


CONDUCTIVE ADHESIVES

**THERMALLY
CONDUCTIVE**

**ELECTRICALLY
CONDUCTIVE**



**Optimal Cure
Temperature of
only 65 °C**



MC Chemicals[®]

Serving you since 1955

mgchemicals.com

WHO IS MG CHEMICALS

MG Chemicals is a manufacturer and wholesaler of chemical products for the electronics industry. Our chemical products include dusters and circuit coolers, electronic cleaners, flux removers, contact cleaners, protective coatings, epoxies, adhesives, RTV silicones, lubricants, EMI/RFI shielding coatings, thermal management products, prototyping supplies, solders, and more. We also distribute related non-chemical products such as wipes, swabs, brushes, desoldering braids, and copper clad boards.

We specialize in the formulation and production of protective coatings for electronics: Conformal Coatings, Epoxy Potting & Encapsulating Compounds, and EMI/RFI Shielding Paints.

MG SERVICE

MG Chemicals recognizes that setting up production comes with various challenges. Our service team offers a wide variety of experience in material production, equipment, and technical issues you may encounter during planning, pilot studies, and production runs. To overcome these challenges, we offer professional services.

As a service, MG Chemicals can

- Provide advice on equipment and materials
- Assist with setup and troubleshooting
- Review your proposed application processes
- Suggest ways of optimizing and customizing processes to best meet your needs
- Offer training on the proper use of our epoxy products.

Quality Assurance

Since 1955, MG Chemicals has provided the North American electronics industry with a full line of high performance chemicals and accessories. The MG Chemicals manufacturing facility operates under the ISO 9001 Quality System Standard. All products undergo MG Chemicals' design process including the testing and analysis of each product to maximize performance, user safety, environmental safeguards and market desirability.

Customer Care

Customer care is what separates MG Chemicals from the rest. Our commitment to all of these principles focus on getting you the quality product and support you deserve.

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ELECTRICALLY CONDUCTIVE ADHESIVES

SILVER CONDUCTIVE EPOXY - HIGH CONDUCTIVITY (10 MINS. WORKING TIME)

DESCRIPTION

The 8331 Silver Conductive Epoxy Adhesive: Moderate Cure / High Conductivity is an economical electronic epoxy with good electrical and thermal conductivities. This adhesive bonds very well to a variety of surfaces. It has a convenient 1-to-1 ratio, a workable ten minutes pot life, and a moderate curing rate. It achieves an operational level in five hours at room temperature. With heat, the 8331 cures in less than 15 minutes and maximizes its conductivity. The cured adhesive bonds very well to most substrates used in electronic assemblies; resists thermal and mechanical shocks; and provides the low resistivity needed for many operating conditions. The 8331 epoxy adhesive is great for forming conductivity seals, bonding, and repairing of electronic devices.

APPLICATIONS & USAGES

The 8331 epoxy has many uses. It is primarily used as a solder replacement for bonding heat-sensitive electronic components. It allows for quick cold soldering repairs, and is effective at bonding heat sinks to other components and PCBs. It also provides excellent EMI/RFI shielding, and is very effective at filling in seams between metal plates.

Its primary applications are repair and assembly of electronics in microelectronics and optoelectronics. It is used in the automobile, aerospace, marine communication, instrumentation, and industrial control equipment industries.

BENEFITS AND FEATURES

- **Economical**
- **Good 0.017 Ω·cm electrical resistivity and 0.90 W/(m·K) thermal conductivity**
- **Adheres to most electronic substrates**
- **Stores and ships at room temperature**—no freezing or dry ice required
- **Very long shelf life of at least two years**—even when stored at room temperature
- **Easy 1:1 mix ratio**
- **Strong water and chemical resistance** to brine, acids, bases, and aliphatic hydrocarbons

APPLICATIONS & USAGES

| Properties | Value |
|-----------------------------|--------|
| Working Life ^{a)} | 10 min |
| Shelf Life | ≥3 y |
| Service Cure @22 °C [72 °F] | 5 h |
| Full Cure @22 °C [72 °F] | 24 h |
| Full Cure @65 °C [149 °F] | 15 min |
| Full Cure @90 °C [194 °F] | 12 min |
| Full Cure @125 °C [257 °F] | 7 min |
| Full Cure @150 °C [302 °F] | 5 min |

a) Cure and life values 5 g and room temperature unless stated otherwise.

