Scotch-Weld™
Structural Adhesive Film
AF 32

Technical Data **Issue No. 3**

Introduction

3M™ Scotch-Weld™ Structural Adhesive AF 32 is an unsupported, thermosetting film adhesive designed for structural bonding especially where high peel strengths or vibration damping is required.

Scotch-Weld AF 32 film adhesive offers the following advantages:

- Exceptionally high peel strength.
- Good flexibility and shear strength.
- Low tack, dry film. Can be pressure, heat or solvent tacked in position.
- Excellent retention of strength after aging in many environments.
- Excellent adhesion to aluminum, titanium, stainless steel, cadmium, nickel, brass, phenolic, and epoxy (must use high bonding pressure).
- Extremely low flow.

General

The technical information and data contained in this technical data sheet should be considered representative or typical only and should not be used for specification purposes.

Description

Form:	Flexible unsupported film, protected by a suitable liner.
Color:	Yellowish Brown
Nominal Caliper:	10 mils
Weight:	.055 ± .005 lbs/ft^2 (270 ± 24 g/m^2)
Volatile Content:	2.5% (2-4 gm sample cured 1 hr. @ 350°F (182°C)
Availability:	Maximum width is 20 inches. Standard roll is 36 yds. long
Shrinkage:	5% maximum (24 hrs @ 75°F ± 5°F [24°C ± 2.8°C]) in horizontal position.

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Product Performance

MMM-A-132 Type I Class 2 Test Data

The following is a summary and a list of average test results for the structural adhesive system Scotch-Weld AF 32 with 3M™ Scotch-Weld™ Structural Adhesive Primer EC-1660 when bonded specimens were prepared and tested in accordance with Military Specification MMM-A-132B, Type 1 Class 2.

Test Condition	MMM-A-132B Type 1 Class 2 Requirement		Scotch-Weld AF 32 / Scotch-Weld EC-1660 Test Results	
A. Tensile Shear	**psi**	**MPa**	**psi**	**MPa**
1. Normal Temperature, 75°F (24°C)	3500	24.1	4085	28.1
2. 10 minutes @ 180°F (82°C)	2000	13.8	2286	15.8
3. 10 minutes @ -67°F (-55°C)	3500	24.1	5086	35.0
4. Normal Temperature, 75°F (24°C) after 30 days immersion in Salt Water Spray	N/A	N/A	3818	26.3
5. Normal Temperature, 75°F (24°C) after 30 days immersion @ 120°F (49°C) and 95-100% Relative Humidity	3250	22.4	3825	26.4
6. Normal Temperature, 75°F (24°C) after 30 days immersion in Tap Water	N/A	N/A	3898	26.9
7. Normal Temperature, 75°F (24°C) after 7 days immersion in JP-4 Fuel (MIL-T-5624)	3250	22.4	3631	25.0
8. Normal Temperature, 75°F (24°C) after 7 days immersion in Anti-icing Fluid (MIL-F-5566)	N/A	N/A	3798	26.2
9. Normal Temperature, 75°F (24°C) after 7 days immersion in Hydraulic Oil	3250	22.4	4238	29.2
10. Normal Temperature, 75°F (24°C) after 7 days immersion in Type III Hydrocarbon Fluid (MIL-S-3136)	N/A	N/A	3643	25.1

B. Creep Rupture		
11. Normal Temperature, 75°F (24°C) 192 hrs @ 1600 psi (11.0 MPa)	0.015" maximum deformation	0.012 inches
12. 180°F, 192 hrs @ 800 psi (82°C, 192 hrs @ 5.5 MPa)	0.015" maximum deformation	0.014 inches

C. Fatigue		
13. Normal Temperature, 75°F (24°C) 750 psi (5.2 MPa) @ 10^6 cycles	No glue line failure	No glue line failure

D. Other Tests				
14. Normal Temperature, 75°F (24°C) T-Peel	15 piw		58 piw	
15. Tensile Shear, 75°F (24°C) Blister Detection	3250 psi	22.4 MPa	3858 psi	26.6 MPa

