

FM[®] 309-1

FM[®] 309-1 is a next generation film adhesive for bonding composite and metallic structures. This new film provides a unique combination of high Tg [360°F (182°C)], high toughness and higher temperature properties. FM[®] 309-1 is compatible with most 350°F (177°C) curing epoxy-based prepreg systems. This new film has excellent resistance to pre-bond and post-bond humidity and has a service temperature of 350°F (177°C).

FM[®] 309-1 adhesive film provides excellent handling properties (good tack and drape) and has a minimum shop life of 30 days at 75°F (24°C).

FM[®] 309-1 adhesive can be supplied as a supported (woven glass, knit or mat carrier) or unsupported film at various weights and thicknesses. For co-cure or co-bond applications, adhesive film weight of 0.030 – 0.050 psf (146 gsm – 244 gsm) with mat carrier is recommended. This adhesive film is suitable for bonding of monolithic or sandwich structures. Honeycomb sandwich panels manufactured using FM[®] 309-1 adhesive film demonstrate excellent laminate quality (void content <1%) and very good filleting.

FM[®] 309-1 adhesive film can be cured at 350°F (177°C) in 90 minutes at 40 psi (0.28 MPa) or can also be cured under vacuum-only pressure. The performance after vacuum cure is comparable to that after pressure cure.

Typical application for FM[®] 309-1 include bonding of composite and metallic structures, as well as co-cure, co-bond, and secondary bonding applications.

Features and Benefits

- 350°F(177°C) curing high performance composite bonding film
- Compatible with most 350°F(177°C) curing epoxy preregs
- Excellent fracture toughness (co-cure, co-bond or secondary bond)
- Service temperature of 350°F(177°C) dry and 285°F (141°C) wet
- Excellent resistance to both pre-bond and post-bond humidity
- Good combination of high peel and shear properties
- Tg > 356°F (180°C)
- Suitable for bonding composite sandwich structures (good filleting properties)
- Good tack and handling properties
- Shop life >30 days at 75°F (24°C)
- Storage life of 12 months from date of shipment when stored at or below 0°F(-18°C)

CHARACTERISTICS

Table 1 | Physical Properties

Shelf Life	12 months at or below 0°F (-18°C) from date of shipment for supported form 12 months at or below 40°F (4°C) from date of shipment for unsupported form
Shop Life	30 days at or below 75°F (24°C)
Volatiles ASTM D 3530	Less than 1% 250°F (121°C)
Density ASTM D 792	~ 69.9 pcf (1.12 g/cc)

Table 2 | Product Availability

Property	Nominal Weight	Nominal Thickness
	psf (gsm)	in (mm)
FM [®] 309-1 Film Adhesive	0.030 (146)	0.005 (0.127)
	0.050 (244)	0.008 (0.203)
	0.060 (293)	0.010 (0.254)
	0.080 (391)	0.013 (0.330)
Carriers	Knit, Mat, Woven Glass, and Unsupported ¹	
Color	Light Red	
Roll Width	36 in or 48 in (91 cm or 122 cm)	
Roll Length	66 yds (55 m)	

¹ Unsupported film also available in 0.055 psf (269 gsm).

PROPERTIES

Metal Bonding

Table 3 | Metal to Metal: Lap Shear with BR[®] 6750 Primer

Property	Test Temperature	FM 309-1K 0.08 psf (391 gsm)	FM 309-1M 0.05 psf (244 gsm)	FM 309-1U 0.05 psf (244 gsm)	Substrate
Lap Shear ASTM D1002	°F (°C)	psi (MPa)			0.063 in (1.60 mm) 2024T-3 Aluminum
	75 (24)	5080 (35.0)	4420 (30.5)	5970 (41.2)	
	275 (135)	4570 (31.5)	3930 (27.1)	5300 (36.5)	
	350 (177)	2500 (17.2)	2000 (13.8)	2320 (16.0)	

Cure Cycle: Heat to 350°F (177°C) at 3°F (1.7°C)/minute, hold at 350°F (177°C) for 90 minutes, 40 psi (0.28 MPa) pressure

Table 4 | Effect of Thermal Aging: FM[®] 309-1 Supported Adhesive Film 0.06 psf (293 gsm), Glass Carrier with BR[®] 6750 Primer

