

3M Scotch-Weld™ Epoxy Adhesive EC-1386

Technical Data

August, 2015

Product Description

3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 is a one-part, 100% solids, thermosetting liquid adhesive.

Features

- Exceptionally high strength properties at service temperatures from -70 to 250°F (-57 to 121°C).
- Higher impact, peel and bond strength properties than normally attainable in many epoxy based adhesives.
- Little or no volatile by-products given off during cure. This unique property makes Scotch-Weld EC-1386 particularly useful for bonding many impervious surfaces and enables curing under little or no pressure.
- Only pressure sufficient to ensure contact between mating surfaces is required.
- Easy application by knife coating, trowel, roller coating, pump and high pressure injection methods.
- Excellent retention of strength after aging in many environments.

Typical Uncured Properties

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

Color:	Light Cream
Solvent:	None
Base:	Modified Epoxy Resin
Net Weight:	9.4 - 9.8 lbs./gallon
Viscosity:	75,000 - 175,000 cps (Brookfield RVF No. 7 Spindle @ 4 rpm)

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Handling/Application Information

Directions for Use

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.

3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 can give excellent properties under many application conditions. The product performance data reported in the Test Results section which follows here developed using the following suggested procedures. Variations from these procedures should be fully evaluated to ensure bond properties sufficient to meet the requirements of the user's particular assembly.

Surface Preparation

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. Vapor Degrease – 3M™ Novec™ Fluid 72DE or 72DA (or equivalent vapor degreasing product) condensing vapors for 5-10 minutes.
2. Alkaline Degrease – Oakite 164 solution (9-11 oz./gallon of water) at $190 \pm 10^\circ\text{F}$ ($87 \pm 5^\circ\text{C}$) 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 $150 \pm 5^\circ\text{F}$ ($66 \pm 5^\circ\text{C}$).

Sodium Dichromate ($\text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$)	4.1 - 4.9 oz./gallon Sulfuric Acid,
66° Be	38.5 - 41.5 oz./gallon 2024T-3
aluminum (dissolved)	0.2 oz./gallon minimum Tap
Water as needed to balance	

***Note:** When using etch solutions, be sure to follow the chemical manufacturer's precautions and directions for use when handling such chemicals.

4. Rinse – Rinse panels in clear running water.
5. Dry – Air dry 15 minutes.
Force dry 10 minutes at $150 \pm 10^\circ\text{F}$ ($66 \pm 5^\circ\text{C}$).
6. It is advisable to coat the freshly cleaned surfaces with primer within 4 hours after surface preparation.

Adhesive Layup

Care should be taken to avoid contaminating adhesive and cleaned aluminum by any substance which will hinder wetting action.

Adhesive Application

Note: Appropriate application equipment can enhance adhesive performance. The user is responsible for evaluating application equipment in light of the user's particular purpose and method of application.

3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 can be applied by a spatula, knife coat, notched trowel, or by extruding into places. Standard equipment is available which allows pumping directly from five-gallon pails. When extruded through a Pyles-Semco cartridge (3/32" orifice 70 psi line pressure), the delivery rate at 72°F (22°C) is approximately 20 grams/minute. A lower viscosity for ease of application can be obtained by warming Scotch-Weld EC-1386 to $100 - 120^\circ\text{F}$ ($38 - 49^\circ\text{C}$). **Note:** 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 may start to thicken if held at 120°F (49°C) for more than 4 hours.

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Handling/Application Information (*continued*)

Important: Care should be taken not to incorporate air into the adhesive during application. Included air can expand during cure which can cause a porous and weakened bond.

Bond Line Thickness

Optimum performance is obtained with a 2-5 mil cured bond line thickness.

Clean-up

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

***Note:** When using solvents extinguish all ignition source and follow manufacturer's precautions and directions for use for handling such materials.

