

3M

Scotch-Weld™

Structural Adhesive Film

AF 31

Technical Data

March, 2006

Introduction

3M™ Scotch-Weld™ Structural Adhesive Film AF 31 is an unsupported, thermosetting structural film adhesive designed for metal-to-metal bonding. It is especially designed for high-temperature resistant application (up to 500°F [260°C]).

Scotch-Weld AF 31 film adhesive offers the following advantages:

- Good flexibility and shear strength at service temperatures from -67°F to 500°F (-55°C to 260°C).
- Easy application in a dry film which can be pressure, heat, or solvent tacked in position.
- Excellent retention of strength after aging in many environments.
- Scotch-Weld AF 31 film adhesive with 3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 on stainless steel, known as the AF-7431 system, meets, and is qualified to, MMM-A-132 Types III and IV.

Description

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

Form:	Flexible unsupported film, protected by suitable liner.
Color:	Yellow to brown.
Nominal Caliper:	9-11 mils (uncured).
Weight:	.0575 - .0725 lbs./sq. ft.
Volatile Content:	Less than 5% (2-4 gm. sample cured 1 hr. at 350°F [177°C]).
Shrinkage:	5% maximum (24 hrs. at 75°F ± 5°F [24°C ± 2°C] in horizontal position).

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Product Performance

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

1. 3M™ Scotch-Weld™ Structural Adhesive Film AF 31/3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 Overlap Shear on Stainless Steel

The following product performance data has been obtained in the 3M Laboratory under the conditions specified. All data reported in this section except as noted, were developed under a cure cycle using 100 psi bonding pressure applied by a platen press. A 10°F/minute bond line temperature rise from 80°F to 350°F (27°C to 177°C) with 120 minutes ± 1 minute at 350°F (177°C) ± 2°F was used. The panels were then removed from the press and post cured for 20 hours at 500°F (260°C). The primer was air dried 30 minutes plus force dried 30 minutes at 200°F-250°F (93°C-121°C). All properties were measured on pre-slotted, .050" thick, 17-7PH-TH 1050 stainless steel panels. The properties were measured on 1" wide by 1/2" overlap specimens. Tests were conducted according to MMM-A-132 Types III & IV methods.

Test Condition	Scotch-Weld AF 31/ Scotch-Weld EC-2174
A. Tensile Shear	
1. Standard Temperature 75°F ± 5°F (24°C ± 2°C)	6166 psi
2. 10 minutes at 300°F ± 5°F (149°C ± 2°C)	2828 psi
3. 192 hours at 300°F ± 5°F (149°C ± 2°C)	3166 psi
4. 10 minutes at 500°F ± 5°F (260°C ± 2°C)	1983 psi
5. 192 hours at 500°F ± 5°F (260°C ± 2°C)	2268 psi
6. 10 minutes at -67°F ± 5°F (-55°C ± 2°C)	6012 psi
7. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 30 days Salt Spray Exposure at 95°F (35°C)	5693 psi
8. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 30 days at 120°F (49°C) and 90-100% relative humidity	5635 psi
9. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 30 days Tap Water Immersion at 75°F (24°C)	5764 psi
10. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 7 days Immersion in Anti-icing Fluid (MIL-F-5566) at 75°F (24°C)	5912 psi
11. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 7 days Immersion in Hydraulic Oil (MIL-H-5606) at 75°F (24°C)	5867 psi
12. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 7 days Immersion in JP4 Fuel (MIL-J-5624) at 75°F (24°C)	5722 psi
13. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 7 days Immersion in in Hydrocarbon Fluid (MIL-S-3136) at 75°F (24°C)	6042 psi
B. Creep Rupture	
14. Standard Temperature 75°F ± 5°F (24°C ± 2°C) after 192 hours at 1600 psi	0.0000 inches
15. 300°F ± 5°F (149°C ± 2°C) after 192 hours at 800 psi	0.0000 inches
16. 500°F ± 5°F (260°C ± 2°C) after 192 hours at 800 psi	0.0017 inches
C. Fatigue Strength	
17. Standard Temperature 75°F ± 5°F (24°C ± 2°C) at 750 psi for 10 ⁶ + cycles	No failures

Scotch-Weld™ Structural Adhesive Film AF 31

Product Performance
(continued)

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

2. 3M™ Scotch-Weld™ Structural Adhesive Film AF 31/3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 Overlap Shear on Aluminum

The following data shows typical values obtained with Scotch-Weld AF 31 film adhesive over Scotch-Weld EC-2174 primer in overlap bonds. All properties were measured on 1" wide 1/2" overlap specimens cut from .063" thick 4" x 7" bonded panels of 2024 T3 clad aluminum. Tests were conducted according to MMM-A-132 methods. All data reported in this section was developed using the following cures.

