

AEROSPACE MATERIAL SPECIFICATION

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Superseding AMS 2980/2

Technical Specification: Carbon Fiber Fabric and Epoxy Resin Wet Lay-up Repair Material Part 2 – Qualification Program

RATIONALE

AMS 2980/2 is revised to include the PRI rules to manage the qualification material process through the Qualified Product Group (QPG). Qualification program has been updated.

FOREWORD

AMS 2980/2 is part of the Technical Specification system described in AMS 2980.

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1. SCOPE:

AMS 2980/2 gives specific information about the qualification program for carbon fiber fabric, epoxy systems and the material combination used for wet lay-up repair of carbon fiber reinforced epoxy structures.

1.1 Field of Application:

This TS is only applicable to carbon fiber fabric materials and epoxy laminating resins.

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2980 Technical Specification: Carbon Fiber Fabric and Epoxy Resin Wet Lay-Up
Repair Material - Part 0 - Introduction

AMS 2980/1 Technical Specification: Carbon Fiber Fabric and Epoxy Resin Wet Lay-Up
Repair Material - General Requirements

3. DEFINITIONS:

Refer to AMS 2980/1.

4. REQUIREMENTS:

Refer to AMS 2980/1 and the relevant MS. The number of specimens per test condition is specified in Figure 15. Refer to Figure 14 for abbreviations used.

5. QUALIFICATION:

Refer to AMS 2980/1. The qualification program is given in:

Figure 1: Material Qualification Program for Carbon Fiber

Figure 2: Material Qualification Program for Carbon Fabric

Figure 3 through Figure 5: Material Qualification Program for Epoxy Resin System

Figure 7 through Figure 12: Material Qualification Program for Composite Material

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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 AMS 2980/1. Substantiating qualification data shall be provided.			
² Normalize to 100% fiber volume.			

FIGURE 1 - Material Qualification Program for Carbon Fiber

id	Property	Number of Batches Tested ¹
2.1	Weaving Style and Yarn Count	-
2.2	Fabric Areal mass	-
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 AMS 2980/1.		

FIGURE 2 - Material Qualification Program for Carbon Fabric

id	Property	Number of Batches				Test Method ¹
		Base Resin		Curing Agent		
		Nom Water Content	Max Water Content	Nom Water Content	Max Water Content	
3.1	Epoxide Equivalent	q3	-	-	-	ASTM D 1652 or ISO 3001
3.2	Amine Value	-	-	q3	q1	ASTM D 2896
3.3	IR (qualitatively)	q3	-	q3	-	EN 6042 or ASTM E 1252
3.4	Water Content	q3	q1	q3	q1	ASTM E 203 or ISO 760
3.5	Viscosity @ 25 °C	q3,s	q1	q3,s	q1	ISO 2555
3.6	Density	q1	-	q1	-	ISO 1183 or ASTM D1875

¹ Method for id 3.1, 3.2, and 3.5 to be agreed to between resin manufacturer and CACRC-QPG. The method shall be specified in the IPS.

NOTE: Reference Figure 14 for nomenclature.

FIGURE 3 - Material Qualification Program for Unmixed Resin and Curing Agent

id	Property	Number of Batches				Test Method ²
		Nominal Water Content			Max Water Content	
		Nom Mixing Ratio	Max Mixing Ratio	Min Mixing Ratio	Min Mixing Ratio	
4.1	Viscosity @ 25 °C	q3,s	q1	-	-	ISO 2555
4.2	Viscosity Profile ¹	q3,s	-	q3	q1	EN 6043
4.3	Gel Time	q3	-	-	-	EN 6043 or ASTM D 2471
¹ With nominal cure cycle as specified for composite panel fabrication. ² Method for id 4.1 and 4.2 to be agreed to between resin manufacturer and CACRC-QPG. The method shall be specified in the IPS. NOTE: Reference Figure 14 for nomenclature.						