Cure Cycle

General Cure Requirements

Time, temperature and pressure determine the final bond properties. These properties may also be affected by the type of curing equipment used for the specific application. In general, the cure properties of 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 are as follows.

Flow and Cure Initiation Temperatures

Normal flow and cure initiation temperatures for 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 are as follows: Flow Temperature: 60°F (16°C)
Cure Initiation Temperature: 325-335°F (163-168°C)

Cure Pressure

The pressure needed during the cure of 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 is typically that required to keep parts in alignment and to overcome distortion and thermal expansion in the adherends.

Cure Temperature

The cure temperature may be varied from 330 to 500°F (166 to 260°C) depending on the materials being bonded, equipment available and bond properties desired. 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 will wet the surface to which it has been applied. Heating at temperatures above 325°F (163°C) will chemically convert the adhesive into a high strength solvent-resistant bond.

The following is a guide to the effect of bondline temperature during cure on 75°F (24°C) overlap shear strengths:

<u>Bond Line Temperature</u>	<u>Time at Temperature</u>	<u>75°F (24°C) Shear Strength</u>
350°F (177°C)	40-60 minutes	5500 psi
375°F (191°C)	20-30 minutes	5500 psi
400°F (204°C)	15-20 minutes	5300 psi
425°F (218°C)	10-15 minutes	4300 psi
450°F (232°C)	5-7 minutes	3500 psi

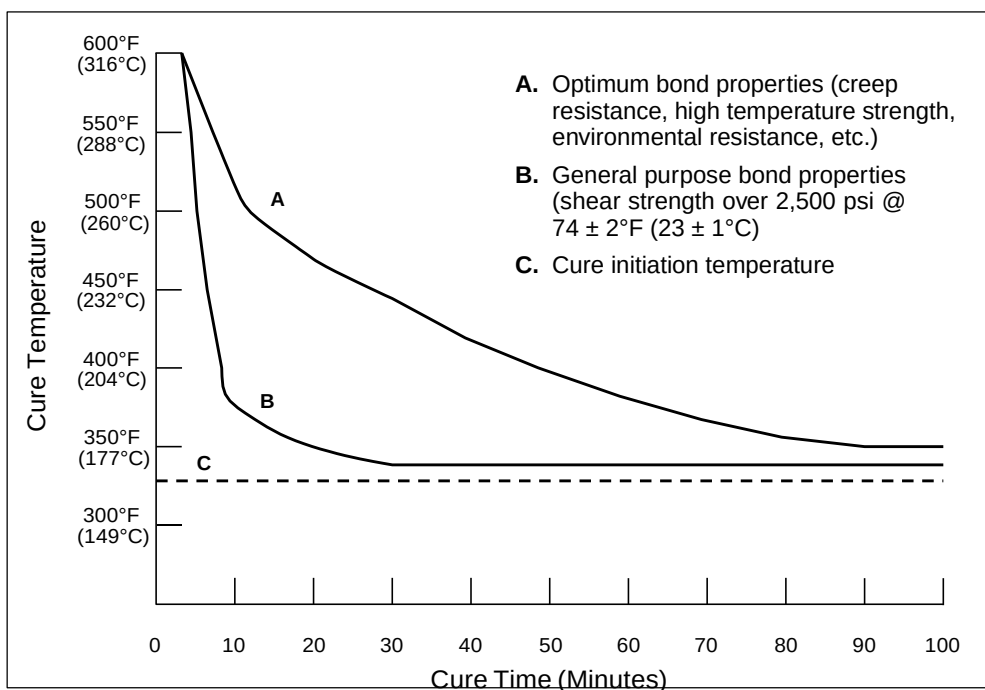
The time required to reach the specified bond line temperature is not included. Time lag for the parts to reach temperature will depend on relative mass and efficiency of the heat source. Temperature of the bond line should be determined experimentally by thermocouple measurements. Cure temperatures in excess of 400°F (204°C) yield useful, but lower than optimum strengths. At these temperatures the indicated time cycles should not be exceeded.