TEMPERATURE SERVICE RANGE

| Properties | Value |
|--------------------------------------|-------------------------------------|
| Constant Service Temperature | -55 °C to 150 °C [-67 to 302 °F] |
| Storage Temperature of Unmixed Parts | 16 to 27 °C [60 to 80 °F] |

PRODUCT AVAILABILITY

| Cat. No. | Form | Net Volume | | Net Weight | | Shipping Weight | |
|------------|-------|------------|-----------|------------|---------|-----------------------|----------------------|
| 8331-14G | Paste | 6 mL | 0.2 fl oz | 14 g | 0.47 oz | 0.22 kg ^{a)} | 0.5 lb ^{a)} |
| 8331-50ML | Paste | 53 mL | 1.8 fl oz | 128 g | 4.12 oz | 0.17 kg | 0.4 lb |
| 8331-200ML | Paste | 200 mL | 6.8 fl oz | 482 g | 1.06 lb | 0.58 kg | 1.3 lb |

a) Pack of 10 syringes

SPECIFICATIONS

| Physical Properties | Method | Value ^{a)} |
|---|---------------------|---|
| Color | Visual | Silver Grey |
| Density (at 26 °C) | | 2.44 g/cm ³ |
| Hardness | (Shore D durometer) | 70D |
| Tensile Strength | ASTM D 638 | 6.28 N/mm ² [911 lb/in ²] |
| Elongation | " | 0.3% |
| Compression Strength | ASTM D 695 | 13 N/mm ² [1 900 lb/in ²] |
| Shear Strength | ASTM D 732 | 1.6 N/mm ² [230 lb/in ²] |
| Lap Shear Strength (Aluminum 5052) | ASTM D 1002 | 8.0 N/mm ² [1 200 lb/in ²] |
| Izod Impact ^{b)} | ASTM D 256 | 1.7 kJ/m ² [0.80 ft-lb/in] |
| Flexural Strength | ASTM D 790 | 17 N/mm ² [2 500 lb/in ²] |
| Water Absorption | ASTM D 570 | 0.04% |
| Outgassing (Total Mass Loss) @ 24 h | ASTM E 595 | 6.27% |
| Water Vapor Release (WVR) | " | 0.09% |
| Collectible Volatile Condensable Material | " | 0.16% |
| Solderable | | No |

| Electrical Properties | Method | Value |
|----------------------------------|----------------------------------|--------------|
| Volume Resistivity ^{c)} | Method 5011.5 in MIL-STD-883H | 0.0174 Ω.cm |

| Thermal Properties | Method | Value |
|--|---------------|----------------|
| Thermal Conductivity @25 °C | ASTM E 1461 | 0.903 W/(m.K) |
| @50 °C | " | 0.893 W/(m.K) |
| @100 °C | " | 0.813 W/(m.K) |
| Glass Transition Temperature (T _g) | ASTM D 3418 | 50 °C [122 °F] |
| Heat Deflection Temperature | ASTM D 648 | 48 °C |
| CTE ^{d)} prior T _g | ASTM E 831 | 54 ppm/°C |
| CTE ^{d)} after T _g | ASTM E 831 | 169 ppm/°C |

Note: Specifications are for epoxy samples that were cured at 65 °C for 1 hour. Additional curing time at room temperature was given to allow for optimum curing. Samples were conditioned at 23 °C and 50% RH prior to most tests.

a) N/mm² = mPa; lb/in² = psi

b) Cantilever beam impact

c) The uncured epoxy mixture does not conduct electricity well and can have high resistance. To attain stated resistivity, ensure that the mix ratio is followed and that the product is fully cured by heat curing. Room temperature cures may give higher resistivity.

d) Coefficient of Thermal Expansion (CTE) units are in ppm/°C = in/in/°C × 10⁻⁶ = unit/unit/°C × 10⁻⁶

COMPATIBILITY

Adhesion—As seen in the substrate adhesion table, the 8331 epoxy adheres to most materials found on printed circuit assemblies; however, it is not compatible with contaminants like water, oil, and greasy flux residues that may affect adhesion. If contamination is present, clean the printed circuit assembly with electronic cleaner such as MG Chemicals 4050 Safety Wash, 406B Superwash, or 824 Isopropyl Alcohol.