Property	Test Temperature	No Thermal Aging	After 1000 hours at 300°F (149°C)	After 1000 hours at 350°F (177°C)	Substrate
Lap Shear ASTM D1002	°F (°C)	psi (MPa)			0.063 in (1.60 mm) 2024T-3 Aluminum
	75 (24) 350 (177)	5120 (35.3) 2610 (17.9)	3750 (25.9) 3110 (21.4)	3140 (21.7) 3460 (23.9)	
Wide Area Lap Shear ASTM D 3165	75 (24) 350 (177)	4200 (29.0) 2650 (18.2)	3180 (21.9) 3010 (20.8)	2700 (18.6) 3080 (21.2)	0.064 in (1.63 mm) 2024T-3 Aluminum

Cure Cycle: Heat to 350°F (177°C) at 3°F (1.7°C)/minute, hold at 350°F (177°C) for 90 minutes, 40 psi (0.28 MPa) pressure

Table 5 | Metal to Metal: Peel Properties with BR[®] 6747-1 Primer¹

Property	Test Temperature	FM 309-1 G 0.05 psf (244 gsm)	FM 309-1 M 0.05 psf (244 gsm)	FM 309-1 K 0.08 psf (391 gsm)	Substrate
Floating Roller Peel ASTM D 3167	°F (°C)	lb/in (kN/m)			0.025 in (0.63 mm) and 0.064 (1.63 mm) 2024T-3 Aluminum
	75 (24) 225 (107)	- -	30 (5.3) 40 (7.0)	40 (7.0) -	
Honeycomb Sandwich Peel ASTM D 1781	°F (°C)	in-lb/3 in (Nm/m)			0.020 in (0.51 mm) and 0.064 in (1.63 mm) 2024T-3 Aluminum
	75 (24)	27 (40)	25 (37)	59 (87)	

¹ Cured at 250°F (121°C)

Cure Cycle: Heat to 350°F (177°C) at 3°F (1.7°C)/minute, hold at 350°F (177°C) for 90 minutes, 40 psi (0.28 MPa) pressure

Table 6 | Metal to Metal: Flatwise Tensile with BR[®] 6747-1 Primer¹

Property	Test Temperature	FM 309-1 M 0.05 psf (244 gsm)	Substrate
Flatwise Tensile ASTM C 297	°F (°C)	psi (MPa)	Face: 0.020 in (0.51 mm) 2024T-3 Aluminum Core: Metallic, 0.250 in (6.35 mm) cell, 8.0 pcf (0.128 g/cc) density, 0.50 in (12.7 mm) thick
	75 (24)	1010 (7.0)	
	250 (121) 275 (135)	810 (5.6) 670 (4.6)	

¹ Cured at 250°F (121°C)

Cure Cycle: Heat to 350°F (177°C) at 3°F (1.7°C)/minute, hold at 350°F (177°C) for 90 minutes, 40 psi (0.28 MPa) pressure

Composite Bonding

FM[®] 309-1 Adhesive Film Fracture Toughness Testing

Pre-bond Humidity Exposure: Cured skins soaked in 160°F (71°C) water until 1% weight gain then bonded with FM[®] 309-1 adhesive film

Post-bond Humidity Exposure: Bonded specimens exposed for 14 days at 160°F (71°C) and 100% RH

