Scotch-Weld™
Structural Adhesive Film
AF 42 • AF 46

Technical Data **Issue No. 3**

Introduction

3M™ Scotch-Weld™ Structural Adhesive Films AF 42 and AF 46 are unsupported, thermosetting film adhesives designed for the structural bonding of metals and glass.

Advantages

- Excellent adhesion to metal and glass
- High shear, peel, and cleavage strengths over a wide temperature range
- High degree of film clarity when in contact with a solid surface
- Flexible cure cycles
- Lightweight and easy to handle
- AF 46 is 1 mil thick version of AF 42
- AF 3542 is 3.5 mil thick AF 42
- Relatively low bonding pressures may be used
- Low tack
- Low flow

Description

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

Product		AF 42	AF 3542	AF 42	AF 42	AF 46
Weight	lb/ft^2	.020 ± .005	.021 ± .003	.040 ± .005	.040 ± .005	.006 ± .0015
	g/m^2	98 ± 24.5	103 ± 14.7	196 ± 24.5	196 ± 24.5	29.3 ± 7.3
Thickness	mils	3	3.5	6	6	1
	micrometers	76.2	88.9	152.4	152.4	25.4
Color		Clear	Clear	Clear	Black	Clear

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I. Electrical Properties

Dissipation Factor at 73.4°F (23°C)					
	100Hz	**1kHz**	**10kHz**	**100kHz**	**1MHz**
AF 42 (3 mil)	0.196	0.111	0.089	0.073	0.061
Dielectric Constant at 73.4°F (23°C)					
	100Hz	**1kHz**	**10kHz**	**100kHz**	**1MHz**
AF 42 (3 mil)	—	6.1	5.3	4.7	4.3

	AF 42
Dielectric Strength (ASTM D149)	1430 Volts/mil
Volume Resistivity (ASTM D257)	2.6×10^{12} ohm/cm
Electrical Corrosion to Copper (ASTM D3482)	Pass
Arc Resistance	64 sec
Surface Resistivity (500 Volts - DC)	4.1×10^{13} ohm/square

II. Thermal Properties

	AF 42
Glass Transition Temperature (by heating DSC with heating rate of 20°C/min (36°F/min). Second heat values given.	66.2°F (19°C)
Thermal Conductivity (btu-ft/ft²-hr °F) ASTM C177	.124 at 44°C
Thermal Coefficient of Expansion (in/in/°C) (by TMA at 5°C/min.) Second heat values given.	117×10^{-6} (0°C to 80°C)
Hardness - Shore D (ASTM D2240)	76
Elongation (approximate) (ASTM D882 using 0.5" x 0.10" [12.7 mm x 0.254 mm] samples)	90%

Environmental Exposure (ASTM D638)	**Initial**		**30 Days**		**90 Days**	
	Ultimate Tensile	**Modulus**	**Ultimate Tensile**	**Modulus**	**Ultimate Tensile**	**Modulus**
75°F Tap Water	5.95	76.0	5.15	83.0	3.99	73.0
120°F 100% R.H.	5.95	76.0	5.49	82.0	4.75	68.0
75°F Ethyl Gasoline	5.95	76.0	5.34	117.0	5.28	93.0
	*All values given in thousands of pounds per square inch (ksi)					
24°C Tap Water	4.1	52.4	3.5	57.2	2.7	50.3
49°C 100% R.H.	4.1	52.4	3.8	56.5	3.3	46.9
24°C Ethyl Gasoline	4.1	52.4	3.7	80.6	3.6	64.1
	*All values given in Megapascals (MPa)					

III. Glass to Steel Bonds

A. Tensile and Cleavage

The following data shows typical values obtained with Scotch-Weld AF 42 on glass to steel bonds. Tensile values were measured on test plugs such as described in ASTM D1205 bonded to tempered safety glass.

The surface of the test plugs and the glass were cleaned as outlined under the section on Product Application. A platen press with platen temperatures of 375°F (191°C) was used to produce a resultant bond line temperature of 350°F (177°C) with 50 psi (345 kPa) for 40 minutes. After removal from the press and cooling to ambient temperature, the bonds were conditioned as indicated and then pulled in an Instron Tensile Tester at a jaw separation of 0.05 inches/minute (1.27 mm/minute).