PROPERTIES OF UNCURED 8331S

| Mixed Property | Mixture (1A: 1B) |
|---------------------------|-------------------------|
| Color | Silver Grey |
| Density ^{a)} | 2.55 g/mL |
| Mix Ratio by Volume (A:B) | 1:0.1:0 |
| Mix Ratio by Weight (A:B) | 1.2:1.0 |
| Solids Content (w/w) | 93% |

| Unmixed Property | Part A | Part B |
|---------------------------------|------------------------|------------------------|
| Density | 2.46 g/mL | 2.37 g/mL |
| Flash Point | >50 °C [302 °F] | >93 °C [199 °F] |
| Resistivity of uncured material | Off-scale (no reading) | Off-scale (no reading) |

a) Calculated value based on measures densities of each part

PRINCIPLES COMPONENTS

| Name | CAS Number |
|-----------------------------|---|
| Part A: Bis-F Epoxide Resin | 28064-14-4 |
| Metallic Silver | 7440-22-4 |
| Part B: Aliphatic Amines | 140-31-8 + 84852-15-3 + 68411-71-2 + 111-40-0 |
| Metallic Silver | 7440-22-4 |

SUBSTRATE ADHESION IN DECREASING ORDER

| Physical Properties | Adhesion |
|-----------------------------|-----------------|
| Aluminum | Stronger |
| Steel | |
| Fiberglass | |
| Wood | |
| Paper, Fiber | |
| Glass | |
| Rubber | |
| Polycarbonate | |
| Acrylic | |
| Polypropylene ^{a)} | Weaker |

a) Does not bond to polypropylene

ELECTRICALLY CONDUCTIVE ADHESIVES

SILVER CONDUCTIVE EPOXY - HIGH CONDUCTIVITY (4 HR. WORKING TIME)

DESCRIPTION

The 8331S Silver Conductive Epoxy Adhesive: Good Conductivity / Slow Cure is an economical electronic grade epoxy that combines long working time and good conductivity with ease of use. It has a convenient 1-to-1 mix ratio and 4–5 hour work life. Once mixed, it behaves essentially like a 1-part adhesive for the duration of a work shift. However, unlike 1-part adhesives that often require high heat of 130 to 170 °C, it will cure at 65 °C in less than 2 hours. The cured conductive adhesive bonds very well to most substrates used in electronic assemblies; resists thermal and mechanical shocks; and provides the low resistivity needed for many operating conditions. The 8331S epoxy adhesive provides high conductivity seals, bonds, and traces for electronic devices in automobile, aerospace, marine, communication, and industrial control.

APPLICATIONS & USAGES

The 8331S epoxy has many uses in the production, repair and assembly of electronics in microelectronics and optoelectronics. It has been designed for production environments as a replacement for one part silver conductive epoxy systems when high cure temperatures can potentially damage heat sensitive components, or where frozen storage requirements or shelf life of one part epoxies are a concern. Like all conductive epoxies, it operates as a lead free replacement for metal solder, and it excels at bonding heat-sensitive electronic components. It also provides excellent EMI/RFI shielding and is very effective at filling seams between metal plates.

BENEFITS AND FEATURES

- **Economical**
- **Good 0.0060 Ω-cm electrical resistivity and 0.85 W/(m·K) thermal conductivity**
- **Easy 1:1 mix ratio and long working time**—may be mixed once and then used as a 1-part epoxy for a four hour production shift
- **Optimal cure temperature of only 65 °C**—lower than most 1-part epoxies and suitable for use on heat sensitive components
- **Stores and ships at room temperature**—no freezing or dry ice required
- **Very long shelf life of at least two years**—even when stored at room temperature
- **Strong water and chemical resistance** to brine, acids, bases, and aliphatic hydrocarbons
- **Room temperature cure is possible** (96 hours)
- **Excellent adhesion to most electronic substrates**

APPLICATIONS & USAGES

| Properties | Value |
|--|---------|
| Working Life ^{a)} | 240 min |
| Shelf Life | ≥3 year |
| Full Cure @25 °C [77 °F] ^{b)} | 96 h |
| Full Cure @65 °C [149 °F] | 120 min |
| Full Cure @100 °C [212 °F] | 50 min |

a) Cure and life values 5 g and room temperature unless stated otherwise.

b) Minimal service cure; for full cure, wait 24 h

TEMPERATURE SERVICE RANGE

| Properties | Value |
|--------------------------------------|--|
| Constant Service Temp. | -40 °C to 150 °C [-40 °F to 302 °F] |
| Storage Temperature of Unmixed Parts | 22 to 27 °C [72 to 80 °F] |