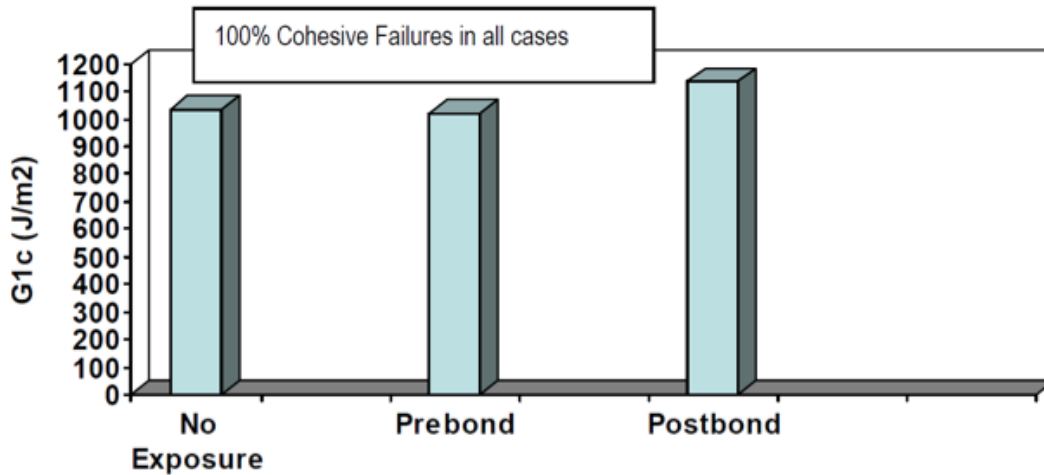


Figure 1 | CYCOM[®] 977-2 Prepreg Co-Bonded Specimens: Effect of Pre-bond and Post-bond Humidity Exposure

Table 7 | Composite Bonding: Effect of Humidity Exposure: Co-bonded Wide Area Lap Shear, FM[®] 309-1M 0.05 psf (244 gsm)

Property	Test Temperature	Before post-bond humidity exposure	After 2000 hours exposure at 160°F (71°C) /100% RH	Substrate
Wide Area Lap Shear ASTM D 3165	°F (°C)	psi (MPa)		0.079 in (2.00 mm) CYCOM [®] 977-2 with Unidirectional carbon fiber
	-67 (-55)	4000 (27.6)	-	
	75 (24)	5370 (37.0)	5080 (35.0)	
	180 (82)	4890 (33.7)	-	
	250 (121)	3700 (25.5)	3200 (22.1)	
	285 (141)	3480 (24.0)	-	

Cure Cycle: Heat to 365°F (185°C) at 3°F (1.7°C)/minute, hold at 365°F (185°C) for 180 minutes, 80 psi (0.55 MPa) pressure.

Table 8 | Composite Bonding: Effect of Humidity Exposure : Secondly Bonded Double Lap Shear, FM[®] 309-1 0.05 psf (244 gsm)

Property	Test Temperature	Before post-bond humidity exposure	After 2000 hours exposure at 160°F (71°C) /100% RH	Substrate
Double Lap Shear ASTM 3528	°F (°C)	psi (MPa)		0.118 in (3.00 mm) center panel with 0.59 in (1.50 mm) outer panels CYCOM [®] 977-2 with Unidirectional Carbon Fiber
	-67 (-55)	5370 (37.0)	-	
	75 (24)	6090 (42.0)	6090 (42.0)	
	180 (82)	5610 (38.7)	-	
	250 (121)	4420 (30.5)	4350 (30.0)	
	285 (141)	3440 (23.7)	-	

Cure Cycle: Heat to 350°F (177°C) at 3°F (1.7°C)/minute, hold at 350°F (177°C) for 90 minutes, 40 psi (0.28 MPa) pressure

Table 9 | Composite Bonding: Flatwise Tensile, FM[®] 309-1 M 0.05 psf (244 gsm)

Property	Test Temperature	No Exposure	After 2000 hours water soak at 160°F (71°C)	Substrate
Flatwise Tensile ASTM C 297	°F (°C)	psi (MPa)		Co-bonded glass honeycomb/CYCOM [®] 977-2 carbon fabric Skin: 0.039 in (1.00 mm) Core: 5052 H191 Aluminum, 0.252 in (6.40 mm) cell, 6.0 pcf (0.096 g/cc) density, 0.51 in (13.0 mm) thick
	75 (24)	925 (6.4)	-	
	182 (83)	885 (6.1)	520 (3.6)	

Cure cycle for core stabilization and bonding to pre-cured skin: Heat to 355°F (179°C) at 3°F (1.7°C)/minute, hold at 355°F (179°C) for 60 minutes, 14 psi (0.1 MPa) pressure.

Cure cycle for co-cure side: Heat to 365°F (185°C) at 3°F (1.7°C)/minute, hold for 180 minutes at 365°F (185°C), 80 psi (0.55 MPa) pressure.

