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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2980/2

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Submitted for recognition as an American National Standard

TECHNICAL SPECIFICATION:
CARBON FIBER FABRIC AND EPOXY RESIN WET LAY-UP REPAIR MATERIAL
PART 2 - QUALIFICATION PROGRAM

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. REFERENCES:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order unless otherwise specified.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

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

PREPARED UNDER THE JURISDICTION OF ATA/IATA/SAE COMMERCIAL AIRCRAFT COMPOSITE REPAIR COMMITTEE

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
3.5	Viscosity @ 25 ºC	q3,s	q1	q3,s	q1	ASTM D 2393 or ISO 2555
3.6	Density	q1	-	q1	-	ISO 1183

[1] Method for id 3.1, 3.2, and 3.5 to be agreed to between resin manufacturer and PRI. 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 ºC	q3,s	q1	-	-	ASTM D 2393 or ISO 2555
4.2	Viscosity Profile[1]	q3,s	-	q3	q1	ASTM D 2393 or ISO 9702
4.3	Gel Time	q3	-	-	-	EN 6043 or ASTM D 4440, ASTM D 3532, and 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 PRI. 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		Nom Water Content		Max Water Content		
		Nom Mixing Ratio			Max Mixing Ratio		Min Mixing Ratio			Nom Mixing Ratio		Min Mixing Ratio		
		Nom Cure Cycle	Aging Effect Cure Cycle	Nom Cure Cycle Minus Hold	Min Cure Cycle Minus Hold	Nom Cure Cycle	Over Cured	Nom Cure Cycle	Min Cure Cycle	Nom Cure Cycle		Wet Condition		
		Dry Condition												
5.1	Shore D	q3	-	-	-	q1		q1	q1	-	-	-	q1	ISO 668
5.2	DSC	q3	q1	q1	q1	q3	q1	q3	q1	q1	-	-	-	EN 6041
5.3	DMA	q3	-	q1	-	-	q1	-	q1	q1	q3	q1	q1	EN 6032 or ASTM E 1640
5.4	Density	q1	-	-	-	-	-	-	-	-	-	-	-	ISO 1183

[1] Result 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 Resin[1]

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 Batch[1]	Fi1	Fi1	Fi1	Fi1	Fi1
Fabric Batch[2]	F1	F1	F2	F2	F2
Resin Batch[3]	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

		Number of Batches															
		Nom Water Content						Max Water Content				Nom Water Content					
		Nom Mixing Ratio		Nom Cure Cycle		Max Mixing Ratio	Nom Mixing Ratio	Min Mixing Ratio	Min Cure Cycle	Nom Cure Cycle		Min Mixing Ratio		Nom Cure Cycle			
		Dry Condition				Wet Condition											
id	Property	-55ºC	Room Temp	80ºC	Over Cured	-55ºC	80ºC	80ºC	80ºC	80ºC	60ºC	80ºC	120ºC				
7.1	Tensile Weft[1] (σX^t, Ex^t, $\nu 12$)	q3	q5, w	-	-	-	q3	-	-	-	-	-	q3				
7.2	Compression Weft(σX^c, Ex^c)	-	q5, s, w, r	q5, w	-	-	q5, s, r	q1	q1	q1	q3	q3	q3				
7.3	Tensile in-plane Shear ($\tau 12$, G12)	q3	q5, s, r	q3	-	q1	q5, s, r	-	-	-	q3	q3	q3				

[1] $\nu 12$ to be determined on one batch at RT/Dry condition only.

NOTE: Reference Figure 13 for fabrication methods. Reference Figure 14 for nomenclature. Reference Figure 16 for aging conditions. Test methods per AMS 2980/1.

FIGURE 7 – Material Qualification Program for Composite Main Properties

id	Property	Number of Batches						
		MEK Soaked	Fuel Soaked	Hydraulic Fluid Soaked	Dry Condition	Condition Wet - A	Condition Wet - B	Condition Wet
		Room Temp	80 °C	80 °C	From Room Temp to Tg + 50°C	From Room Temp to Tg + 50°C	From Room Temp to Tg + 50°C	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	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	Number of Batches			
		Dry Condition		Wet Condition	
		-55 ºC	Room Temp	80 ºC	120 ºC
9.1	Tensile QI Lam (σx^t,Ex^t)	-	q3	-	-
9.2	Tensile Openhole QI Lam (σoh^t)	q3	q3	q3	-
9.3	Compression QI Lam (σx^c,Ex^c)	-	q3	q3	-
9.4	Compression Openhole QI (σoh^t)	q3,r	q3,r	q3,r	q1
9.5	Bearing QI Lam ($P_{2\%}$,P_b)	-	q3	q3	-
9.6	Compression After Impact (σ_{cai} , ε_{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									
		Nom Mixing Ratio		Max Mixing Ratio		Min Mixing Ratio		Nom Mixing Ratio			
		Nom Cure Cycle		Over Cured		Min Cure Cycle		Nom Cure Cycle			
		Dry Condition				Wet Condition					
		-55ºC	Room Temp	-55ºC	80ºC	80ºC	60ºC	120ºC			
10.1	Tensile Tapered Joint Adherent Material A	q3, s	q5, s, r	q1	q3, s, r	q1	q3	q3			
10.2	Tensile Tapered Joint Adherent Material B	q1	q1	-	q1	-	-	-			
10.3	Tensile Stepped Joint Adherent Material A	q1	q3	-	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 ºC	Room Temp	80 ºC	120 ºC
11.1	Tensile In-plane Shear (τ_{12},G_{12})	-	q1	q1	-
11.2	Compression Open Hole QI (σ_{oh}[c])	-	q1	q1	-
11.3	Tensile Tapered Joint Adherent Material A[1]	q1	q 1	q1	-
11.4	Sandwich Flexure (P_{flex})	-	q 3	q3	q1
11.5	Flatwise Tension (σ_{33})	-	q3,s	q3,s	q1

[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 manufactured using nominal water content, nominal mixing ratio, and nominal cure cycle.

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

id	Test	Handleability[1] Test	C-Scan Test (AMS 2980/1)	Number of Batches Void Content Test (AMS 2980/1)
12.1	Laminate shop trial; squeeze-out process, two panels, lay-up [(90/0)] 2S[2], panel size 600x600 mm min	s	s	s
12.2	Sandwich panel shop trial; vertical bleeding process, two panels, wet lay-up [(90/0)]2[3], panel size 200x200 mm min	s	s	s
12.3	Laminate void content; squeeze-out process; use panel for test id 9.4	-	-	q1
12.4	Laminate void content; vertical bleeding; use panel for test id 11.2	-	-	q1

[1] Handleability to be evaluated by the PRI.
[2] Alternatively a laminate 300x600 mm $(0/90]_{6s}$ may be produced which can be used for test id 7.2 in the screening program.
[3] Alternatively a panel may be produced which can be used for test id 11.5 in the screening program.

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