

## FM<sup>®</sup> 94

FM<sup>®</sup> 94 adhesive is a 220°F (104°C) service temperature, modified epoxy film adhesive designed for bonding metallic and composite structures. FM<sup>®</sup> 94 adhesive offers a unique combination of high temperature performance, toughness and moisture resistance as demonstrated by its ability to bond to wet Nomex<sup>®</sup> honeycomb and retention of shear properties after pre- and post-bond humidity exposure. FM<sup>®</sup> 94 adhesive is designed for applications demanding the best of both 220°F (104°C) service temperature and -67°F (-55°C) peel strength.

For composite and metal bonding applications, FM<sup>®</sup> 94 adhesive is formulated to exhibit superior elongation, toughness and shear strength properties. The controlled flow characteristics allow for its use in co-cured applications as well as bonding pre-cured structures. Also, FM<sup>®</sup> 94 adhesive provides excellent electrical insulation between metal and graphite composites, reducing the potential for galvanic corrosion.

FM<sup>®</sup> 94 film adhesive is manufactured as a supported adhesive, with knit or mat carriers, as well as an unsupported film. When supported with a knit carrier, optimal mechanical properties can be obtained. The random mat provides superior handling characteristics. With the mat carrier, FM<sup>®</sup> 94 adhesive can be supplied in a one-side tacky (OST) version which helps reduce air entrapment when bonding large metal or composite parts.

Typical applications for FM<sup>®</sup> 94 include bonding of metallic and composite structures.

### Features and Benefits

- Demonstrates superior strength in bonding both metallic and composite structures
- Provides structural performance from -67°F to 220°F (-55°C to 104°C)
- Offers exceptional elongation and toughness
- Higher service temperature version of FM<sup>®</sup> 73 film adhesive
- Recommended for use with BR<sup>®</sup> 6747-1, FM<sup>®</sup> 490A and BR<sup>®</sup> 127

## CHARACTERISTICS

**Table 1 | Physical Properties**

Shelf Life	12 months at or below 0°F (-18°C) from date of shipment for supported forms 6 months at or below 40°F (4°C) from date of shipment for unsupported forms
Shop Life	30 days at or below 75°F (24°C)
Volatiles ASTM 3530	1% Maximum 250°F (121°C)

**Table 2 | Product Availability**

Property	Film Adhesive	Nominal Weight <sup>1</sup> psf (gsm)	Nominal Thickness in (mm)	Color	Carrier
Product Form	FM <sup>®</sup> 94K	0.030 (146) 0.045 (220) 0.060 (293) 0.080 (391)	0.006 (0.15) 0.007 (0.18) 0.010 (0.25) 0.012 (0.30)	Green	Polyester Knit
	FM <sup>®</sup> 94 M	0.030 (146) 0.060 (293)	0.005 (0.13) 0.010 (0.25)	Green	Polyester Mat
	FM <sup>®</sup> 94 M OST	0.060 (293)	0.010 (0.25)	Green	Polyester Mat (One-side tacky)
	FM <sup>®</sup> 94 U	0.030 (146)	0.005 (0.13)	Green	Unsupported
Roll Width <sup>2</sup>	36 in ( 91 cm)				
Roll Length	60 yds (55 m)				

<sup>1</sup> Weight tolerance equals nominal weight  $\pm$  0.005 psf ( $\pm$  24 gsm)

<sup>2</sup> Available in slit form. Please contact Solvay for more information.

**Table 3 | Physical Properties: BR<sup>®</sup> 6747-1 Corrosion Inhibiting Primer**

Shelf Life	12 months at or below 40°F to 55°F (4°C to 13°C) from date of shipment 6 months at or below 56°F to 75°F (14°C to 24°C) from date of shipment DO NOT FREEZE
Shop Life	30 days at 90°F (32°C)
Color	Yellow
Solids	20% or 30%
Density	20%: 8.78 lbs/gal (1050 g/L) 30%: 9.10 lbs/gal (1090 g/L)
Recommended Primer Thickness	0.10 mil – 0.30 mil ( .0025 mm - .0076 mm )
Recommended Cure	Airy dry 30 minutes in ambient conditions Cure 60 minutes at 250°F (121°C)