FIGURE 4 - Material Qualification Program for Mixed Uncured Resin

id	Property	Number of Batches												Test Method
		Nom Water Content								Max Water Content		Min Water Content		
		Nom Mixing Ratio				Max Mixing Ratio				Min Mixing Ratio		Nom Mixing Ratio		
		Nom Cure Cycle	Agin Effect Cure Cycle	Nom Cure Cycle Minus Hold	Min Cure Cycle Minus Hold	Over Cured Cycle	Nom Cure Cycle	Min Cure Cycle	Min Cure Cycle	Min Cure Cycle	Nom Maxing Ratio	Max Water Content	Min Maxing Ratio	
		Dry Condition								Wet Condition				
5.1	Shore D	q ³	--	--	--	q ¹	q ¹	q ¹	q ¹	--	--	q ¹	ISO 868	
5.2	DSC (Extent of cure)	q ³	q ¹	q ¹	q ¹	q ¹	q ³	q ¹	q ¹	q ¹	--	--	--	EN 6064 or ISO 11357-5
5.3	DMA	q ³	--	q ¹	--	q ¹	--	--	q ¹	q ¹	q ³	q ¹	q ¹	EN 6032 or ASTM E 1640
5.4	Density	q ¹	--	--	--	--	--	--	q ¹	--	--	--	--	ISO 1183 or EN 542

¹ Results to be used to evaluate process variables.

NOTE: Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions

¹ Results to be used to evaluate process variables.

NOTE: Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions

FIGURE 5 - Material Qualification Program for Cured Neat Resin¹

Code	Base Material Batches and Batch Combinations To Be Tested	Base Material Batches and Batch Combinations To Be Tested	Base Material Batches and Batch Combinations To Be Tested	Base Material Batches and Batch Combinations To Be Tested	Base Material Batches and Batch Combinations To Be Tested
Composite Batch Combination	1	2	3	4	5
Fiber Batch1	Fi1	Fi1	Fi1	Fi1	Fi1
Fabric Batch2	F1	F1	F2	F2	F2
Resin Batch3	R1	R2	R1	R2	R3
¹ It is sufficient to test one fiber-fabric-resin combination for fiber batch (Fi1). ² Preferably two fabric batches (F1, F2) shall be qualification tested. Fabric batch F1 is an acceptable replacement for fabric batch F2. ³ Three base resin batches and three curing agent batches shall be qualification tested. Each base resin batch forms with one curing agent batch a resin batch code (R1,R2,R3).					

FIGURE 6 - Composite Batch Combinations for Qualification Program

id	Property	Number of Batches					
		MEK Soaked Room Temp	Fuel Soaked 80 °C	Hydraulic Fluid Soaked 80 °C	Dry Condition From Room Temp to Tg + 50 °C	Condition Wet - A From Room Temp to Tg + 50 °C	Condition Wet - B From Room Temp to Tg + 50 °C
8.1	Tensile In-plane Shear (τ_{12}, G_{12})	q1 ¹	q1 ¹	q1 ¹ s	-	-	-
8.2	DMA Composite (G_{12}, T_g)	-	-	-	q3, s	s	q3

¹ Strength, shear modulus and stress-strain curve shall not significantly differ from that of test id 7.3 at the test conditions RT/Dry and 80 °C/Dry, respectively. PRI shall evaluate test results and decide if, what type and amount of additional tests are required.

NOTES: Reference Figure 13 for fabrication methods. Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions. Test methods per AMS 2980/1. Laminates shall be fabricated using nominal water content, nominal mixing ratio, and nominal cure cycle.

FIGURE 8 - Material Qualification Program for Composite-Fluid Resistancy and Shear Modulus

id	Property ¹	Number of Batches			
		Dry Condition		Wet Condition	
		-55 °C	Room Temp	80 °C	120 °C
9.1	Tensile QI Lam ($\sigma x^t, \epsilon x^t$)	-	q3	-	-
9.2	Tensile Openhole QI Lam (σoh^t)	q3	q3	q3	-
9.3	Compression QI Lam ($\sigma x^c, \epsilon x^c$)	-	q3	q3	-
9.4	Compression Openhole QI (σoh^t)	q3,r	q3,r	q3,r	q1
9.5	Bearing QI Lam (P2%, P _b)	-	q3	-	-
9.6	Compression After Impact ($\sigma_{cai}, \epsilon_{cai}$)	-	q3	-	-
¹ QI = Quasi-Isotropic laminates. NOTE: Reference Figure 13 for fabrication methods. Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions. Test methods per AMS 2980/1. Laminates shall be manufactured using nominal water content, nominal mixing ratio, and nominal cure cycle.					