ENVIRONMENT

- ✓ RoHS
- ✓ REACH compliant

PRODUCT AVAILABILITY

| Cat. No. | Form | Net Volume | | Net Weight | | Shipping Weight | |
|-------------|-------|------------|------------|------------|---------|----------------------|----------------------|
| 8331S-15G | Paste | 6 mL | 0.20 fl oz | 15 g | 0.47 oz | 400 g ^{a)} | 0.9 lb ^{a)} |
| 8331S-50ML | Paste | 50 mL | 1.7 fl oz | 117 g | 3.8 oz | 2.0 kg ^{a)} | 4.4 lb ^{a)} |
| 8331S-200ML | Paste | 200 mL | 7 fl oz | 254 kg | 15.6 oz | 0.6 kg | 1.3 lb |

a) Pack of ten

SPECIFICATIONS

| Physical Properties | Method | Value |
|--|---------------------|--|
| Color | Visual | Silvery Grey |
| Density @ 25 °C [77 °C] | | 2.191 g/cm ³ |
| Hardness | (Shore D durometer) | 73D |
| Tensile Strength ^{a)} | ASTM D 638 | 14 N/mm ² [2 000 lb/in ²] |
| Elongation | " | 5.3% |
| Young's Modulus ^{a)} | " | 760 MPa |
| Lap Shear Strength (Stainless Steel 304) ^{a)} | ASTM D 1002 | 1.1 N/mm ² [160 lb/in ²] |
| Lap Shear Strength (Aluminum 5052) ^{a)} | ASTM D 1002 | 4.8 N/mm ² [690 lb/in ²] |
| Compressive Strength ^{a)} | ASTM D 695 | 65 N/mm ² [9 400 lb/in ²] |
| Flexural Strength ^{a)} | ASTM D 790 | (d) |
| Solderable | | No |
| Outgassing (Total Mass Loss) @ 24 h | ASTM E 595 | 0.43% |
| Water vapor release | " | 0.27% |
| Collectable Volatile Condensable Material | " | 0.04% |
| Water absorption | | 0.12% |

| Electric Properties ^{b)} | Method | Value |
|---|----------------------------------|--------------|
| Volume Resistivity After 65 °C [149 °F] cure | Method 5011.5 in MIL-STD-883H | 0.0060 Ω cm |

| Thermal Properties | Method | Value |
|--|---------------|---------------|
| Thermal Conductivity @25 °C | ASTM E 1461 | 0.850 W/(m·K) |
| @50 °C | " | 0.826 W/(m·K) |
| @100 °C | " | 0.961 W/(m·K) |
| Glass Transition Temperature (T _g) | ASTM D 3418 | 34 °C [93 °F] |
| CTE prior T _g ^{c)} | ASTM E 831 | 78 ppm/°C |
| CTE after T _g ^{c)} | ASTM E 831 | 158 ppm/°C |
| Specific Heat @25 °C [77 °F] | | 0.904 J/(g·K) |

Note: Specifications are for epoxy samples that were cured at 65 °C for 1 hour. Additional curing time at room temperature was given to allow for optimum curing. Samples were conditioned at 23 °C and 50% RH prior to most tests.

a) N/mm² = mPa; lb/in² = psi

b) The uncured epoxy mixture does not conduct electricity well and can have high resistance. To attain stated resistivity, ensure that the mix ratio is followed and that the product is fully cured by heat curing. Room temperature cures may give higher resistivity.

c) Coefficient of Thermal Expansion (CTE) units are in ppm/°C = in/in/°C × 10⁻⁶ = unit/unit/°C × 10⁻⁶

d) To be determined

COMPATIBILITY

Adhesion—As seen in the substrate adhesion table, the 8331S epoxy adheres to most materials found on printed circuit assemblies; however, it is not compatible with contaminants like water, oil, and greasy flux residues that may affect adhesion. If contamination is present, clean the printed circuit assembly with electronic cleaner such as MG Chemicals 4050 Safety Wash, 406B Superwash, or 824 Isopropyl Alcohol.

PROPERTIES OF UNCURED 8331S

| Mixed Property | Mixture (1A: 1B) | |
|---------------------------|-------------------------|--|
| Color | Silver Grey | |
| Density ^{a)} | 2.43 g/mL | |
| Mix Ratio by Volume (A:B) | 1:00:1.00 | |
| Mix Ratio by Weight (A:B) | 1.17:1.00 | |
| Solids Content (w/w) | 100% | |


| Unmixed | Part A | Part B |
|---------------------------------|------------------------|------------------------|
| Density | 2.61 g/mL | 2.25 g/mL |
| Flash Point | >127 °C [261 °F] | >93 °C [200 °F] |
| Resistivity of uncured material | Off-scale (no reading) | Off-scale (no reading) |

a) Calculated value based on measures densities of each part

PRINCIPLES COMPONENTS

| Name | CAS Number |
|--------------------------|---|
| Part A: Epoxide Resin | 28768-32-3 + 17557-23-3 |
| Metallic Silver | 7440-22-4 |
| Part B: Aliphatic Amines | 68082-29-1, 112-24-3, 68541-13-9, 4246-51-9 |
| Metallic Silver | 7440-22-4 |