**Handling/Curing
Information (continued)**

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

Figure 1 – Curing Temperature vs Curing Time for 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386



B. 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. Apply a pressure of 25 psi prior to reaching a bond line temperature of 150°F (66°C) and maintain throughout the press cure cycle. (Pressure was used to ensure flat test panels.)
2. Raise the bond line temperature from ambient to 350°F (177°C) at a rate of 10 ± 2°F (-12 ± 1°C).
3. Cure for 60 ± 1 minutes at 350 ± 2°F (177 ± 1°C).
4. Cool to below 200°F (93°C) bond line temperature prior to release to pressure. (In 3M laboratory tests, panels have been removed at 350°F (177°C) with no adverse effects.)

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Typical Adhesive Performance Characteristics

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

1. Aluminum to Aluminum Bonds

The following data show typical values obtained with 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 in aluminum bonds. All properties were measured on 1 in. wide 1/2 in. overlap specimens cut from .063 in. thick 4 in. x 7 in. bonded panels of 2043-T3 clad aluminum except as noted. Tests conducted according to MMM-A-132 or MIL-A-8623 methods.

A. Original Properties

Shear, Creep, Fatigue, Bend, Impact and Cleavage Strengths

Test	Test Temperature	Minimum MMM-A-132 Requirement	Minimum MIL-A-8623 Type III Requirement	Average	Type Failure
Shear Strength	-67 ± 2°F (-55 ± 1°C) 74 ± 2°F (23 ± 1°C) 180 ± 2°F (82 ± 1°C) 250 ± 2°F (121 ± 1°C)	2500 psi 2500 psi 1250 psi None	2500 psi 2500 psi 1500 psi None	3000 psi 5500 psi 4600 psi 2800 psi	Cohesive Cohesive Cohesive Cohesive
Creep Rupture	74 ± 2°F (23 ± 1°C)	.015 in max. creep (1600 psi load)		.0007 in.	No Failure
	180 ± 2°F (82 ± 1°C)	.015 in. max. creep (800 psi load)		.0008 in.	No Failure
Creep Rupture	74 ± 2°F (23 ± 1°C)		No Creep (1600 psi load)		No Creep
	180 ± 2°F (82 ± 1°C)		No Creep (300 psi load)		No Creep
Fatigue (3/8 in. overlap)	74 ± 2°F (23 ± 1°C)	10 ⁷ cycles (600 psi load)	10 ⁷ cycles (600 psi load)	Over 10 ⁷ cycles	No Failure
Bend Strength	74 ± 2°F (23 ± 1°C)	None	None	200 lbs.	Cohesive
Impact Strength (FED STD- MMM-A-175)	74 ± 2°F (23 ± 1°C)	None	5 ft./lbs.	6.3 ft./lbs.	Cohesive
Cleavage Strength (ASTM D 1062-49T)	74 ± 2°F (23 ± 1°C)	None	1500 lbs.	3730 lbs.	Cohesive

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Typical Adhesive Performance Characteristics (continued)

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

Storage Life Testing

The following is an indication of the aging stability at $75 \pm 5^\circ\text{F}$ ($24 \pm 2^\circ\text{C}$) of uncured 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 as measured by overlap shear strength and work life per MIL-A-8623 Type III with a cure cycle of 25 psi bonding pressure applied by a platen press, a $10 \pm 2^\circ\text{F}$ ($-12 \pm 1^\circ\text{C}$) / minute bond line temperature rise from 80 to 350°F (26 to 177°C) with 60 ± 1 minutes at $350 \pm 2^\circ\text{F}$ ($177 \pm 1^\circ\text{C}$).