Test	Test Temperature	Scotch-Weld AF 31/Scotch-Weld EC-2174	
		350°F (177°C) for 120 min. 100 psi 10°F rise rate/min.	350°F (177°C) for 60 min. 45 psi 10°F rise rate/min.
Shear Strength	-67°F ± 2°F (-55°C ± 1°C) 73.5°F ± 2°F (23°C ± 1°C) 260°F ± 2°F (127°C ± 1°C) 300°F ± 2°F (149°C ± 1°C) 350°F ± 2°F (177°C ± 1°C)	2750 psi 4430 psi 2700 psi 2550 psi 2350 psi	2310 psi 4070 psi — 2330 psi —
Creep Rupture (192 hours)	73.5°F ± 2°F (23°C ± 1°C) 300°F ± 2°F (149°C ± 1°C)	.003" .006"	

3. Scotch-Weld AF 31 Film Adhesive T-Peel on Aluminum

T-Peel bonds consist of bonded areas of 1" x 6" 2024 T3 clad 1" x 8" x .032" panels with one layer of Scotch-Weld AF 31 film adhesive. Each metal skin of the T-Peel panels were pulled at a 90° angle to the bond line or 180° in relation to themselves with a jaw separation rate of 20 inches per minute.

A. Original Properties

Cure Cycle	T-Peel (lbs./inch width)					
	-40°F (-40°C)	75°F (24°C)	180°F (82°C)	250°F (121°C)	350°F (177°C)	450°F (232°C)
350°F (177°C), 60 min., 150 psi, 200°F (93°C) per min. rise rate to cure temperature.	4	25	12	8	7	4
450°F (232°C) press temperature, 350 psi, 15 seconds in the press, maximum bond line temperature attained 412°F (211°C).	4	27	11	8	7	4

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Product Performance (continued)

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

4. 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 Overlap Shear on Aluminum Using Varied Cure Times, Temperatures, and Pressures

The following data shows typical values obtained with Scotch-Weld AF 31 film adhesive in aluminum overlap bonds. All properties were measured on 1" wide, 1/2" overlap specimens cut from .063" thick 4" x 7" bonded panels of 2024 T3 clad aluminum. Tests were conducted according to MMM-A-132 methods. All bonds were formed in a platen press.

Cure Cycle					Overlap Shear (psi) Test Temperature									
Temp.		Time	Pressure	Rise Rate	-67°F (-55°C)	75°F (24°C)	180°F (82°C)	250°F (121°C)	300°F (149°C)	350°F (177°C)	400°F (204°C)	450°F (232°C)	500°F (260°C)	600°F (316°C)
(°F)	(°C)	(min.)	(psi)	(°F/min)										
350	177	60	150	200	2700	3700	2850	2500	2390	1700	1150	1100	800	250
350	177	10	150	200	2850	4200		2430	1975					
350	177	5	150	200	2260	4200		2260	1610					
350	177	60	45	200	2675	3740			2050					
350	177	60	45	9	2800	3700			2100			1300		
350	177	120	100	10					2647		2165		1790	
250	121	120	75	10		4285			1225					
250	121	24 hrs.	75	10		4375			2090					
260	127	120	75	10		4150			1510					
260	127	8 hrs.	75	10		4360			2000					
325	163	60	20	200	2720	3360	1830	1370	840					
350	177	60	20	200	2820	3280	2020	1720	1530					

Cure Cycle					
Platen Temp.	Time at Temp.	Time in Press	Pressure (psi)	Test Temp.	Overlap Shear (psi)
450°F (232°C)	5 sec.	85 sec.	300	75°F (24°C)	3000
450°F (232°C)	1 min.	140 sec.	300	75°F (24°C)	2900
450°F (232°C)	10 min.	11.25 min.	300	75°F (24°C)	2800
450°F (232°C)	384*	10 sec.	300	75°F (24°C)	2350
450°F (232°C)	412*	15 sec.	350	-40°F (-40°C)	3400
450°F (232°C)	412*	15 sec.	350	75°F (24°C)	3050
450°F (232°C)	412*	15 sec.	350	180°F (82°C)	2400
450°F (232°C)	412*	15 sec.	350	250°F (121°C)	1850
450°F (232°C)	412*	15 sec.	350	350°F (177°C)	1650
450°F (232°C)	412*	15 sec.	350	450°F (232°C)	1240
450°F (232°C)	419*	30 sec.	350	75°F (24°C)	3200

*Maximum bondline temperature attained (°F). Bond line did not attain platen temperature.