SUBSTRATE ADHESION IN DECREASING ORDER

| Physical Properties | Adhesion |
|-----------------------------|---|
| Steel | <p>Stronger</p>  <p>Weaker</p> |
| Aluminum | |
| Fiberglass | |
| Wood | |
| Paper, Fiber | |
| Glass | |
| Rubber | |
| Polycarbonate | |
| Acrylic | |
| Polypropylene ^{a)} | |

a) Does not bond to polypropylene

ELECTRICALLY CONDUCTIVE ADHESIVES

SILVER CONDUCTIVE EPOXY - EXTREME CONDUCTIVITY (10 MINS WORKING TIME)

DESCRIPTION

The 8330 Silver Conductive Epoxy Adhesive: Moderate Cure / Extreme Conductivity is a higher conductivity version of the 8331 Silver Conductive Epoxy. It is an electronic grade epoxy that combines moderate curing rate and high conductivity with ease of use. It has a convenient 1-to-1 ratio, a workable ten minutes working life, and a moderate curing rate. It achieves an operational level in five hours at room temperature. With heat, the 8330 cures in less than 15 minutes and maximizes its conductivity. The cured adhesive bonds very well to most substrates used in electronic assemblies; resists thermal and mechanical shocks; and provides the low resistivity needed for many operating conditions. The 8330 epoxy adhesive provides high conductivity seals, bonds, and repairs of electronic devices.

APPLICATIONS & USAGES

The 8330 epoxy has many uses. It is primarily used as a cold solder: a metal solder replacement for bonding heat-sensitive electronic components. It allows for quick cold soldering repairs, and is effective at bonding heat sinks to other components and PCBs. It also provides excellent EMI/RFI shielding, and is very effective at filling in seams between metal plates.

Its primary applications are repair and assembly of electronics in microelectronics and optoelectronics. It is used in the automobile, aerospace, marine communication, instrumentation, and industrial control equipment industries.

BENEFITS AND FEATURES

- **Excellent 0.0010 Ω ·cm electrical resistivity and 1.6 W/(m·K) thermal conductivity**
- **Easy 1:1 mix ratio**
- **Adheres to most electronic substrates**
- **Stores and ships at room temperature**—no freezing or dry ice required
- **Very long shelf life of at least two years**—even when stored at room temperature
- **Strong water and chemical resistance** to brine, acids, bases, and aliphatic hydrocarbons

CURING & WORK SCHEDULE

| Properties | Value |
|-----------------------------|--------|
| Working Life ^{a)} | 10 min |
| Shelf Life | ≥3 y |
| Service Cure @22 °C [72 °F] | 6 h |
| Full Cure @22 °C [72 °F] | 24 h |
| Full Cure @65 °C [149 °F] | 20 min |

a) Cure and life values 5 g and room temperature unless stated otherwise.

TEMPERATURE SERVICE RANGE

| Properties | Value |
|--------------------------------------|--|
| Constant Service Temp. | -55 °C to 150 °C [-67 °F to 302 °F] |
| Storage Temperature of Unmixed Parts | 22 to 27 °C [72 to 80 °F] |

ENVIRONMENT

- ✓ RoHS
- ✓ REACH compliant

PRODUCT AVAILABILITY

| Cat. No. | Form | Net Volume | | Net Weight | | Shipping Weight | |
|-------------|-------|------------|------------|------------|---------|-----------------|---------|
| 8330S-19G | Paste | 6 mL | 0.20 fl oz | 19 g | 0.61 oz | 20 g | 1.26 lb |
| 8330S-50ML | Paste | 50 mL | 1.69 fl oz | 157 g | 5.08 oz | 0.17 kg | 0.4 lb |
| 8330S-200ML | Paste | 200 mL | 6.76 fl oz | 631 g | 1.39 lb | 0.625kg | 1.4 lb |