**PROPERTIES**

**Metal Bonding**

**Table 4 | Mechanical Performance: Aluminum Substrate with BR<sup>®</sup> 6747-1**

Property	Test Temperature	FM 94K 0.06 psf (293 gsm)	FM 94M 0.06 psf (293 gsm)	Substrate
Wide Area Lap Shear ASTM D 3165	<b>°F (°C)</b>	<b>psi (MPa)</b>		0.064 in (1.63 mm) 2024-T3 Aluminum
	-67 (-55)	5810 (40.1)	5220 (36.0)	
	75 (24)	5520 (38.1)	5200 (35.8)	
	180 (82)	4000 (27.5)	3700 (25.5)	
	220 (104)	3520 (24.3)	3410 (23.5)	
250 (121)	2390 (16.4)	2490 (17.2)		
Lap Shear ASTM D 1002	-67 (-55)	6510 (44.9)	6080 (41.9)	0.063 in (1.60 mm) 2024-T3 Aluminum
	75 (24)	6760 (46.6)	6340 (43.7)	
	180 (82)	5040 (34.8)	4860 (33.5)	
	220 (104)	4240 (29.2)	3520 (24.2)	
Metal-to-Metal Climbing Drum Peel ASTM D 1781	<b>°F (°C)</b>	<b>in-lb/in (Nm/m)</b>		0.020 in (0.51 mm) and 0.064 in (1.63 mm) 2024-T3 Aluminum
	75 (24)	85 (378)	80 (356)	
	200 (93)	70 (311)	78 (347)	
	220 (104)	65 (289)	75 (334)	
Floating Roller Peel ASTM D 3167	<b>°F (°C)</b>	<b>lb/in (kN/m)</b>		0.025 in (0.63 mm) and 0.064 in (1.63 mm) 2024-T3 Aluminum
	-67 (-55)	65 (11.4)	52 (9.1)	
	75 (24)	74 (12.9)	70 (12.3)	
	180 (82)	75 (13.1)	70 (12.3)	
220 (104)	60 (10.5)	60 (10.5)		
Honeycomb Sandwich Peel ASTM D 1781	<b>°F (°C)</b>	<b>in-lb/3in (Nm/m)</b>		Skin: 0.020 in (0.51 mm) 2024-T3 Aluminum, Core: 5052 Aluminum, 0.25 in (6.35 mm) cell, 7.9 pcf (0.127 g/cc) density, 0.50 in (12.7 mm) thick
	-67 (-55)	68 (101)	60 (89)	
	75 (24)	84 (125)	72 (107)	
	220 (104)	61 (90)	51 (76)	
Flatwise Tensile ASTM C 297	<b>°F (°C)</b>	<b>psi (MPa)</b>		Skin: 0.020 in (0.51 mm) 2024-T3 Aluminum, Core: 5052 Aluminum, 0.25 in (6.35 mm) cell, 7.9 pcf (0.127 g/cc) density, 0.50 in (12.7 mm) thick
	-67 (-55)	1660 (11.4)	1680 (11.8)	
	75 (24)	1190 (8.2)	1250 (8.6)	
	180 (82)	665 (4.6)	645 (4.4)	
220 (104)	250 (1.7)	355 (2.4)		

**Table 5 | Environmental Exposure, Aluminum Substrate with BR<sup>®</sup> 6747-1**

Property	Exposure Condition	Test Temperature	FM 94K 0.06 psf (293 gsm)	Substrate
Lap Shear ASTM D 1002		°F (°C)	psi (MPa)	0.063 in (1.60 mm) 2024-T3 Aluminum
	30 days exposure to salt spray per ASTM B117	75 (24) 160 (71)	6250 (43.1) 4980 (34.3)	
	30 days exposure to 140°F (60°C), 100% RH	75 (24)	5950 (41.0)	
	30 days exposure to tap water at 75°F (24°C)	75 (24) 160 (71)	6210 (42.8) 5370 (37.0)	
	30 days exposure to 180°F (82°C), 100% RH	180 (82)	4140 (28.5)	
	7 days exposure to JP-4 at 75°F (24°C)	160 (71)	5420 (37.3)	
	7 days exposure to MIL-H-5606 fluid at 75°F (24°C)	160 (71)	4690 (32.3)	
	7 days exposure to MIL-L-7808 fluid at 75°F (24°C)	160 (71)	4790 (33.0)	

**Table 6 | Effect of Cure Cycle: FM<sup>®</sup> 94K 0.06 psf (293 gsm), Aluminum Substrates with BR<sup>®</sup> 6747-1**