Test	Test Temp	Average Values	
		psi	MPa
1. Tensile, Control	-40°F (-40°C) 75°F (24°C) 200°F (93°C)	9200 4000 1710	63.4 27.6 11.8
2. Tensile, 7 days Exposure to 100% R.H. at 120°F	75°F (24°C)	4900	33.8
3. Tensile, after exposure to 5 cycles 200°F suddenly plunged into ice water at 32°F	75°F (24°C)	4100	28.2
4. Cleavage, Control	-40°F (-40°C) 75°F (24°C) 200°F (93°C)	1300 720 400	9.0 5.0 2.8

B. Overlap Shear

The following data shows typical values obtained with Scotch-Weld AF 42 on glass to steel bonds in overlap shear. Values were measured on 1" (2.54 mm) wide strips of 20 gauge CRLCOH steel bonded to tempered safety glass. The surface of the steel and the glass were cleaned as outlined under the section on Product Application. A platen press set at the indicated temperature was used to bond one strip on each end of the glass.

Test	Cure	Test Temp	Average Values	
			psi	MPa
1. Overlap Shear, Control	40 min. @ 350°F (177°C), 50 psi (345 kPa)	75°F (24°C)	2400	16.5
2. Overlap Shear, Quick Cures	30 sec. @ 450°F (232°C), 50 psi (345 kPa) 60 sec. @ 450°F (232°C), 50 psi (345 kPa)	75°F (24°C) 75°F (24°C)	2760 3060	19.0 21.1
3. Overlap Shear, 7 days exposure to 100% R.H. at 120°F (49°C)	40 min. @ 350°F (177°C), 50 psi (345 kPa)	75°F (24°C)	2700	18.6
4. Overlap Shear, after exposure to 5 cycles, 200°F (93°C) suddenly plunged into ice water @ 32°F (0°C)	40 min. @ 350°F (177°C), 50 psi (345 kPa)	75°F (24°C)	2540	17.5

III. Glass to Steel Bonds ***(continued)***

C. **Ultra-Violet Exposure**

A 4" x 8" (101.6 mm x 203.2 mm) 20 gauge CRLCOH steel panel was polished with a 3M™ Scotch-Brite™ Scour Pad and bonded to tempered safety glass using Scotch-Weld AF 42. The assembly was bonded in a platen press @ 350°F (177°C) with 50 psi (345 kPa) for 40 minutes. A high degree of film clarity was apparent and good resolution of the detail on the metal was noted.It was exposed for 120 hours to an S-1 Sunlamp in accordance with ASTM D1148. No noticeable change was observed in the exposed areas.

IV. Aluminum to Aluminum Bonds

The following product performance data has been obtained in the 3M Laboratory under the conditions specified. General application methods and bonding procedure are described later. All data reported in this section was developed under the following cure cycle:

Cure Cycle – 50 psi (345 kPa) bonding pressure applied by a platen press at 10°F per minute bond temperature rise from 80°F to 350°F, with 60 ± 1 minute at 350°F ± 2°F (5.6°C per minute bond temperature rise from 27°C to 177°C, with 60 ± 1 minute at 177°C ± 1.1°C).

A. **Overlap Shear Bonds**

The following data shows typical values obtained with Scotch-Weld AF 42 in aluminum overlap panels. Overlap shear properties were measured on 1" x 1/2" overlap specimens cut from .063" x 4" x 7" (1.6 mm x 101.6 mm x 177.8 mm) 2024-T3 clad aluminum panels bonded with AF 42 film adhesive. (Specimens were tested per MIL-A-5090D or ASTM D 1002).

Original properties:

Product	AF 42		AF 46	
	Average		Average	
Test Temp	psi	MPa	psi	MPa
-67°F (-55°C	7295	50.3	5000	34.5
75°F (24°C)	5548	38.2	4000	27.6
180°F (82°C)	4535	31.2	2000	13.8
250°F (121°)	3010	20.7		

IV. Aluminum to Aluminum Bonds *(continued)*

B. **T-Peel Bonds**

The following data shows typical values obtained with Scotch-Weld AF 42 in T-Peel. T-Peel bonds consist of 1" x 6" (25.4 mm x 152.4 mm) bonded areas of 2024-T3 clad 1" x 8" x .032" (25.4 mm x 203.2 mm x 0.8 mm) specimens with one layer of AF 42 film adhesive. Each metal skin of the T-Peel panels was pulled at a 90° angle to the bond line or 180° in relation to themselves. The jaw separation rate was 20" (508 mm) per minute.

Original Properties:

Product	AF 42 (3 mil)		AF 46 (1 mil)	
	Average		Average	
Test Temp	piw	N/25 mm	piw	N/25 mm
-67°F (-55°C	19	84.6	8	35.6
75°F (24°C)	75	333.8	40	178.0
180°F (82°C)	75	333.8	15	66.8

C. **Cure Properties**

Overlap Shear at 75°F (24°C)						
AF 42 (3 mil)	350°F (177°C) Cure			450°F (232°C) Cure		
	Time	psi	MPa	Time	psi	MPa
	60 min	5822	40.1	5 min	6068	41.8
	30 min	5234	36.1	4 min	6006	41.4
	20 min	5654	39.0	3 min	5434	37.4
	10 min	6872	47.3	2 min	5533	38.1
	5 min	726	5.0	1 min	5290	36.4
				30 sec	3293	22.7

Product Application

Proper adhesive application is an 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.