SPECIFICATIONS

| Physical Properties | Method | Value ^{a)} |
|--|---------------------|---|
| Color | Visual | Silver Grey |
| Density @ 26 °C [79 °C] | | 3.3 g/cm ³ |
| Hardness | (Shore D durometer) | 83D |
| Lap Shear Strength (Stainless Steel-grade 2) | ASTM D 1002 | 6.5 N/mm ² [940 lb/in ²] |
| Solderable | - | No |

| Electric Properties | Method | Value |
|----------------------------------|----------------------------------|--------------|
| Volume Resistivity ^{b)} | Method 5011.5 in MIL-STD-883H | 0.0010 Ω·cm |

| Thermal Properties | Method | Value |
|--|---------------|--------------------------|
| Thermal Conductivity @25 °C | ASTM E 1461 | 1.63 W/(m·K) |
| @50 °C | " | 1.79 W/(m·K) |
| @100 °C | " | 1.65 W/(m·K) |
| Glass Transition Temperature (T _g) | ASTM D 3418 | 51 °C [124 °F] |
| CTE ^{c)} Prior T _g | ASTM E 831 | 91 ppm/°C ^{c)} |
| CTE ^{c)} After T _g | ASTM E 831 | 278 ppm/°C ^{c)} |
| Specific Heat @25 °C [77 °F] | | 0.558 J/(g·K) |

Note: Specifications are for epoxy samples that were cured at 65 °C for 20 min. Additional curing time at room temperature was given to allow for optimum curing.

a) N/mm² = MPa; lb/in² = psi

b) The uncured epoxy mixture does not conduct electricity well and can have high resistance. To attain stated resistivity, ensure that the mix ratio is followed and that the product is fully cured by heat curing. Room temperature cures may give higher resistivity.

c) Coefficient of Thermal Expansion (CTE) units are in ppm/°C = in/in/°C × 10⁻⁶ = unit/unit/°C × 10⁻⁶

PROPERTIES OF UNCURED 8330S

| Mixed Property | Mixture (1A: 1B) | |
|---------------------------|-------------------------|--|
| Color | Silver Grey | |
| Density ^{a)} | 3.30 g/mL | |
| Mix Ratio by volume (A:B) | 1:0:1.0 | |
| Solids Content (w/w) | 100% | |

| Unmixed Property | Part A | Part B |
|---------------------------------|------------------------|------------------------|
| Density | 3.40 g/mL | 2.92 g/mL |
| Flash Point | >150 °C [302 °F] | >93 °C [200 °F] |
| Resistivity of uncured material | Off-scale (no reading) | Off-scale (no reading) |

a) Calculated value based on measures densities of each part

PRINCIPLES COMPONENTS

Name

Part A: Epoxide Resin

Metallic Silver

Part B: Aliphatic Amines

Metallic Silver

CAS Number

28768-32-3, 17557-23-2

7440-22-4

140-31-8, 84852-15-3, 111-40-0, 68411-71-2, 80-05-7

7440-22-4

COMPATIBILITY

Adhesion—As seen in the substrate adhesion table, the 8330 epoxy adheres to most materials found on printed circuit assemblies; however, it is not compatible with contaminants like water, oil, and greasy flux residues that may affect adhesion. If contamination is present, clean the printed circuit assembly with electronic cleaner such as MG Chemicals 4050 Safety Wash, 406B Superwash, or 824 Isopropyl Alcohol.

SUBSTRATE ADHESION IN DECREASING ORDER

| Physical Properties | Adhesion |
|-----------------------------|-----------------|
| Steel | Stronger |
| Aluminum | |
| Fiberglass | |
| Wood | |
| Paper, Fiber | |
| Glass | |
| Rubber | |
| Polycarbonate | |
| Acrylic | |
| Polypropylene ^{a)} | Weaker |

a) Does not bond to polypropylene

ELECTRICALLY CONDUCTIVE ADHESIVES

SILVER CONDUCTIVE EPOXY - EXTREME CONDUCTIVITY (4 HR. WORKING TIME)

DESCRIPTION

The 8330S Silver Conductive Epoxy Adhesive: Slow Cure / Extreme Conductivity is an electronic grade epoxy that combines long working time and high conductivity with ease of use. It has a convenient 1-to-1 mix ratio and 240 minutes (4 h) working life, which once mixed behaves essentially like a 1-part adhesive for the duration of a work shift. However, unlike 1-part adhesives that often require high heat (130–170 °C), it will cure at 65 °C in less than 120 minutes.

The cured conductive adhesive bonds very well to most substrates used in electronic assemblies, resists thermal and mechanical shocks, and provides the low resistivity needed for many operating conditions. The 8330S epoxy adhesive forms excellent high conductivity seals, bonds, and traces for electronic devices in automobile, aerospace, marine, communication, and industrial control.