Miscellaneous Data Scotch-Weld AF 32

A. Scotch-Weld AF 32 Coefficient of Thermal Expansion

Below 5°F (-15°C)	860 x 10^{-7} in/in°F
Above 5°F (-15°C)	1700 x 10^{-7} in/in°F

B. Scotch-Weld AF 32 Modulus of Elasticity

-67°F	-55°C	234,000 psi	1612.3 MPa
75°F	24°C	3,900 psi	26.9 MPa
180°F	82°C	1,630 psi	11.2 MPa
300°F	149°C	1,415 psi	9.7 MPa

C. Scotch-Weld AF 32 Ultimate Tensile Stress

-67°F	-55°C	9320 psi	64.2 MPa
75°F	24°C	2290 psi	15.8 MPa
180°F	82°C	763 psi	5.3 MPa
250°F	121°C	606 psi	4.2 MPa

D. Scotch-Weld AF 32/3M™ Scotch-Weld™ Structural Adhesive Primer EC-1660 Shear Strength on Aluminum

-67°F	-55°C	5087 psi	35.0 MPa
75°F	24°C	3835 psi	26.4 MPa
180°F	82°C	2287 psi	15.8 MPa
250°F	121°C	1480 psi	10.2 MPa
350°F	177°C	970 psi	6.7 MPa
400°F	204°C	830 psi	5.7 MPa
500°F	260°C	390 psi	2.7 MPa

E. Scotch-Weld AF 32/Scotch-Weld EC-1660 Metal to Metal Climbing Drum Peel (ASTM D 1781)

75°F	24°C	168 $\frac{\text{in•lbs}}{\text{in}}$	747 mN/m

Metal = 2024-T3 clad aluminum.
Surface Prep = FPL etch.
Primer = 3M EC-1660, 75°F air dry for 30 minutes + 225°F oven dry for 30 minutes.
Adhesive Cure = 300°F for 60 minutes, 75 psi autoclave pressure, 10°F/min rise rate.

F. Scotch-Weld AF 32/Scotch-Weld EC-1660 T-Peel Strength (ASTM D 1876)

T-Peel bonds consist of two Scotch-Weld EC-1660 primed 8" x 8" x .020" 2024-T3 clad panels bonded together with a 6" x 8" section of film. This panel was then cut into 1" x 8" T-peel specimens which were peeled at a 90° angle to the bond line with a jaw separation rate of 20 inches/minute. Cure cycles were as indicated.

Plate Press Cure: 350°F (177°C), 60 minutes, 150 psi, 10°F/minute temperature rise rate.

-67°F	-55°C	10 piw
75°F	24°C	60 piw
180°F	82°C	25 piw
250°F	121°C	15 piw

Miscellaneous Data Scotch-Weld AF 32 *(continued)*

G. Scotch-Weld AF 32/3M™ Scotch-Weld™ Structural Adhesive Primer EC-1660 Overlap Shear After Aging for 1, 2 and 3 Years in South Florida

		Control		1 Year		2 Years		3 Years	
-67°F	-55°C	4491 psi	30.9 MPa	4560 psi	31.4 MPa	4900 psi	33.8 MPa	4800 psi	33.1 MPa
75°F	24°C	4216 psi	29.6 MPa	3880 psi	26.7 MPa	4350 psi	30.0 MPa	3930 psi	27.1 MPa
180°F	82°C	2186 psi	15.1 MPa	2250 psi	15.5 MPa	2510 psi	17.3 MPa	2340 psi	16.1 MPa
250°F	121°C	1336 psi	9.2 MPa	1320 psi	9.1 MPa	1550 psi	10.7 MPa	1520 psi	10.5 MPa
300°F	149°C	1036 psi	7.1 MPa	1120 psi	7.7 MPa	1140 psi	7.9 MPa	940 psi	6.5 MPa

Cured 60 minutes @ 350°F (177°C), 100 psi, 10°F/minute rise rate.