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Product Performance (continued)

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

5. Environmental Aging of 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 Using a 350°F (177°C) Cure for 120 Minutes, 100 psi, 10°F rise rate/minute.

Environment	Overlap Shear Strength (psi)								
	-67°F (-55°C)	75°F (24°C)	200°F (93°C)	300°F (149°C)	350°F (177°C)	400°F (204°C)	450°F (232°C)	500°F (260°C)	600°F (300°C)
Control	3500	3700		2390	1700	1150	1100	800	250
Air @ 300°F (149°C) for 222 hours	4750	4200		2540	2510	1960			320
Air @ 350°F (177°C) for 216 hours					1578			1130	
Air @ 450°F (232°C) for 100 hours	2600			1920			1430		
Air @ 450°F (232°C) for 200 hours	2250			1560			1470		
Air @ 500°F (260°C) for 192 hours	1600	1440		1080			1060		
¹ Air @ 400°F (204°C) for 1 hour				2840		2300		1930	
² Air @ 450°F (232°C) for 10 hours	2350	3590		2450			1910		
Salt Spray @ 95°F (23°C) for 30 days		3950							
Tap Water @ 75°F (24°C) for 30 days		3790							
Anti-Icing @ 75°F (24°C) for 7 days (MIL-F-5566)		3720							
Hydraulic Oil @ 75°F (24°C) for 7 days (MIL-O-5606)		3790							
Type III Hydrocarbon @ 75°F (24°C) for 7 days (MIL-H-3136)		3750							
JP-4 @ 75°F (24°C) for 7 days (MIL-F-5624)		3970							
JP-4 @ 140°F (60°C) for 7 days (MIL-F-5624)		3740							
60% H ₂ O – 40% Methyl Alcohol by volume, plus 1% soluble oil: @ 170°F (79°C) for 7 days				³ 2430					
@ 170°F (79°C) for 30 days				³ 2246					
60% H ₂ O – 40% Ethylene Glycol by volume, plus 1% soluble oil: @ 200°F (93°C) for 7 days				³ 2450					
@ 200°F (93°C) for 30 days				³ 2430					
99% H ₂ O – 1% soluble oil: @ 200°F (93°C) for 7 days				³ 2220					
@ 200°F (93°C) for 30 days				³ 2210					

¹Cure Cycle – 350°F (177°C), 2 hours, 150 psi – 10°F/min. rise rate.

²Cure Cycle – 350°F (177°C), 60 min., 45 psi – 9°F/min. rise rate.

³Specimens cut to one inch width prior to immersion.

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Product Performance
(continued)

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

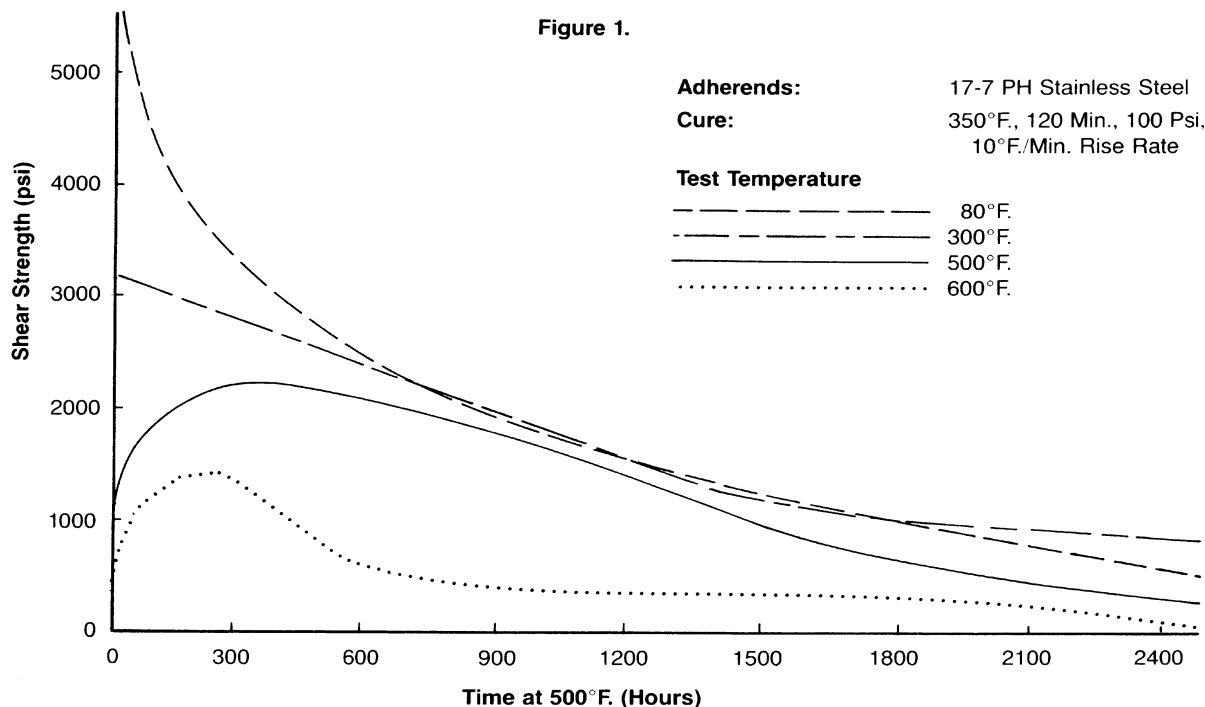
6. Heat aging of 3M™ Scotch-Weld™ Structural Adhesive Film AF 31/3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 on Aluminum and Titanium. The adhesive was cured as indicated below.