Test	Test Temperature	Minimum MIL-A-8623 Type III Requirement	Average	Range	Type Failure
Shear Strength (Control)	$74 \pm 2^\circ\text{F}$ ($23 \pm 1^\circ\text{C}$) $180 \pm 2^\circ\text{F}$ ($82 \pm 1^\circ\text{C}$)	2500 psi 1500 psi	4184 psi 3996 psi	3700-4900 psi 3640-4590 psi	Cohesive Cohesive
Shear Strength (1 year $75 \pm 5^\circ\text{F}$) [$24 \pm 2^\circ\text{C}$]	$74 \pm 2^\circ\text{F}$ ($23 \pm 1^\circ\text{C}$) $180 \pm 2^\circ\text{F}$ ($82 \pm 1^\circ\text{C}$)	2500 psi 1500 psi	4260 psi 3496 psi	3690-4480 psi 3000-4900 psi	Cohesive Cohesive
Work Life		1 year	Satisfactory handling properties after 18 months		

Etched Aluminum Overlap Shear Strength at Elevated Temperatures

<u>Test Temperatures</u>	<u>Test Results</u>
250°F (121°C)	2620 psi
300°F (149°C)	650 psi
350°F (177°C)	405 psi
Cure Cycle: 60 minutes @ 350°F (177°C), 25 psi	

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Typical Adhesive Performance Characteristics (continued)

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

Etched Aluminum Overlap Shear Strength After Environmental Aging

Environment	Environment Temperature	Immersion Time	Minimum MIL-A-8623 Type III Requirement	Average	Type Failure
Tap Water	75 ± 5°F (24 ± 2°C)	30 days		5700 psi	Cohesive
Tap Water	120 ± 2°F (49 ± 1°C)	30 days		4744 psi	Cohesive
Tap Water	150 ± 2°F (66 ± 1°C)	30 days		4252 psi	Cohesive
Tap Water	180 ± 2°F (82 ± 1°C)	30 days		2760 psi	Cohesive
28.6% Ethylene Glycol 71.4% Tap Water Blend	180 ± 2°F (82 ± 1°C)	30 days		3650 psi	Cohesive
.8% (Rust Inhibitor) 99.2% Tap Water	180 ± 2°F (82 ± 1°C)	30 days		1950 psi	Cohesive
26% Methyl Alcohol 74% Tap Water	180 ± 2°F (82 ± 1°C)	30 days		2440 psi	Cohesive
1.2% (Radiator Conditioner) 98.9% Tap Water	180 ± 2°F (82 ± 1°C)	30 days		1390 psi	Cohesive
Salt Spray (FED STD TT-P-141 Method 606.1)	92 ± 97°F (33 ± 36°C)	250 hours	2000 psi	4220 psi	Cohesive
Accelerated Weathering (FED STD TT-P-141 Method 615.2)	145 ± 5°F (63 ± 2°C)	60 hours	2000 psi	4234 psi	Cohesive
Type III Hydrocarbon Fluid (MIL-H-3136)	75 ± 5°F (24 ± 2°C)	7 days	2500 psi	4208 psi	Cohesive

Etched Aluminum T-Peel Strength

T-Peel bonds consist of 1 in. x 7 in. bonded areas made from two 1 in. x 8 in. x .020 in. clad 2024 T3 aluminum panels. 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 was applied in a thin coat (.003 in. - .005 in. thick) on both surfaces. T-Peel panels peeled at a 90° angle to the bond line with a jaw separation rate of 2 in. per minute.

<u>Test Temperature</u>	<u>Average</u>	<u>Type Failure</u>
74 ± 2°F (23 ± 1°C)	10 lbs. per inch width	Cohesive

Cure Cycle: 1 hour @ 350°F (177°C), 25 psi, 10°F (-12°C) / minute rise

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Typical Adhesive Performance Characteristics (continued)