Scotch-Weld AF 42 and AF 46 will give excellent properties under many application conditions. The Product Performance data reported in the previous section was developed using the following recommended procedures. Variations from these recommended procedures should be fully evaluated to insure bond properties sufficient to meet the requirements of user's particular assembly.

I. Surface Preparation

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

A. **Aluminum**

1. **Alkaline Degrease** – Oakite #164 solution (9-11 oz/gallon of water) at 190°F ± 10°F (87.8°C ± 5.6°C) for 15 ± 5 minutes. Rinse immediately in large quantities of cold running water.
2. **Optimized FPL Etch Solution (1 liter):**

Material	**Amount**
Distilled Water	700 ml plus balance of liter (see below)
Sodium Dichromate	28 to 67.3 grams
Sulfuric Acid	287.9 to 310.0 grams
Aluminum Chips	1.5 grams/liter of mixed solution

To prepare 1 liter of this solution, dissolve sodium dichromate in 700 ml of distilled water. Add sulfuric acid and mix well. Add additional distilled water to fill to 1 liter. Heat mixed solution to 150 to 160°F (66 to 71°C). Dissolve 1.5 grams of 2024 bare aluminum chips per liter of mixed solution. Gentle agitation will help aluminum dissolve in about 24 hours.

To FPL etch panels, place them in the above solution at 150 to 160°F (66 to 71°C) for 12 to 15 minutes.

Note: Review and follow MSDS and other safety recommendations provided by chemical manufacturer prior to preparation of this etch solution.

3. **Rinse** – Rinse panels in clear distilled, deionized or tap running water.
4. **Dry** – Air dry 15 minutes; force dry 10 minutes minimum at 140°F (60°C) maximum.

B. **Steel**

1. Solvent wipe with alcohol, acetone, MEK.*
2. Polishing – Rub gently with 3M™ Scotch-Brite™ Scour Pad, if desired.
3. Wipe with solvent again.

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

Product Application ***(continued)***

C. **Glass**

1. Acid Clean – Place in sulfuric acid-sodium dichromate solution as described in section under Aluminum Preparation.
2. Rinse – Rinse panels in clear running water.
3. Dry – Air dry 15 minutes; force dry 10 minutes minimum at 140°F (60°C) maximum.

II. Adhesive Layup

Care should be taken to avoid contaminating adhesive and cleaned metal or glass by any substance which will hinder wetting action of film.

Film Application

1. Cut portion of film to be used from roll with protective liner in place.
2. Place film on metal using the separating liner as a protective cover.
3. Remove protective liner.
4. Assemble parts and cure.

III. Standard Cure Cycle

The following cure cycle envelope is recommended to obtain dense glue lines:

Press Cure Cycle

1. Apply a pressure of 50 psi (345 kPa) 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 330-350°F (166-177°C) at a rate of 10°F (5.6°C) per minute.
3. Cure for 30-60 minutes at 330-350°F (166-177°C).
4. Cool to below 200°F (93°C) bond line temperature prior to release of pressure.

IV. Effect of Cure Cycle Variations on Performance

In addition to the standard cure cycle, Scotch-Weld AF 42 exhibits broad capabilities to accommodate many types of existing Structural Adhesive Bonding Equipment and still produce excellent strength bonds. However, temperatures of 330°F (166°C) are minimum cure conditions.

Storage Stability

Storage at 40°F (4°C) or lower is recommended for Scotch-Weld AF 42 and AF 46 to obtain maximum shelf life.

3M Standard Shelf Life for Scotch-Weld AF 42 is 15 months from date of shipment from 3M when stored at 40°F (4°C) or below.

3M Standard Shelf Life for Scotch-Weld AF 46 is 6 months from date of shipment from 3M when stored at 40°F (4°C) or below.

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Precautionary Information

Refer to Product Label and Material Safety Data Sheet for health and safety information before using this product.

For Additional Information

To request additional product information or to arrange for sales assistance, call toll free (800) 235-2376. Our fax number is (417) 869-5219. Address correspondence to: 3M Aerospace Central, 3211 E. Chestnut Expressway, Springfield, MO 65802.

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This Adhesives Division product was manufactured under a 3M quality system registered to ISO 9002 standards.

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