The primer was air dried 30 minutes plus force dried 30 minutes at 250°F (121°C).

Exposure Time and Temperature	Cure Cycle	Overlap Shear Strength (psi)		
		75°F (24°C)	300°F (149°C)	400°F (204°C)
2024 T-3 Alclad Aluminum				
Control	A	3800	1960	
500 hours at 300°F (149°C)	A	3410	2180	
1000 hours at 300°F (149°C)	A	2980	2070	
2000 hours at 300°F (149°C)	A	3240	2150	
3000 hours at 300°F (149°C)	A	3170	2190	
Control	B	4150		1710
192 hours at 400°F (204°C)	B	3850		1730
Control	C	3390		1240
192 hours at 400°F (204°C)	C	2790		1420
6,4 Titanium Alloy				
Control	B	880		880
192 hours at 400°F (204°C)	B	640		820
Control	C	1490		630
192 hours at 400°F (204°C)	C	1310		1030
Cure Cycle A – 350°F (177°C), 45 minutes, 100 psi, 10°F/minute rise rate. Cure Cycle B – 350°F (177°C), 120 minutes, 100 psi, 10°F/minute rise rate. Cure Cycle C – Cure Cycle B plus post cured 120 minutes at 500°F (260°C).				

7. Long Term Aging at 500°F (260°C) on Stainless Steel using a 350°F (177°C) cure for 120 minutes, 100 psi, 10°F rise rate/min.

Effect of 500°F (260°C) Aging on Overlap
Shear Strength of Scotch-Weld AF-31 / Scotch-Weld EC-2174



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Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

Environmental Aging of 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 on Aluminum Using Short Time Cure Cycle (Specimens Cut to 1" Width Prior To Immersion)

Cure Cycle – 15 seconds in a 450°F (232°C) platen press, 350 psi, maximum bond line temperature attained 412°F (210°C).

Environment	Overlap Shear Strength (psi)				
	-40°F (-40°C)	75°F (24°C)	180°F (82°C)	250°F (121°C)	350°F (177°C)
Control	3400	3050	2400	1850	1650
100% R.H. @ 100°F (38°C)					
7 Days	3450	3000	2400	1800	1400
14 Days	3400	3200	2600	1800	1700
30 Days	3950	3300	2400	1900	1500
60 Days	3950	3400	2400	1800	1000
1/2 Year	4300	3900	2000	1800	1300
1 Year	4300	3300	2000	1900	1200
Tap Water @ 120°F (49°C)					
7 Days	3450	2800	2600	1600	1400
14 Days	3800	3200	2500	1900	1600
30 Days	3950	3200	2400	1700	1500
60 Days	3800	3200	2450	1600	1100
1/2 Year	3800	3750	2200	2200	1300
1 Year	3300	2250	2200	1800	900
Gasoline @ 75°F (24°C)					
7 Days	3800	3100	2400	1600	1450
14 Days	3800	3100	2200	1350	1350
30 Days	3800	3100	2350	1550	1400
60 Days	3800	3150	2400	1550	1350
1/2 Year	3400	3200	2600	2050	1300
1 Year	3000	2850	2400	1550	1150
Methanol @ 75°F (24°C)					
7 Days	3950	3200	2350	2100	1250
14 Days	3250	3350	2050	2000	1600
30 Days	3800	2800	2250	1900	1250
60 Days	3750	3000	1950	1000	750
1/2 Year	3800	2500	1600	1000	600
1 Year	4050	2700	2400	1250	900
Salt Spray @ 75°F (24°C)					
7 Days	3700	2950	1900	1750	1400
14 Days	3800	3250	1900	2000	1600
30 Days	4300	3300	2300	1700	1550
60 Days	4000	2950	2100	1800	1000
1/2 Year	3200	3100	1750	2000	1050