Property	Test Temperature	Cure Cycle			Substrate
		60 min. at 250°F (121°C)	60 min. at 300°F (149°C)	60 min. at 350°F (177°C)	
Lap Shear ASTM D 1002	°F (°C)	psi (MPa)			0.063 in (1.60 mm) 2024-T3 Aluminum
	75°F (24) 180°F (82)	6250 (43.1) 4600 (31.7)	6100 (42.1) 4550 (31.4)	6000 (41.4) 4350 (30.0)	
Honeycomb Sandwich Peel ASTM D 1781	°F (°C)	in-lb/3 in (Nm/m)			Skin: 0.020 in (0.51 mm) 2024-T3 Aluminum, Core: 5052 Aluminum, 0.187 in (4.76 mm) cell, 5.7 pcf (0.090 g/cc) density, 0.625 in (15.9 mm) thick
	-67 (-55) 75 (24) 180 (82)	75 (111) 85 (126) 80 (119)	78 (116) 90 (133) 80 (119)	80 (119) 90 (133) 85 (126)	

Cure Cycle Heat-up Rates:

- 250°F (121°C) cure: 3°F (1.6°C)/minute, 40 psi (0.28 MPa)
- 300°F (149°C) cure: 3.7°F (2.1°C)/minute, 40 psi (0.28 MPa)
- 350°F (177°C) cure: 4.6°F (2.6°C)/minute, 40 psi (0.28 MPa)

**Table 7 | Durability Data: Aluminum Substrates and BR<sup>®</sup> 6747-1**

Test	Test Condition	FM 94M 0.06 psf (293 psf)
Crack Extension ASTM D 3433		<b>lb/in (N)</b>
	None (G1a)	12.0 (53.3)
	5 weeks exposure to 140°F (60°C) 100% RH, (G1scc)	6.0 (26.7)
	15 weeks exposure to 140°F (60°C) 100% RH, (G1scc)	6.0 (26.7)
	7 days exposure to JP-4 at 75°F (24°C)	8.5 (37.8)
	7 days exposure to hydraulic fluid at 75°F (24°C)	7.1 (31.6)
Fatigue ASTM D 3166 R-ratio: 0.1 Frequency: 30 Hz	> 10 <sup>7</sup> cycles at max. stress 2600 psi (17.9 MPa)	No Failure
Creep Rupture Deformation ASTM E 139	1600 psi (11.0 MPa) for 192 hours at 75°F (24°C)	No Creep
	1500 psi (10.3 MPa) for 192 hours at 180°F (82°C)	No Creep
Cyclic Fatigue (RAAB)	2000 psi (13.8 MPa) with 60 minutes loaded & 15 minutes unloaded	No failure up to 3000 cycles

**Table 8 | Effect of Out-Time: FM<sup>®</sup> 94K 0.06 psf (293 gsm) with BR<sup>®</sup> 6747-1**

Property	Test Temperature	Out Time Condition						Substrate
		Control	15 days at 75°F (24°C)	15 days at 90°F (32°C)	30 days at 75°F (24°C)	30 days at 90°F (32°C)	60 days at 75°F (24°C)	
Lap Shear ASTM D 1002	<b>°F (°C)</b>	<b>psi (MPa)</b>						0.063 in (1.60 mm) 2024-T3 Aluminum
	75 (24)	6500 (44.8)	6420 (44.2)	6290(43.3)	6320 (43.6)	6410 (44.2)	6560 (45.2)	
Honeycomb Sandwich Peel ASTM D 1781	<b>°F (°C)</b>	<b>in-lb/3 in (Nm/m)</b>						Skin: 0.020 in (0.51mm) 2024-T3 Aluminum, Core: 5052 Aluminum, 0.187 in (4.76 mm) cell, 5.7 pcf (0.090 g/cc) density, 0.625 in (15.9 mm) thick
	75 (24)	80 (119)	80 (119)	72 (107)	75 (111)	64 (95)	69 (102)	
Floating Roller Peel ASTM D 3167	<b>°F (°C)</b>	<b>lb/in (kN/m)</b>						0.025 in (0.63 mm) and 0.064 in (1.63 mm) 2024-T3 Aluminum
	75 (24)	80 (14.0)	-	-	72 (12.6)	72 (12.6)	75 (13.1)	