H. Scotch-Weld AF 32 Radiation Exposure Data

Radiation Temperature: 75°F (24°C)
Test: ASTM D 1002 Overlap Shear

Test Temperature	-67°F (-55°C)	75°F (24°C)	250°F (121°C)
Average Strength	4578 psi (31.6 MPa)	4783 psi (33.0 MPa)	1150 psi (7.9 MPa)

		Strength Retention (%)		
Megarad Dosage	**Failure**	**-67°F (-55°C)**	**75°F (24°C)**	**250°F (121°C)**
0	Cohesive	100	100	100
100	Cohesive	88	100	85
200	Cohesive	83	100	77
300	Cohesive	80	93	47
500	Adhesion	73	83	47
700	Adhesion	56	74	47
900	Adhesion	30	38	47

Metal = 2024-T3 clad aluminum.
Surface Prep = FPL etch.
Primer = None.
Adhesive Cure = 350°F (177°C) for 60 minutes, 150 psi press pressure, hot entry.

These overlap shear data imply that Scotch-Weld AF 32 nitrile phenolic film adhesive can withstand about 300 megarad dosage level at 75°F (24°C) with satisfactory strength retention. The ability to withstand service at elevated temperature up to 250°F (121°C) is lost at high dosages.

I. Scotch-Weld AF 32/Scotch-Weld EC-1660 Storage Life Testing

The following data indicates that the uncured Scotch-Weld AF 32/Scotch-Weld EC-1660 system does not degrade with storage at 75°F ± 5°F (24°C ± 2.2°C) for 3 months.

A cure cycle of 100 psi bonding pressure applied by a platen press and a 200°F/minute bond line temperature rise from 80°F to 350°F (26°C to 182°C) with 120 ± 1 minute at 350°F ± 2°F (182°C ± 1.1°C) was used. 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.

Test	Test Temperature		Unaged		Average Aged 3 months 75°F ± 5°F (24°C ± 2.2°C)		Type Failure
Shear Strength	75°F ± 2°F	(24°C ± 1.1°C)	3825 psi	26.4 MPa	4191 psi	28.9 MPa	Cohesive
Shear Strength	180°F ± 2°F	(82°C ± 1.1°C)	2287 psi	15.8 MPa	2222 psi	15.3 MPa	Cohesive
Shear Strength (After 30 day Salt Spray FED STD 151)	75°F ± 2°F	(24°C ± 1.1°C)	3818 psi	26.3 MPa	4020 psi	27.7 MPa	Cohesive

Product Application

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.

Scotch-Weld AF 32 performance data reported in this data sheet was developed using the following suggested procedures. Variations from these procedures should be fully evaluated to insure bond properties sufficient to meet the requirements of your particular application.

Surface Preparations

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.

Suggested Cleaning Procedure for Aluminum

1. Alkaline Degrease – Oakite 164 solution (9-11 oz/gallon water) at 190°F ± 10°F (88°C ± 5.6°C) for 10-20 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 66 to 71°C (150 to 160°F). 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.
3. Rinse – Rinse panels in clear running water.
4. Dry – Air dry 15 minutes
   Force dry 10 minutes (minimum) at 140°F (60°C) maximum.
5. It is advisable to coat the freshly cleaned surfaces with primer within 4 hours after surface preparation.

Note: Read and follow safety and handling recommendations provided by the suppliers of these materials prior to preparing this solution.

Primer Application

Advantages

Priming of bonding surfaces offer two distinct advantages: (1) Priming insures complete wetting of metal surfaces which normally results in superior environmental and low temperature properties, and (2) Priming simplifies production by protecting cleaned parts until bonding can be completed. 3M™ Scotch-Weld™ Structural Adhesive Primer EC-1660 has been applied successfully by flow coating, brushing and spraying.

Caution: 3M™ Scotch-Weld™ Structural Adhesive Primer EC-1660 is flammable. See the Scotch-Weld EC-1660 Technical Data Sheet for additional information.

Primer Dry

A primer dry 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 the wetting action of the adhesive film to the primer. Suggested Scotch-Weld EC-1660 Dry Cycle:

Air Dry	30 minutes at 75°F ± 5°C (24°C ± 2.8°C).
Force Dry	Circulating air oven with part above 200°F (93°C) but not exceeding 250°F (121°C) for 30 minutes.

Film Application

1. Cut portion of film to be used from roll with protective liner in place.
2. Place film on substrate using the liner as a protective cover.

Product Application *(continued)*

3. Roll film into position with a rubber roller insuring that no air is trapped between primer and film.
4. Remove protective liner.
5. Assemble parts and cure.