Scotch-Weld™ Structural Adhesive Film AF 31

Product Performance (continued)

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

9. Environmental Aging of 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 on Steel

The following data shows typical values obtained with Scotch-Weld AF 31 film adhesive in steel overlap bonds. All properties were measured on 1" wide, 1/2" overlap specimens cut from .035" thick 4" x 8" bonded panels of 1020 cold rolled steel. The 1020 steel was cleaned with toluene solvent. Tests were conducted according to MMM-A-132 methods.

A. Original Properties

	Overlap Shear Strength (psi)				
	-40°F (-40°C)	75°F (24°C)	250°F (121°C)	350°F (177°C)	450°F (232°C)
Cure Cycle A 350°F (177°C), 60 min., 150 psi, 200°F (93°C) per minute rise rate to cure temperature.	2600	2195	1800	1720	660
Cure Cycle B 450°F (232°C) press temp., 350 psi, 15 seconds in the press, maximum bond line temperature attained 412°F (212°C).	250	2510	1520	1400	480

B. Environmental Aging Properties (Specimens cut to 1" width prior to immersion)

Environment	75°F (24°C) Overlap Shear (psi)	
	Cure Cycle A	Cure Cycle B
Control	2195	2510
100% RH @ 100°F (38°C) for 7 days	1910	2530
120°F (49°C) Tap Water for 7 days	1650	1530
75°F (24°C) Gasoline for 7 days	2090	2530
75°F (24°C) Methanol for 7 days	2020	2410
95°F (35°C) Salt Spray for 7 days	1760	2810

10. Effect of Overlap Length on Scotch-Weld AF 31 Film Adhesive Shear Strength

The effect of overlap length on shear strength of Scotch-Weld AF 31 film adhesive was determined on 1" wide specimens of varying length overlap, cut from .063" thick bonded panels of 2024 T3 clad aluminum. The cure cycle used was 350°F (177°C), 60 minutes, 150 psi, 200°F (93°C)/min. rise rate.

Length of Overlap	Actual Load (lbs.)	psi
1/4"	1425	5700
3/8"	1740	4640
1/2"	2000	4000
3/4"	2500	3340
1"	2900	2400
1 1/2"	3230	2150
2"	3270	1634
3"	3600	1200

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Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

11. Shear Strength of 3M™ Scotch-Weld™ Structural Adhesive Film AF 31/3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 on 410 Stainless Steel

Surface Preparation – Abraded with a Scotch-Brite™ Hand Pad soaked in methyl ethyl ketone – rinsed with methyl ethyl ketone and air dried.*

Primer Dry – two brush coats – (30 minutes between coats) – air dried overnight.

Cure Cycle – 350°F (177°C) for 60 minutes, 50 psi, 10°F rise rate/minute.

***Note:** When using solvents, extinguish all ignition sources and follow manufacturer’s precautions and directions for use.

	Scotch-Weld AF 31/Scotch-Weld EC-2174	
	75°F (24°C)	300°F (149°C)
Overlap Shear Strength	4365 psi	2230 psi

12. Scotch-Weld AF 31 Film Adhesive Outgassing

The outgassing data at 10⁻⁶ torr was obtained on Scotch-Weld AF 31 film adhesive which had been cured for 60 minutes at 350°F (177°C). The total weight loss and volatiles condensed were measured using SP-R-0022A procedures.

Total Weight Loss = 2.34%
Volatile Condensable Material = 0.33%

13. Scotch-Weld AF 31 Film Adhesive Coefficient of Thermal Expansion

The coefficient of thermal expansion was obtained on Scotch-Weld AF 31 film adhesive cured at 350°F (177°C) for 60 minutes under 100 psi with a rise rate to cure temperature of 200°F (93°C) per minute.

	Coefficient of Thermal Expansion
Below 35°F (2°C)	550 x 10 ⁻⁷ per °F
Above 35°F (2°C)	1360 x 10 ⁻⁷ per °F

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Product Performance
(continued)

Note: The following technical information and data should be considered representative or typical only and should not be used for specification purposes.

14. Effect of Radiation on 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 Bonds

The effect of radiation was determined using a spent fuel source (Particle energy .75 MEV avg.) Dosage 1.0 megarads per hour on 1" wide 1/2" overlap shear specimens cut from 4" x 7" x .064" thick bonded 2024 T3 clad aluminum panels. Bonds were formed with a 350°F (177°C), 60 minutes, 150 psi, 200°F (93°C)/minute temperature rise rate cure cycle. Radiation temperature was 75°F (24°C). Overlap shear tests were run per MMM-A-132 Methods.

