3M

Scotch-Weld™

Structural Adhesive Films

AF 6 • AF 10 • AF 13

Technical Data **July, 2001**

Introduction

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10, AF 13 are unsupported, thermosetting adhesives in film form developed for the structural bonding of metals. These products are especially suggested for use where high peel strengths are required. Some of the advantages of these films are:

- Good flexibility and shear strength at service temperatures from -67°F to 180°F (-55°C to 82°C).
- Easy application in a dry film which can be pressure, heat or solvent tacked into position.
- Excellent retention of strength after aging in many environments.
- Qualification to military specification MMM-A-132 Type 1, Class 2, (Scotch-Weld AF 6 only).

Description

	Scotch-Weld AF 6	Scotch-Weld AF 10	Scotch-Weld AF 13
Color:	Yellow	Yellow	Yellow
Form:	Flexible unsupported film, protected by a suitable liner		
	0.006 in. 0.152 mm	0.010 in. 0.254 mm	0.003 in. 0.076 mm
Caliper:	0.025 in. 0.635 mm	0.05 in. 1.25 mm	0.015 in. 0.381 mm
Weight:	0.04 lb/ft^2 196.13 g/m^2	0.06 lb/ft^2 294.19 g/m^2	0.018 lb/ft^2 88.26 g/m^2
Volatile Content:	Approximately 10%		

Product Performance

3M™ Scotch-Weld™ Structural Adhesive Film AF 6

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

The following is a summary of typical test results for Scotch-Weld AF 6 when bonded specimens were prepared and tested in accordance with Military Specification MMM-A-132 Type 1, Class 2.

Tensile Shear

Test Condition	Film AF 6 Unprimed
1. Normal temperature 75°F (24°C)	3400 psi (23.4 MPa)
2. 10 minutes at 180°F (82°C)	1600 psi (11.0 MPa)
3. 10 minutes at -67°F (-55°C)	3000 psi (20.7 MPa)
4. Normal temperature 75°F (24°C) after 30 days salt water spray	3200 psi (22.0 MPa)
5. Normal temperature 75°F (24°C) after 30 days – 120°F (49°C) and 95-100% RH	3300 psi (22.7 MPa)
6. Normal temperature 75°F (24°C) after 30 days immersion in tap water	3700 psi (25.5 MPa)
7. Normal temperature 75°F (24°C) after 7 days immersion in JP-4 fuel	3300 psi (22.7 MPa)
8. Normal temperature 75°F (24°C) after 7 days immersion in anti-icing fluid	3100 psi (21.4 MPa)
9. Normal temperature 75°F (24°C) after 7 days immersion in hydraulic oil	3600 psi (24.8 MPa)
10. Normal temperature 75°F (24°C) after 7 days immersion in type III hydrocarbon fluid	3200 psi (22.0 MPa)

Creep Rupture

11. Normal temperature 75°F (24°C) for 192 hours at 1600 psi	0.0072 in. (0.1829 mm)
12. 180°F (82°C) for 192 hours at 800 psi	0.0065 in. (0.1651 mm)

Fatigue

13. Normal temperature 75°F (24°C) 750 psi at 10^6 cycles	No failures

Other Tests

14. Tensile shear 75°F (24°C) blister detection	3200 psi (22.0 MPa)	
15. Tensile shear Scotch-Weld AF 6/3M™ Scotch-Weld™ Structural Adhesive Primer EC-1290 10%	**Test Temp.**	**Test Results**
	-67F (-55°C)	2400 psi (16.5 MPa)
	75°F (24°C)	3400 psi (23.4 MPa)
	180°F (82°C)	1600 psi (11.0 MPa)
16. T-Peel Scotch-Weld AF 6/Scotch-Weld EC-1290 10%	**Test Temp.**	**Test Results**
	-67F (-55°C)	7 piw (31.2 N/25mm)
	75°F (24°C)	60 piw (267 N/25mm)
	180°F (82°C)	25 piw (111 N/25mm)
17. Scotch-Weld AF 6 unprimed overlap shear strength on chromic anodized aluminum	**Test Temp.**	**Test Results**
	75°F (24°C)	3800 psi (26.2 MPa)
	180°F (82°C)	1700 psi (11.7 MPa)
	250°F (121°C)	1200 psi (8.3 MPa)
	300°F (149°C)	1000 psi (6.9 MPa)
	350°F (177°C)	900 psi (6.2 MPa)
	400°F (204°C)	800 psi (5.5 Mpa)
Cure Cycle: 60 minutes at 350°F, 90 psi, 10°F/minute rise. (60 minutes at 177°C, 0.62 MPa, 5.6°C/minute rise.)		
18. **Thermal Conductivity:** 0.062 BTU/HR. SQ. FT./°F;/FT		

Product Performance ***(continued)***

3M™ Scotch-Weld™ Structural Adhesive Film AF 10

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

The following is a summary of typical test results for Scotch-Weld AF 10 when bonded specimens were prepared and tested in accordance with Military Specification MMM-A-132 Type 1, Class 2.