**Table 9 | Effect of Humidity, Wet Nomex<sup>®</sup> Bonding with BR<sup>®</sup> 6747-1**

Property	Nomex Core Exposure	Test Temperature	FM 94M 0.06 psf (293 gsm)	Substrate
Flatwise Tensile ASTM C 297	Immersed in water for 24 hours at 140°F (60°C) then bonded within 2 hours	°F (°C)	psi (MPa)	Skins: 0.063 in (1.60 mm) 2024-T3 Aluminum, Core: Nomex <sup>®</sup> , 0.125 in (3.18 mm) cell, 8.0 pcf (0.128 g/cc) density, 0.50 in (12.7 mm) thick
		75 (24) 160 (71)	610 (4.2)* 540 (3.7)*	

\* 100% Core failure.

**Composite Bonding**

**Table 10 | Composite Substrates Co-cure Data**

Property	Test Temperature	Exposure Condition	FM 94M 0.06 psf (293 gsm)	Substrate
Wide Area Lap Shear ASTM D 3165	°F (°C)		psi (MPa)	Co-cured with CYCOM <sup>®</sup> 985 3K 70PW
	75 (24)	None	3710 (25.6)	
		30 days at 160°F (71°C), 100% RH	4200 (29.0)	
Wide Area Lap Shear ASTM D 3165	180 (82)	None	2850 (19.7)	Co-cured with CYCOM <sup>®</sup> 985 3K 70PW
		30 days at 160°F (71°C), 100% RH	3040 (21.0)	
Flatwise Tensile Strength ASTM C 297	75 (24)	None	1120 (7.7)	Co-cured with CYCOM <sup>®</sup> 7701 (epoxy/glass), Core: HRP 0.1875 in (4.76 mm) cell, 8.0 pcf (0.127 g/cc) density, 0.50 in (1.7 mm) thick
Honeycomb Sandwich Peel ASTM D 1781	°F (°C)		in-lb/3 in (Nm/m)	Co-cured with CYCOM <sup>®</sup> 7701 (epoxy/glass), Core: HRP, 0.1875 in (4.76 mm) cell, 8.0 pcf (0.127 g/cc) density, 0.50 in (12.7 mm) thick
	75 (24)	None	62 (92)	

Panel Layout: 8 plies of prepreg/FM 94 adhesive/8 plies of prepreg

Cure Cycle: For CYCOM<sup>®</sup> 985, Heat to 350°F (177°C) at 3°F (1.7°C)/minute, hold at 350°F (177°C) for 120 minutes, 40 psi (0.28 MPa)

For CYCOM<sup>®</sup> 7701 prepreg, Heat to 250°F (121°C) at 3°F (1.7°C)/minute, hold at 250°F (121°C) for 120 minutes, 40 psi (0.28 MPa)

**Table 11 | Secondary Bonding of Epoxy/Graphite Substrates**

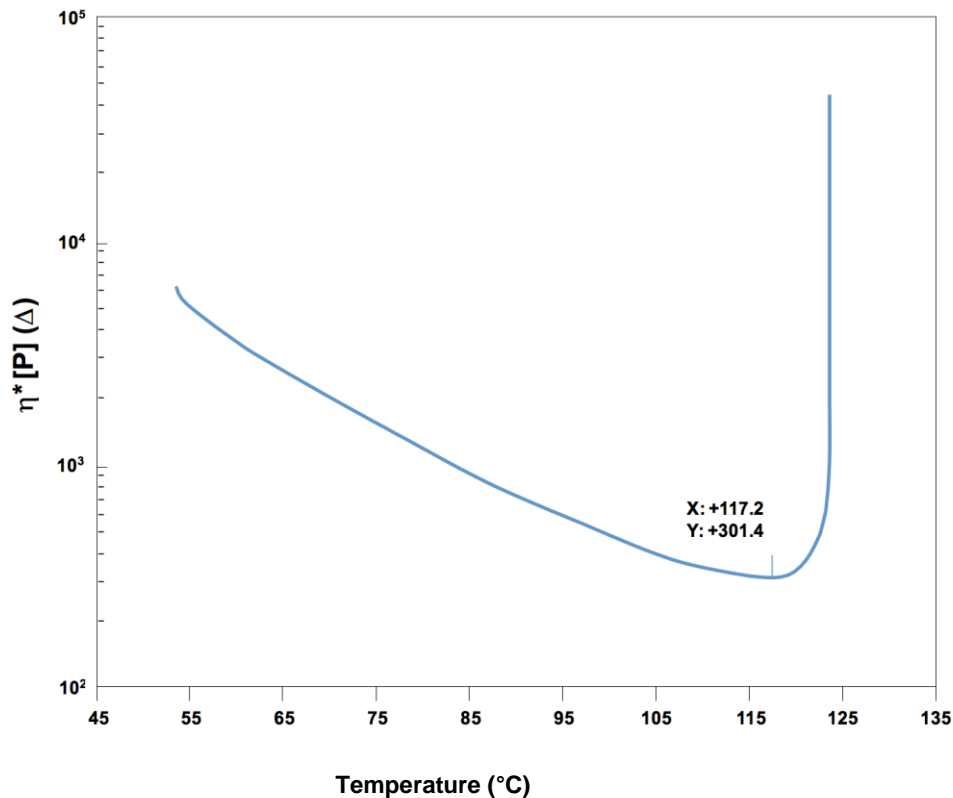
Test	Test Temperature	FM 94M 0.06 psf (293 gsm)	Substrate
Lap Shear ASTM D 1002	°F (°C)	psi (MPa)	0.10 in (2.54 mm) CYCOM <sup>®</sup> 985 3K 70PW
	75 (24)	3450 (23.8)	
	160 (71)	3000 (20.7)	
	180 (82)	2570 (17.7)	
Flatwise Tensile ASTM C 297	75 (24)	442 (3.0)*	3 plies <sup>1</sup> CYCOM <sup>®</sup> 950-1 3K 70PW
	160 (71)	-	
	180 (82)	446 (3.1)*	