Megarad Dosage	Overlap Shear (psi)		
	-67°F (-55°C)	75°F (24°C)	300°F (149°C)
0	3500	4200	2390
100	3120	4200	1620
200	2950	4070	1500
300	2840	3910	1500
500	2340	3020	1500
700	1850	2180	1330
900	1400	1340	870

15. Dynamic Mechanical Properties of Scotch-Weld AF 31 Film Adhesive

The dynamic mechanical properties were obtained using a Maxwell rotating beam apparatus on Scotch-Weld AF 31 film adhesive cured at 350°F (177°C) for 60 minutes under 100 psi pressure with a rise of 10°F per minute.

E^1 = Storage Modulus

$$\text{Tan}\delta = \frac{E^{11}}{E^1}$$

E^{11} = Loss Modulus

E^* = Complex Young's Modulus

$$E^* = \sqrt{(E^1)^2 + (E^{11})^2}$$

Temperature	Frequency Cycles/minute	E^1 , psi	E^{11} , psi	Tan δ	E^* , psi
-67°F (-55°C)	1	498600	34000	.0682	499800
	10	527100	28000	.0531	527800
	100	557200	22850	.0410	557600
	500	557200	19330	.0347	557500
	3700	534400	26780	.0501	535100
77°F (25°C)	1	62660	6900	.1101	63040
	10	72500	11050	.1524	73330
	100	87670	17270	.1969	89350
	500	103200	23150	.2244	105700
	3700	104900	28110	.2679	108600
180°F (82°C)	1	34620	3340	.0964	34790
	10	37950	2400	.0895	38100
	100	42270	2890	.0684	42370
	500	44000	3620	.0821	44190
	3700	46800	4730	.1011	47030
300°F (149°C)	1	29390	2160	.0737	29470
	10	31990	2745	.0858	32110
	100	34360	3300	.0970	34520
	500	36220	2920	.0805	36330
	3700	37280	2820	.0756	37390

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Product Application **Note: Prior to using or handling chemicals or solutions listed below, read and follow supplier's environmental, health and safety information.**

Proper adhesive application is as important as proper bond design and adhesive choice to obtain maximum joint properties. Improper adhesive application techniques can result in partial or complete failure of an assembly.

A thoroughly cleaned, dry, grease-free surface is essential for maximum performance. Cleaning methods which will produce a break-free water film on metal surfaces are generally satisfactory. Surface preparations should be fully evaluated with the adhesive, especially if resistance to specific environments are anticipated.

1. Surface Preparations

A. Suggested Surface Preparation for Aluminum

1. Vapor Degrease – Perchloroethylene condensing vapors for 5-10 minutes.
2. Alkaline Degrease – Oakite 164 solution (9-11 oz./gallon water) at 190°F ± 10°F (88°C ± 5°C) for 10-20 minutes. Rinse immediately in large quantities of cold running water.
3. Acid Etch – Place panels in the following solution for 10 minutes at 150°F ± 5°F (66°C ± 2°C).

Sodium Dichromate (Na ₂ Cr ₂ O ₇ ·2H ₂ O)	4.1 - 4.9 oz./gallon
Sulfuric Acid, 66° Be	38.5 - 41.5 oz./gallon
2024-T3 aluminum (dissolved)	0.2 oz./gallon minimum
Tap Water as needed to balance	
4. Rinse – Rinse panels in clear running tap water.
5. Dry – Air dry 15 minutes; force dry 10 minutes at 150°F ± 10°F (66°C ± 5°C).
6. If primer is to be used, it should be applied within four hours after surface preparation.

B. Suggested Surface Preparation for Stainless Steel (17-7PH-TH [1050])

1. Vapor Hone – #120 Al₂O₃ grit.
2. Vapor Degrease – Perchloroethylene condensing vapors for 5-10 minutes..
3. Acid Etch – Place panels in the following solution for two minutes at 145°F ± 5°F (62°C ± 2°C).

59.9 grams, M.F. Acid (Wyandotte) 170 mls Commercial Concentrated Nitric Acid. The balance of one liter of distilled or ion-free water.
4. Rinse – Rinse immediately in cold running tap water. Remove smut with distilled water-air spray under 90 psi pressure.
5. Acid Etch – Place panels in the following solution at 160°F ± 5°F (71°C ± 2°C).