Tensile Shear

Test Condition	Film AF 10 Unprimed	Film AF 10 EC-1290
1. Normal temperature 75°F (24°C)	3200 psi (22.0 MPa)	3500 psi (24.1 MPa)
2. 10 minutes at 180°F (82°C)	1600 psi (11.0 MPa)	1600 psi (11.0 MPa)
3. 10 minutes at -67°F (-55°C)	3000 psi (20.7 MPa)	2400 psi (16.5 MPa)
4. Normal temperature 75°F (24°C) after 30 days salt water spray	4000 psi (27.6 MPa)	4000 psi (27.6 MPa)
5. Normal temperature 75°F (24°C) after 30 days at 120°F (49°C) and 95-100% RH	4000 psi (27.6 MPa)	4000 psi (27.6 MPa)
6. Normal temperature 75°F (24°C) after 30 days immersion in tap water	4300 psi (29.6 MPa)	4300 psi (29.6 MPa)
7. Normal temperature 75°F (24°C) after 7 days immersion in JP-4 fuel	4000 psi (27.6 MPa)	3800 psi (26.2 MPa)
8. Normal temperature 75°F (24°C) after 7 days immersion in anti-icing fluid	4200 psi (28.9 MPa)	4100 psi (28.2 MPa)
9. Normal temperature 75°F (24°C) after 7 days immersion in hydraulic oil	4300 psi (29.6 MPa)	4000 psi (27.6 MPa)
10. Normal temperature 75°F (24°C) after 7 days immersion in type III hydrocarbon fluid	4000 psi (27.6 MPa)	4000 psi (27.6 MPa)

Fatigue

11. Normal temperature 75°F (24°C) 750 psi at 10^6 cycles	No failures	Not tested

Other Tests

12. Normal temperature 75°F (24°C) T-Peel	60 piw (267 N/25mm)	60 piw (267 N/25mm)
13. Youngs modulus or tensile modulus @ 75°F (24°C): 20,000-40,000 psi (138-276 MPa)		
14. Shear modulus @ 75°F (24°C): 7,000-13,000 psi (48.2-89.6 MPa)		
15. Thermal conductivity: 0.062 BTU/HR/Ft^2/°F/FT		
16. Tensile and Elongation – Specimens prepared by curing eight thicknesses in a platen press at 325°F, 60 minutes, 150 psi, 10°F/minute rise rate (163°C, 60 minutes, 1.0 MPa, 5.6°C/minute rise rate). Dumbbell specimens size: 3/4 in. x 8 in. (19.05 mm x 203 mm). Elongation 30-100% Tensile 2700-4300 psi (18.6-29.6 MPa)		

Product Performance *(continued)*

3M™ Scotch-Weld™ Structural Adhesive Film AF 13

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

The following is a summary of typical test results for Scotch-Weld AF 13 when bonded specimens were prepared and tested in accordance with Military Specification MMM-A-132 Type 1, Class 2.

Test Condition		
Tensile Shear	**Test Temp.**	**Test Results**
	-67F (-55°C)	2800 psi (19.3 MPa)
	75°F (24°C)	2800 psi (19.3 MPa)
	180°F (82°C)	1600 psi (8.6 MPa)
T-Peel Strength	**Test Temp.**	**Test Results**
	75°F (24°C)	35 piw (156 N/25mm)
Thermal Conductivity: 0.062 BTU/HR/FT^2/°F/FT		

Application

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

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.

Adhesive performance data reported in an earlier section (Test Results) was developed using the following suggested procedures. Variations from these procedures should be fully evaluated to ensure bond properties sufficient to meet the requirements of your particular assembly.

Surface Preparation

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

Aluminum (optimized FPL etch – 3M Company)

1. Vapor – Degrease – Perchloroethylene condensing vapors for 5-10 minutes.
2. Alkaline Degrease – Oakite 164 solution 9-11 oz./gallon water at 190 ± 10°F (87 ± 6°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 ± 3°C).

Sodium Dichromate ($Na_2Cr_2O_7$•$2H_2O$)	4.1-4.9 oz./gallon (32.04-38.29 ml/liter)
Sulfuric Acid, 66° Be	38.5-41.5 oz./gallon (300.8-324.3 ml/liter)
2024T-3 aluminum (dissolved)	0.2 oz./gallon 1.56 ml/liter)minimum
Tap Water	Balance

*Review and follow component suppliers environmental, health and safety recommendations prior to preparing this etch solution. Caution: Use adequate respiratory, eye and skin protection when using etch solutions.