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

Etched Aluminum Climbing Drum Peel Strength

Climbing Drum Peel bonds consist of 3 in. x 8 in. bonded areas made from one 3 in. x 10 in. x .020 clad 2024 T3 aluminum panel bonded to one 3 in. x 8 in. .064 in. clad 2024 T3 aluminum panel. 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 was applied in a thin coat (.003 in. - .005 in. thick) on both surfaces. Climbing Drum Peel strength was measured per MIL-A-25463 (Para. 4.6.1-4.6.3) methods. This method subtracts the force required to bend the 20 mil face sheet and the force required to lift the drum from the peel (+:) value.

$$+:(\text{lb.-in.}/1 \text{ in. width}) = \frac{\text{Machine Load (lbs./3 in. width)} - 33}{6}$$

<u>Test Temperature</u>	<u>+:(lb.-in./in. width)</u>
74 ± 2°F (23 ± 1°C)	30

Cure Cycle: 1 hour @ 350°F (177°C), 25 psi, 10°F (-4°C) / minute rise

Overlap Shear Strength on Anodized Aluminum

<u>Test Temperature</u>	<u>Test Results</u>
75°F (24°C)	3898 psi

Cure Cycle: 1 hour @ 350°F (177°C), 1 psi

Tensile Strength

<u>Test Temperature</u>	<u>Tensile</u>
-40°F (-40°C)	8293 psi
75°F (24°C)	10189 psi
180°F (82°C)	3178 psi

Cure Cycle: 1 hour @ 350°F (177°C)

Coefficient of Thermal Expansion

4.65 x 10⁻⁵/°F between -40 and 112°F (-40 and 44°C)
4.96 x 10⁻⁵/°F between 112 and 240°F (44 and 116°C)

Cure Cycle: 4½ hours @ 280°F (138°C) plus 1 hour @ 350°F (177°C)

Impact Strength

Impact strength was measured according to ASTM D 950-54 (Izod Impact Tester - 30 lbs. wt.) methods using 1/2 in. x 1/2 in. square specimens of 2024 T3 aluminum. Scotch-Weld EC-1386 was applied in a thin coat (.003 in. x .005 in. thick) on both surfaces.

<u>Test Temperature</u>	<u>Average</u>	<u>Type Failure</u>
75°F ± 5°F (24 ± 2°C)	45 ft./lbs.	Cohesive

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Typical Adhesive Performance Characteristics (continued)

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

Electrical Properties

1. Dielectric Strength – In excess of 400 volts/mil
2. Dielectric Constant –

73°F (23°C)	5.11
140°F (60°C)	5.28
194°F (90°C)	5.55
221°F (105°C)	6.07
248°F (120°C)	7.35
275°F (135°C)	8.37
3. Dissipation Factor –

73°F (23°C)	.057
140°F (60°C)	.059
194°F (90°C)	.101
221°F (105°C)	.129
248°F (120°C)	.138
275°F (135°C)	.183

Etched Aluminum Overlap Shear Strength Quick Cure Data

<u>Cure Temperature</u>	<u>Cure Time at Temperature</u>	<u>Test Results</u>
350°F (177°C)	10 minutes	4322 psi
400°F (204°C)	5 minutes	4663 psi
425°F (218°C)	1 minute	3325 psi
450°F (232°C)	1 minute	4260 psi
500°F (260°C)	10 seconds	2208 psi
550°F (288°C)	3 seconds	2025 psi
600°F (316°C)	2 seconds	2620 psi

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Storage and Shelf Life

Store 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 at 40°F (4°C) or lower for optimum storage life. 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 should be permitted to thoroughly warm to room temperature before opening in order to prevent moisture condensation of the adhesive surface. Rotate stock on a “first in-first out” basis. 3M™ Scotch-Weld™ Epoxy Adhesive EC-1386 has a shelf life of 15 months from date of shipment when stored at 40°F (4°C) and 24 months from date of shipment when stored at 0°F (-17°C) or below in original, unopened container.

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.

Technical Information

The technical information, recommendations and other statements contained in this document are based upon tests or experience that 3M believes are reliable, but the accuracy or completeness of such information is not guaranteed.

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