30 parts by wt. Distilled or Ion-free Water
10 parts by wt. Concentrated Sulfuric Acid
4 parts by wt. Sodium Dichromate
6. Rinse – Rinse in cold tap water. Remove smut with a distilled water-air spray under 90 psi pressure.
7. Dry – Air dry 15 minutes; force dry 10 minutes at 150°F ± 10°F (66°C ± 5°C).
8. If primer is to be used, it should be applied within one hour after surface preparation.

Scotch-Weld™

Structural Adhesive Film

AF 31

Product Application (continued)

C. Suggested Surface Preparation for Titanium

1. Use Scotch-Brite™ Hand Pad to remove all lettering.
2. Clean in Oakite 164 for 10 minutes at 190°F (88°C). Water break necessary.
3. Etch in acid solution for 5 to 7 minutes at 120-135°F (49-57°C).

Acid make-up (to make approximately one gallon)

Distilled Water	2.36 Liters
HNO ₃ (70%)	1.29 Liters
HF (48%)	.13 Liters

4. Rinse in distilled water.
5. Soak in Phosphate-fluoride bath for 60-90 seconds at 90°F (32°C).

Bath make-up (to make approximately one gallon)

NA ₃ PO ₄ 12H ₂ O	162 grams
Potassium Fluoride	41.7 grams
Hydrofluoric Acid (48%)	0.113 liters
Distilled Water	3.57 liters

6. Rinse in distilled water at 180°F (82°C) for 15 minutes. Rinse three times in solution.
7. Rinse in distilled water.
8. Air dry at 190°F (88°C) for 20 minutes.

2. Adhesive Layup

A. Primer Application

1. Advantages

Priming of bonding surfaces offers two distinct advantages: (1) ensures complete wetting of metal surfaces, which normally results in superior environmental properties and (2) simplifies production by protecting cleaned parts until bonding can be completed. 3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 is recommended to use with 3M™ Scotch-Weld™ Structural Adhesive Film AF 31.

2. Application

Scotch-Weld EC-2174 primer may be applied by brushing or flow coating using one or two coats. A camel hair, horsehair or similar type brush is recommended. Dried primer thickness should be 0.0002-0.0006 inches.

3. Primer Dry

- a. Air dry for 60 minutes minimum at 75°F ± 5°F (24°C ± 2°C).
- b. Force dry in an air circulating oven for 60 minutes at 265°F (129°C).

B. Film Application

1. Cut portion of film to be used from roll with protective liner in place.
2. Place film on metal using a separating liner as a protective cover.
3. Roll film into position with a rubber roller, ensuring that no air is trapped between primer and film.
4. Remove protective liner.
5. Assemble parts and cure.

Excess primer and equipment may be cleaned prior to curing, with ketone* type solvent.

***Note:** When using solvents, extinguish all ignition sources and follow manufacturer's precautions and directions for use.

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Product Application
(continued)

3. Cure Cycle

A. General Cure Requirements

The cure requirements for 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 are a function of Scotch-Weld AF 31 film adhesive properties, specific application, equipment available, production limitations and bond properties required. General cure properties of Scotch-Weld AF 31 film adhesive are as follows:

Tack, Flow, Cure Initiation Temperatures

The tack, flow and cure initiation temperatures for Scotch-Weld film adhesive AF 31 are a time-temperature relationship and depend upon the rate of heat input. Normally, Scotch-Weld AF 31 film adhesive will have the following properties:

Tack Temperature:	160°F-180°F (71°C-82°C)
Flow Temperature:	180°F-220°F (82°C-103°C)
Cure Initiation Temp.:	220°F-270°F (104°C-132°C)

B. Cure Pressure

Pressure is required during cure to form the part being bonded and contain any volatiles given off by the adhesive. Cure pressure may be applied in any manner which will insure uniform constant pressure throughout the bond area. *Pressure must be uniformly applied before the curing reaction begins* and maintained until a complete cure has been effected. The pressure required to contain volatiles is dependent on the rate at which bond line temperature is brought to the cure temperature. The bond line temperature rise rate for Scotch-Weld AF 31 film adhesive can be varied from 1°F to 300°F/minute. Rise rate (and cure pressure required) will depend on specific application, cure temperature, bonding equipment, method of heat application, production limitations and bond properties required. Figure I, Page 5, depicts typical pressures required for various bond-line temperature rise rates in platen presses.