APPLICATIONS & USAGES

The 8330S epoxy has many uses in the production, repair and assembly of electronics in microelectronics and optoelectronics. It has been designed for production environments as a replacement for one part silver conductive epoxy systems when high cure temperatures can potentially damage heat sensitive components, or where frozen storage requirements or shelf life of one part epoxies are a concern. Like all conductive epoxies, it operates as a lead free replacement for metal solder, and it excels at bonding heat-sensitive electronic components. It also provides excellent EMI/RFI shielding and is very effective at filling seams between metal plates.

BENEFITS AND FEATURES

- **Excellent 0.0007 Ω -cm electrical resistivity and 1.75 W/(m-K) thermal conductivity**
- **Easy 1:1 mix ratio and long working time**—may be mixed once and then used as a 1-part epoxy for a four hour production shift
- **Optimal cure temperature of only 65 °C**—lower than most 1-part epoxies and suitable for use on heat sensitive components
- **Stores and ships at room temperature**—no freezing or dry ice required
- **Very long shelf life of at least two years**—even when stored at room temperature
- **Strong water and chemical resistance** to brine, acids, bases, and aliphatic hydrocarbons
- **Room temperature cure is possible** (96 hours)
- **Excellent adhesion to most electronic substrates**

CURING & WORK SCHEDULE

| Properties | Value |
|----------------------------|--------------|
| Working Life ^{a)} | 240 min (4h) |
| Shelf Life | ≥3 y |
| Full Cure @25 °C [77 °F] | 96 h |
| Full Cure @65 °C [149 °F] | 120 min (2h) |
| Full Cure @80 °C [176 °F] | 60 min (1h) |

a) Cure and life values 5 g and room temperature unless stated otherwise.

TEMPERATURE SERVICE RANGE

| Properties | Value |
|--------------------------------------|--|
| Constant Service Temperature | -40 °C to 150 °C [-40 °F to 302 °F] |
| Storage Temperature of Unmixed Parts | 22 to 27 °C [72 to 80 °F] |

ENVIRONMENT

- ✓ RoHS
- ✓ REACH compliant

PRODUCT AVAILABILITY

| Cat. No. | Form | Net Volume | | Net Weight | | Shipping Weight | |
|-------------|-------|------------|-----------|------------|----------|---------------------|----------------------|
| 8330S-21G | Paste | 6 mL | 0.2 fl oz | 20 g | 0.65 oz | 400 g ^{a)} | 0.9 lb ^{a)} |
| 8330S-50ML | Paste | 50 mL | 0.7 fl oz | 168 g | 5.40 oz | 200 g | 0.5 lb |
| 8330S-200ML | Paste | 200 mL | 6.7 fl oz | 672 g | 21.61 lb | 800 g | 1.8 lb |

a) Pack of ten

SPECIFICATIONS

| Physical Properties | Method | Value ^{a)} |
|---|---------------------|--|
| Color | Visual | Silvery Grey |
| Density @ 26 °C [79 °C] | | 2.82 g/cm ³ |
| Hardness | (Shore D durometer) | 73D |
| Tensile Strength | ASTM D 638 | 9.0 N/mm ² [3 000 lb/in ²] |
| Elongation | " | 7.8% |
| Compression Strength | ASTM D 695 | 36.0 N/mm ² [5 200 lb/in ²] |
| Lap Shear Strength (Stainless Steel 304) | ASTM D 1002 | 1.3 N/mm ² [190 lb/in ²] |
| (Aluminum 5052) | " | 2.6 N/mm ² [380 lb/in ²] |
| Water absorption | | 0.32% |
| Outgassing (Total Mass Loss) @ 24h | ASTM E 595 | 0.40% |
| Water vapor release (WVR) | " | 0.14% |
| Collectable Volatile Condensable Material | " | 0.03% |
| Solderable | — | No |

Note: Specifications are for epoxy samples that were cured at 65 °C for 20 min. Additional curing time at room temperature was given to allow for optimum curing.

a) N/mm² = MPa; lb/in² = psi

b) The uncured epoxy mixture does not conduct electricity well and can have high resistance. To attain stated resistivity, ensure that the mix ratio is followed and that the product is fully cured by heat curing. Room temperature cures may give higher resistivity.