FIGURE 9 - Material Qualification Program for Composite-Design Related Laminate Properties

id	Property	Number of Batches							
		Dry Condition		Max Mixing Ratio		Norm Mixing Ratio		Wet Condition	
		Norm Mixing Ratio		Over Cured		Norm Cure Cycle		Min Cure Cycle	
		Norm Cure Cycle		Norm Mixing Ratio		Norm Cure Cycle		Norm Mixing Ratio	
10.1	Tensile Tapered Joint Adherent Material A	-55 °C	q3,s	Room Temp	q5,s,r	-55 °C	q1	80 °C	q3
10.2	Tensile Tapered Joint Adherent Material B	q1	q1	q1	q1	q1	q1	q1	q3
10.3	Tensile Stepped Joint Adherent Material A	q1	q1	-	q3	q1	q1	-	-

NOTE: Reference Figure 13 for fabrication methods. Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions. Reference Figure 17 for Adherent Materials A and B. Test methods per AMS 2980/1. Laminates shall be fabricated using nominal water content.

FIGURE 10 - Material Qualification Program for Composite-Joint Tests

id	Property	Number of Batches			
		Dry Condition		Wet Condition	
		-55 °C	Room Temp	80 °C	120 °C
11.1	Tensile Weft (σ_x^t, E_x^t)	q3	q3	q3	q3
11.2	Compression Weft (σ_x^t, E_x^t)	-	q3	q3	q3
11.3	Tensile In-plane Shear (τ_{12}, G_{12})	q3	q3	q3	q3
11.4	Compression Open Hole QI (σ_{oh}^c)	-	q1	q1	-
11.5	Tensile Tapered Joint Adherent Material A ¹	q1	q1	q1	-
11.6	Sandwich Flexure (p_{flex})	-	q3	q3	q1
11.7	Flatwise Tension (σ_{33})	-	q3,s	-	-

¹ For Adherent Material A reference Figure 17.

NOTE: Reference Figure 13 for fabrication methods. Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions. Test methods per AMS 2980/1. Laminates shall be fabricated using nominal water content, nominal mixing ratio, and nominal cure cycle.

FIGURE 11 - Material Qualification Program for Composite-Influence of Vertical Bleeding

Test No.	Configuration ¹	Number of batches			
		Test methods			
		Handleability ⁴⁾	C-scan ⁵⁾ ₇₎	Porosity ⁶⁾	V ₀ , V _f (%) ⁸⁾
12.1	shop trial solid laminate: squeeze out process, size 600x600 mm lay up [0/90] _{2s} ²	q ¹ , s	s	s	s
12.2	shop trial sandwich laminate: vertical bleeding process, size 200 x 200 mm lay up [0/90] ₃ ³	q ¹ , s	s	s	s
12.3	Porosity solid laminate; squeeze out process, use laminate prepared for Test 9.4			s	s
12.4	Porosity solid laminate; vertical bleeding process, use laminate prepared for Test 11.4			s	s
¹⁾ Refer to Figure 14 for nomenclature. ²⁾ Alternatively a laminate 300 x 600 mm [0/90] _{6s} may be made which can be used for mechanical testing in the screening program. (Test 7.2) ³⁾ Alternatively a sandwich panel which can be used to do the flatwise tensile testing may be made. (Test 11.7) ⁴⁾ Handleability to be evaluated by the Qualification Body. ⁵⁾ C-scan: reference AMS2980/1 ⁶⁾ Determine the porosity: reference AMS2980/1 ⁷⁾ All panels intended for mechanical testing shall be inspected by C-scan. ⁸⁾ All panels intended for mechanical testing shall be subjected to Void and Fiber volumen determination as per EN 2564.					

FIGURE 12 - Material Qualification Program for Composite Shop Trial and Porosity