\*Core failure.

<sup>1</sup> Composite surface preparation: nylon peel ply

**Table 12 | KGR-1 Stress Strain Data for FM<sup>®</sup> 94 0.06 psf (293 gsm) with BR<sup>®</sup> 6747-1 Primer, ASTM D 5656**  
**(f = Shear Stress, psi (MPa), γ = Shear Strain, in/in, G = Shear Modulus, psi (MPa))**

Test Temperature °F (°C)	Linear Limit (LL)			Knee (KN)		Ultimate Failure (UL)	
	f	γ	G	f	γ	f	γ
-67 (-55)	3620 (25.0)	0.0238	153,100 (1056)	8760 (60.4)	0.1053	10140 (70.0)	0.5398
75 (24)	2820 (19.5)	0.0237	119,300 (823)	4640 (32.0)	0.0738	6990 (48.2)	0.1934
180(82)	1060 (7.3)	0.0220	45,100 (311)	1910 (13.2)	0.0722	5620 (38.8)	1.7834



**Figure 1 | Rheology Data for FM<sup>®</sup> 94K 0.08 psf (391 gsm), 0.56°F (1°C)/minute ramp**

## PROCESSING

### Recommended Cure Cycle

Autoclave 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 250°F (121°C) at 2°F - 5°F (1°C - 3°C)/minute. Hold at 250°F (121°C) for 60 minutes. Cool under pressure below 140°F (60°C) at 2°F - 5°F (1°C - 3°C)/minute.
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### Surface Preparation

#### Non-Metallic Cured Substrates

Most high performance composites employ a removable peel ply of nylon or Dacron<sup>®</sup> 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<sup>®</sup> 94 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. Best results for aluminum feature priming after appropriate surface preparation, with BR<sup>®</sup> 6747-1, BR<sup>®</sup> 6747-1 NC or BR<sup>®</sup> 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.

#### Primer Application

Although not mandatory, BR<sup>®</sup> 6747-1 or BR<sup>®</sup> 127 corrosion inhibiting primer are recommended for use with FM<sup>®</sup> 94 adhesive in the bonding of aluminum details. These primers offers superior durability and resistance to hostile environments within the bond line and also may be used as a protective coating outside the bonded areas. Apply the individual primer as follows:

1. Allow material 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 inch (0.0025 mm) nominal with a 0.0003 inch (0.0076 mm) maximum thickness
4. Air dry 30 minutes minimum prior to using
5. Oven cure 60 minutes at 250°F ± 10°F (121°C ± 6°C)

## LAY-UP PROCEDURE

1. When FM<sup>®</sup> 94 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. If additional tack is desired, the adhesive may be heated to as high as 140°F (60°C) for up to 30 minutes without altering the adhesive properties. Before heat tacking, ensure the film is properly positioned, otherwise removal will be difficult.
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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