Cleanup

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

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

Cure Cycle

General Cure Requirements

Time, temperature and pressure determine the final bond properties and may be effected by the type of curing equipment used for each specific application. In general, the cure properties of Scotch-Weld AF 32 are as follows:

Tack, Flow and Cure Initiation Temperatures

The tack, flow and cure initiation temperatures for Scotch-Weld AF 32 are a time temperature relationship and depend upon the rate of heat input. Normally, Scotch-Weld AF 32 has the following properties:

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

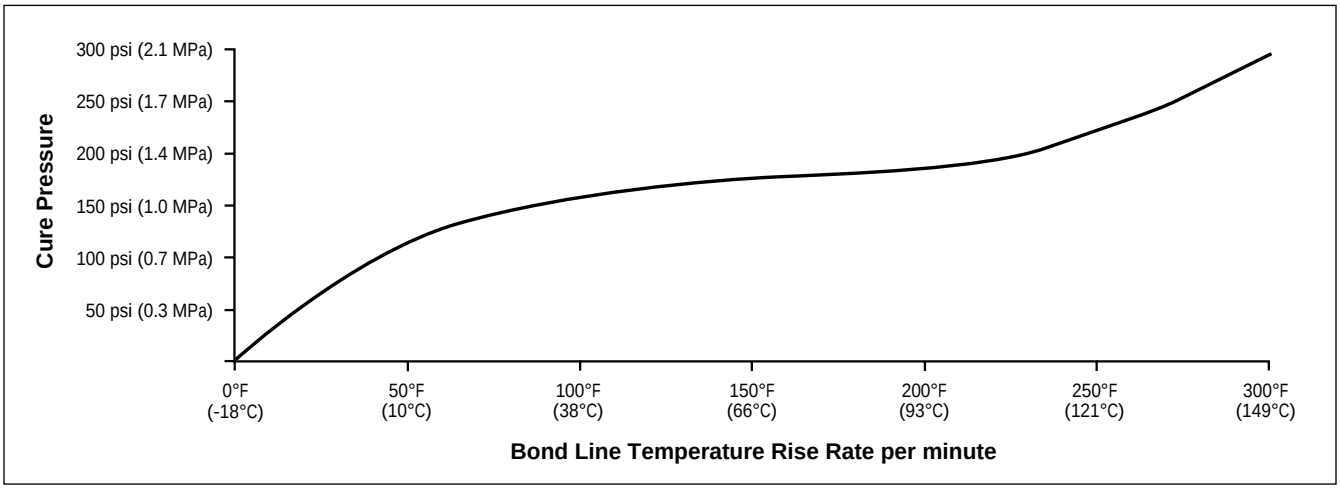
Cure Pressure

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 matter 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 set has been effected.* (i.e., the bond line temperature has reached approximately 300°F (149°C). After this point is reached, the cure may be completed without pressure if the hot strength of the adhesive is sufficient to maintain contact of the parts being bonded.

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 32 can be varied from 1°F to 300°F/minute (0.6°C to 149°C/minute). Rise rate (and cure pressure required) will depend on application, cure temperature, bonding equipment, method of heat application, production limitations and bond properties required.

Figure I depicts typical pressures required for various bond line temperature rise rates in platen presses.