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 ± 6°C).
6. It is advisable to coat freshly cleaned surfaces with adhesive within 4 hours after surface preparation.

Primer Application

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

Priming of adherends offers two distinct advantages: a) ensures complete wetting of metal surfaces which normally results in superior environmental properties, and b) simplified production by protecting clean parts until bonding can be completed. 3M™ Scotch-Weld™ Structural Adhesive Primer EC-1290 has been applied successfully by flow coating, brushing and spraying.

Application: See the Scotch-Weld EC-1290 data sheet for the suggested primer applications.

Primer Dry: A primer dry coat which will result in a solvent-free coating is generally satisfactory. Drying temperatures above 300°F (149°C) should be avoided since a primer overcure will hinder wetting action of the adhesive film to the primer.

The following chart lists suggested dry cycles for Scotch-Weld EC-1290.

	Air Dry	Force Dry	Force Dry Temp.
EC-1290	60 min.	30 min.	180°F (82°C)
	60 min.	30 min.	240°F (116°C)

The primer surface, after cooling to ambient temperature, is ready for adhesive bonding. The primed surface should be protected from contamination introduced by dust, finger prints, oil, etc.

Film Application

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

Care should be taken to avoid contaminating adhesive and cleaned or primed aluminum by an substance which will hinder wetting action of the adhesive.

a. Cut portion of film to be used from roll with protective liner in place.

b. Place film on metal using the liner as a protective cover.

c. Roll film into position with a rubber roller insuring that no air is trapped between primer and film.

d. Film can be heat or solvent tacked (Scotch-Weld EC-1290 primer or ketone) into position.

e. Remove protective liner.

f. Assembly parts and cure.

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

***Note:** When using solvents for cleanup, extinguish all sources of ignition in the area

Cure Cycle

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

General Cure Requirements: Time, temperature and pressure determine final bond properties. These properties may also be effected by the type of curing equipment used for each specific application. In general, cure properties are as follows:

Tack, Flow and Cure Initiation Temperatures

Tack, flow and cure initiation temperatures are a time temperature relationship which depend upon the rate of heat input. Normally the properties are as follows:

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

Cure Pressure: Pressure is required during cure to form the part being bonded and to contain any volatiles given off by the adhesive. Cure pressure may be applied in any manner which will ensure uniform constant pressure throughout the bond area. Pressure must be uniformly applied before the curing reaction begins and maintained until a complete set 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 can be varied from 1°F to 300°F/minute (0.6°C to 167°C/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.

Cure Temperature: Cure temperature may be varied from 275°F to 400°F (135°C to 204°C), depending upon the materials being bonded, equipment available and bond properties desired. The desired pressure must be applied before the glue line reaches 160°F (71°C). Film will soften as temperature is increased to 180°F-220°F (82°C-104°C) and will wet the surface to which it has been applied. A chemical cure will be initiated between 220°F and 270°F (104°C and 132°C) and a low strength gel formed. Continued heating chemically, converts the adhesive into a high-strength, solvent-resistant bond.

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.

Suggested Cure Cycle: The following press cure cycle is suggested to obtain dense glue lines and was used to obtain the strengths reported in the test results section.

1. Place bonds in press and apply 150 psi (1.03 MPa) of pressure.
2. Temperature rise rate 10°F/minute from ambient to 350°F (6°C/minute from ambient to 177°C).
3. Cure for 60 minutes at 350°F (177°C).
4. Bonds can be removed from the press at 350°F (177°C).

Storage

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

Storage at 40°F ± 5°F (4°C ± 3°C) is suggested for adhesive film to obtain maximum shelf life. Rotate stock on a "first-in – first out" basis.

Caution: Adhesive film should be permitted to thoroughly warm to room temperature 75°F ± 5°F (24°C ± 3°C) before being used to prevent moisture condensation.

Shipping Information

3M™ Scotch-Weld™ Structural Adhesive Films AF 6, AF 10 and AF 13

National Motor Freight Classification:	Adhesive, NOI

The following information is provided to help you determine the proper packaging, labeling and marking in accordance with hazardous materials regulations.

D.O.T. Proper Shipping Name:	Not regulated
D.O.T. Hazard Classification:	Not regulated
Technical Name of Hazardous Ingredient:	Not applicable
Flash Point:	None

3M™ Scotch-Weld™ Structural Adhesive Primer EC-1290-10%

National Motor Freight Classification:	Paint and related material

The following information is provided to help you determine the proper packaging, labeling and marking in accordance with hazardous materials regulations.

D.O.T. Proper Shipping Name:	Paint, Liquid
D.O.T. Hazard Classification:	Flammable Liquid UN1263
Technical Name of Hazardous Ingredient:	Ethyl alcohol
Flash Point:	55°F (13°C) (C.C.)

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 (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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ISO 9002

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

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