C. Cure Temperature

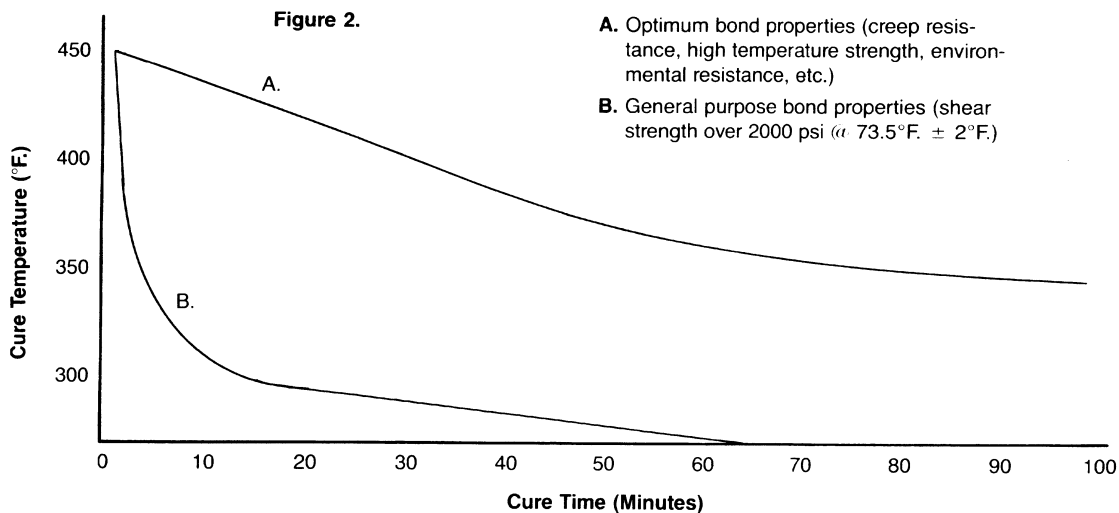
The cure temperature may be varied from 250°F (121°C) to 450°F (232°C), depending upon the materials bonded, equipment available and bond properties desired. The desired pressure must be applied before the glue line reaches 160°F (71°C). The film will soften as temperature is increased to 180-210°F (82-99°C) and will wet the surface to which it has been applied. A chemical cure will be initiated between 220-270°F (104-132°C) and a low strength gel formed. Continued heating chemically converts the adhesive into a high strength, solvent-resistant bond. Scotch-Weld AF 31 film adhesive will change color only slightly upon application of heat. Edges of the bond that are exposed to air will change from yellow to rusty brown.

D. Cure Time

Cure time depends on the cure temperature used, methods of heat application, production limitations and bond properties required. Since no two bonding operations are exactly alike, it is suggested that a few simple experiments be conducted, varying both temperature and cure time to determine optimum conditions for the particular application. Figure 2, Page 14, is a guide from which an approximate cure cycle can be taken for various cure times or temperatures.

Scotch-Weld™ Structural Adhesive Film AF 31

Product Application (continued)



E. Suggested Cure Cycle

The following press cure cycle is suggested to obtain dense glue lines and maximum strengths:

1. Apply a pressure of 45 psi prior to reaching a bond-line temperature of 150°F (66°C) and maintain throughout the press cure cycle.
2. Raise the bond line temperature from ambient to 350°F (177°C) at a rate of 10°F per minute.
3. Cure for 60 minutes at 350°F (177°C).
4. Cool to below 200°F (93°C) bond-line temperature prior to release of pressure. (In lab tests, panels have been removed at 350°F (177°C), with no adverse effects).

Storage and Handling

Storage at 40°F \pm 5°F (4°C \pm 2°C) is suggested for 3M™ Scotch-Weld™ Structural Adhesive Film AF 31 and 3M™ Scotch-Weld™ Structural Adhesive Primer EC-2174 to obtain maximum shelf life. Rotate stock on a “first in-first out” basis.

Caution: Scotch-Weld AF 31 film adhesive and Scotch-Weld EC-2174 primer should be permitted to thoroughly warm to room temperature (75°F \pm 5°F [24°C \pm 2°C]) before being used to prevent moisture condensation.

Shelf Life

When stored at 40°F (4°C) or below Scotch-Weld AF 31 has a shelf life of 6 months from date of shipment from 3M.

Scotch-Weld™ Structural Adhesive Film AF 31

**Precautionary
Information**

Refer to Product Label and Material Safety Data Sheet for health and safety information before using this product. For additional health and safety information, call 1-800-364-3577 or (651) 737-6501.

**For Additional
Information**

To request additional product information or to arrange for sales assistance, call toll free 1-800-235-2376 or fax 1-800-435-3082 or 651-737-2171. For U.S. Military, call 1-866-556-5714 or fax 651-737-4380. If outside of the U.S., please contact your nearest 3M office.

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