CURE PRESSURE vs. BOND LINE TEMPERATURE RISE RATE IN PLATEN PRESS



Product Application *(continued)*

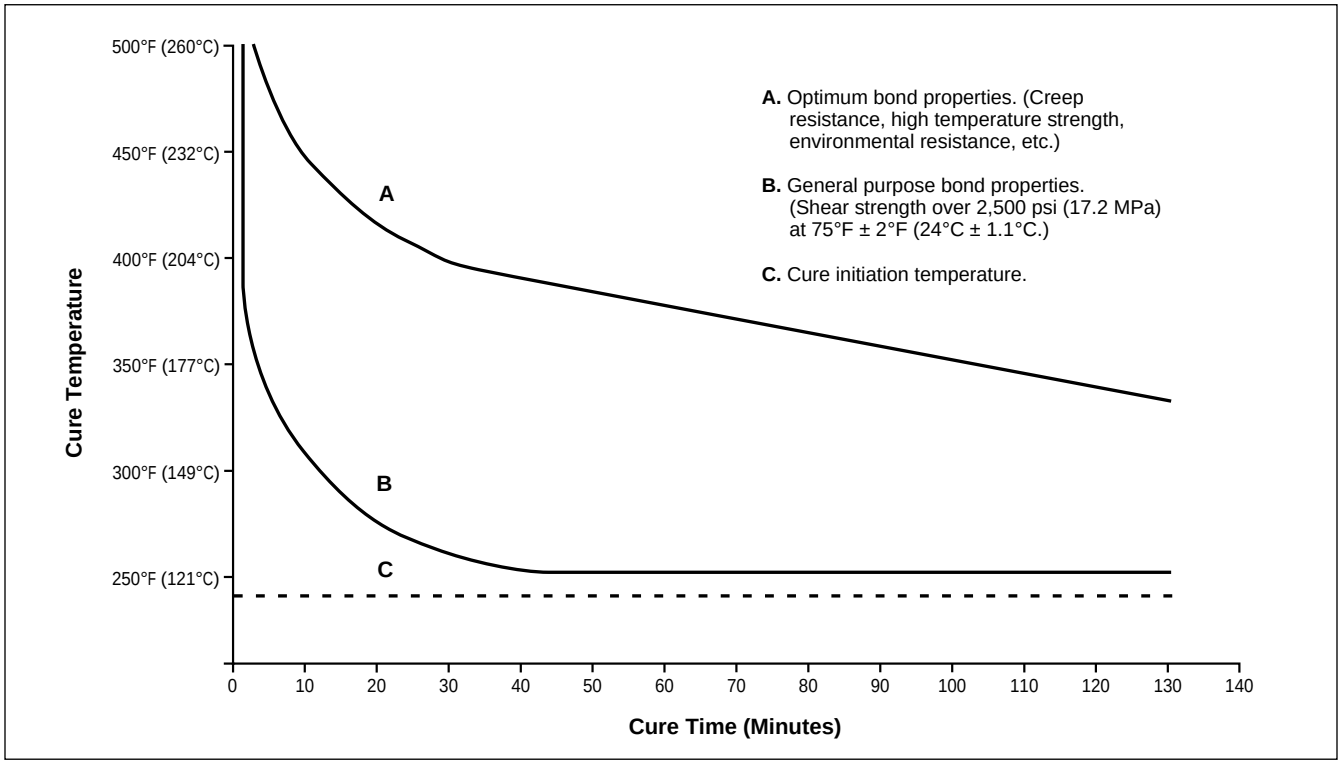
Cure Temperature

The cure temperature may be varied from 250°F to 450°F (121°C to 232°C), depending on 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). The film will soften as temperature is increased to 180°F-210°F (82°C-99°C) and will wet the surface to which it has been applied. A chemical cure will be initiated between 200°F and 270°F (93°C and 132°C) and a low strength gel formed. Continued heating chemically converts this gel into a high strength, solvent resistant bond. Scotch-Weld AF 32 will change color only slightly upon application of heat. Edges of the bond which are exposed to air will change from yellow to rusty brown.

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 II is a guide from which an approximate cure cycle can be taken for various cure times or temperatures.

Figure II



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 Data section unless otherwise stated.

1. Apply a pressure of 100 psi (.7 MPa) 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-12°F (5.6°C-6.7°C) per minute.
3. Cure for 120 minutes at 350°F (177°C).
4. Cool to below 200°F (93°C) bond line temperature prior to release of pressure. (In laboratory tests, panels have been removed at 350°F (177°C) with no adverse effects.

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Storage and Handling

Storage at 40°F (4°C) or below is suggested for Scotch-Weld AF 32 (film) and Scotch-Weld EC-1660 (primer) to obtain maximum shelf life. Rotate stock on a "first in-first out" basis.

Caution: Scotch-Weld AF 32 should be permitted to warm to room temperature 75°F ± 5°F (24°C ± 2.8°C) before being used to prevent moisture condensation.

Shelf Life

When stored at 40°F (4°C) or below, the 3M Standard shelf life of Scotch-Weld AF 32 is 6 months from date of shipment from 3M.

Precautionary Information

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

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