOSITE DESIGN RELATED LAMINATE PROPERTIES

id	Property ¹	Number of Batches				
		Dry Condition		Wet Condition		
		-55 °C	RT	55 °C	80 °C	120 °C
11.1	Tensile QI Lam (σ_x^t , E_x^t)	-	q3	-	-	-
11.2	Tensile Openhole QI Lam (σ_{oh}^t)	q3	q3	-	q3	-
11.3	Compression QI Lam (σ_x^c , E_x^c)	-	q3	-	q3	-
11.4	Compression Openhole QI (σ_{oh}^c)	-	q3, r	q3, r	q3, r	q1
11.5	Double Shear Bearing QI Lam (P_{offset} , P_b)	-	q3	-	-	-
11.6	Compression After Impact ³ (σ_{cai})	-	q3	-	-	-
11.7	G_{1c} co-cured ²	-	q3, a	-	-	-
11.8	G_{2c} co-cured ²	-	q3, a	-	-	-

¹ QI = Quasi-Isotropic laminates.

² Test only to be performed if film adhesive is part of the prepreg system.

³ Impact energy levels shall be tested in compression. Levels to be determined in accordance with 6.5.12.2 of AMS3970/1.

NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Test methods per AMS3970/1.

TABLE 12 - MATERIAL QUALIFICATION PROGRAM FOR COMPOSITE/DESIGN RELATED JOINT PROPERTIES

id	Property	Number of Batches				
		Nominal Cure Cycle				
		Dry Condition		Wet Condition		
		-55 °C	RT	55 °C	80 °C	120 °C
12.1	Tensile Tapered Joint Adherent Material A ¹	q3, s, a	q3, s, r, a	q3	q3, s, r a	q3, s, a
12.2	Tensile Stepped Joint Adherent Material A ¹	q1	q3	-	q1	q1
12.3	Tensile Single Lap Shear ¹ Film Adhesive Adherent Material A	-	q3, a	-	q3, a	

¹ Tests only to be performed if film adhesive is part of the prepreg system.
NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Reference Table 20 for Adherent Material A. Test methods per AMS3970/1.

TABLE 13 - MATERIAL QUALIFICATION PROGRAM FOR COMPOSITE/SANDWICH PROPERTIES

id	Property	Number of Batches			
		Dry Condition	Wet Condition		
		RT	55 °C	80 °C	120 °C
13.1	Sandwich Flexure (P_{flex}) Adherent Material A	q3	q1	q3	q3
13.2	Flatwise Tension (σ^{33}) Adherent Material A	q3, s, r, p, a	q1 ¹	q3 ¹ , s, r, p, a	q3 ¹

¹ Test to be performed in Dry Condition.
NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Reference Table 20 for Adherent Material A. Test methods per AMS3970/1.

TABLE 14 - ADHESIVE - BONDLINE PROPERTIES

id	Property ¹	Number of Batches				
		Dry Condition	Wet Condition			
		RT	55 °C	80 °C	100 °C	120 °C
14.1	Adhesive Characterization Shear Stress, Modulus and Strain	q1, a	q1, a	q1, a	q1, a	q1, a

¹ Tests only to be performed if film adhesive is part of the prepreg system.
NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Reference Table 19 for aging conditions. Test methods per AMS3970/1.

TABLE 15 - MATERIAL QUALIFICATION PROGRAM FOR COMPOSITE - SHOP TRIAL AND POROSITY

id	Test	Number of Batches			
		Handleability Test ¹	C-Scan Test ²	Void Content Test ³	Fiber Volume Test ³
15.1	Laminate Shop Trial, Laminate for test id 9.3	s	s	q1	q1
15.2	Laminate Shop Trial, Laminate for test id 9.5	s	s	q1	q1
15.3	Sandwich Panel Shop Trial, Sandwich Panel for test id 13.1	s	s	q1, s	-
¹ Handleability to be evaluated by CACRC-QPG. ² All panels intended for mechanical testing shall be inspected by C-Scan. ³ All panels intended for mechanical testing shall be subjected to Void and Fiber volume determination as per EN 2564 Method A or ASTM D 3171 Method 1, Procedure B. NOTE: Reference Table 16 for fabrication methods. Reference Table 17 for nomenclature. Test methods per AMS3970/1.					

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