PROCESSING

Recommended Cure Cycle

Co-bonded Cure Cycle Apply full vacuum, 24 in Hg (0.081 MPa) minimum.
Apply 80 psi (0.55 MPa) pressure, vent vacuum at 20 psi (0.14 MPa).
Heat from 75°F (24°C) to 365°F (185°C) at 2°F - 5°F (1°C - 3°C)/minute.
Hold at 365°F (185°C) for 120 minutes.
Cool under pressure below 140°F (60°C) at 2°F - 5°F (1°C - 3°C)/minute.

Secondary Bonded & Metal Substrate Cure Cycle Apply full vacuum, 24 in Hg (0.081 MPa) minimum.
Apply 40 psi (0.28 MPa) pressure, vent vacuum at 20 psi (0.14 MPa).
Heat from 75°F (24°C) to 350°F (177°C) at 2°F - 5°F (1°C - 3°C)/minute.
Hold at 350°F (177°C) for 90 minutes.
Cool under pressure below 140°F (60°C) at 2°F - 5°F (1°C - 3°C)/minute.

Metallic Substrates

Primers featured BR[®] 6747-1 cured at 250°F (121°C) for 60 minutes or BR[®] 6750 cured at 350°F (177°C) for 15 minutes.

Composite Substrates

Prepreg featured CYCOM[®] 977-2-34-12K HTS-196 T1-300.

SURFACE PREPARATION

Non-Metallic Cured Substrates

Most high performance composites employ a removable peel ply of nylon or Dacron[®] fabric. Remove the peel ply and bond immediately. For surfaces without peel ply:

1. Lightly sand the surface to be bonded using 240 grit – 280 grit sandpaper.
2. Clean the surface using clean cotton (lint free) cloth and MEK or acetone.
3. Dry thoroughly at 160°F ± 10°F (71°C ± 6°C) for 1 hour - 2 hours.

Aluminum Skins

A clean, dry, grease-free surface is required for bonding. FM[®] 309-1 is used with standard cleaning techniques involving a four step procedure of solvent degreasing, alkaline cleaning, chemical deoxidizing (etching), and phosphoric acid anodizing*. General guidance for etching and phosphoric acid anodizing can be found in ASTM 2651 and ASTM 3433, respectively. Although not required, best results for aluminum feature priming after appropriate surface preparation, with BR[®] 6747-1, BR[®] 6747-1 NC, BR[®] 6750 or BR[®] 127 primer.

*Boeing patent 4,085,012. April 1978. Phosphoric acid anodizing is now being used by a large number of aircraft manufacturers due to the improved surface bond durability it provides.

Metallic Core

No cleaning is necessary unless the core has been contaminated by foreign matter, in which case degrease with MEK or vapor degrease may be used.

Primer Application

Although not mandatory, BR[®] 6747-1 and BR[®] 6750 water-based, corrosion inhibiting primers are recommended for use with FM[®] 309-1 adhesive in the bonding of aluminum details. Both primers offer superior durability and resistance to hostile environments within the bond line and also may be used as a protective coatings outside the bonded areas. For higher temperature applications or continuous service at 350°F (177°C), high Tg, BR[®] 6750 primer is recommended. Apply as follows:

1. Allow the chosen primer to warm to room temperature, 75°F (24°C), prior to opening container
2. Thoroughly mix before application and agitate during application
3. Spray or brush coat to a dry primer thickness of 0.0001 in (0.0025 mm) nominal with a 0.0003 in (0.0076 mm) maximum thickness.
4. Air dry 30 minutes minimum prior to using
5. Oven cure at respective temperature and time. See metallic substrate section.

LAY-UP PROCEDURE

1. When FM[®] 309-1 is removed from refrigerator storage, the adhesive must be allowed to reach room temperature [75°F (24°C)] before the roll is unpackaged. Note that the adhesive film is sandwiched between release paper and polyliner.
2. Remove either of the interliners and place the adhesive against the surface to be bonded. Care should be taken to prevent air entrapment between the film adhesive and substrate, especially in large area bonds.
3. FM[®] 309-1 provides excellent tack and drape; the use of a heat gun or tack table is not required.
4. Complete the assembly after removing the other interliner.

HEALTH & SAFETY

Please refer to the product SDS for safe handling, personal protective equipment recommendations and disposal considerations.

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Composite Materials
4500 McGinnis Ferry Rd
Alpharetta, GA 30005-3914 USA

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