c) Coefficient of Thermal Expansion (CTE) units are in ppm/°C = in/in/°C × 10⁻⁶ = unit/unit/°C × 10⁻⁶

d) To be determined

| Electric Properties ^{b)} | Method | Value |
|---|----------------------------------|--------------|
| Volume Resistivity After 65 °C [149 °F] cure | Method 5011.5 in MIL-STD-883H | 0.0007 Ω cm |

| Thermal Properties | Method | Value |
|--|---------------|---------------|
| Thermal Conductivity @25 °C | ASTM E 1461 | 1.748 W/(m K) |
| @50 °C | " | 1.750 W/(m K) |
| @100 °C | " | 1.684 W/(m K) |
| Glass Transition Temperature (T _g) | ASTM D 3418 | 34 °C [93 °F] |
| CTE ^{c)} prior T _g | ASTM E 831 | 97 ppm/°C |
| CTE ^{c)} prior T _g | ASTM E 831 | 208 ppm/°C |
| Specific Heat @25 °C [77 °F] | | 0.787 J/(g·K) |

COMPATIBILITY

Adhesion—As seen in the substrate adhesion table, the 8330S epoxy adheres to most materials found on printed circuit assemblies; however, it is not compatible with contaminants like water, oil, and greasy flux residues that may affect adhesion. If contamination is present, clean the printed circuit assembly with electronic cleaner such as MG Chemicals 4050 Safety Wash, 406B Superwash, or 824 Isopropyl Alcohol.

PROPERTIES OF UNCURED 8330S

| Mixed Property | Mixture (1A:1B) |
|---------------------------|------------------------|
| Color | Dark Grey |
| Density ^{a)} | 3.4 g/mL |
| Mix Ratio by Volume (A:B) | 1:00:1.00 |
| Solids Content (w/w) | 100% |

| Unmixed Property | Part A | Part B |
|---------------------------------|------------------------|------------------------|
| Density | 3.4 g/mL | 3.3 g/mL |
| Flash Point | >127 °C [261 °F] | >93 °C [200 °F] |
| Resistivity of uncured material | Off-scale (no reading) | Off-scale (no reading) |

a) Calculated value based on measures densities of each part

PRINCIPLES COMPONENTS

| Name | CAS Number |
|--------------------------|---|
| Part A: Epoxide Resin | 28768-32-3 + 17557-23-3 |
| Metallic Silver | 7440-22-4 |
| Part B: Aliphatic Amines | 68082-29-1, 112-24-3, 68541-13-9, 4246-51-9 |
| Metallic Silver | 7440-22-4 |

SUBSTRATE ADHESION IN DECREASING ORDER

| Physical Properties | Adhesion |
|-----------------------------|-----------------|
| Steel | Stronger |
| Aluminum | |
| Fiberglass | |
| Wood | |
| Paper, Fiber | |
| Glass | |
| Rubber | |
| Polycarbonate | |
| Acrylic | |
| Polypropylene ^{a)} | Weaker |

a) Does not bond to polypropylene

THERMALLY CONDUCTIVE ADHESIVES

MEDIUM CURE THERMAL CONDUCTIVE ADHESIVE (45 MINS WORKING TIME)

DESCRIPTION

The 8329TCM Medium Cure Thermal Conductive Epoxy Adhesive is an electronically insulating epoxy that combines moderate curing rate and high thermal conductivity. It has a convenient 1-to-1 ratio, a 45 minutes work life, and a moderate curing rate. It may achieve a minimal service cure in seven hours at room temperature. The cured adhesive bonds very well to most substrates used in electronic assemblies; and resists thermal and mechanical shocks.

APPLICATIONS & USAGES

The 8329TCM epoxy has many uses. The excellent conductivity improves thermal management for modern high powered devices, such as high-powered electronics and LEDs, increasing their long term reliability. It is used for thermal management situations requiring superior bonding strengths and good thermal transfers.

BENEFITS AND FEATURES

- **Excellent 1.36 W/(m·K) thermal conductivity**
- **Easy 1:1 mix ratio**
- **Adheres to most electronic substrates**
- **Stores and ships at room temperature**—no freezing or dry ice required
- **Very long shelf life of at least two years**—even when stored at room temperature
- **Strong water and chemical resistance** to brine, acids, bases, and aliphatic hydrocarbons

CURING & WORK SCHEDULE

| Properties | Value |
|---------------------------------|---------|
| Working Life ^{a)} | 45 min |
| Shelf Life ^{b)} | ≥2 y |
| Min. Service Cure ^{c)} | 7 h |
| Full Cure @22 °C [77 °F] | 24 h |
| Full Cure @45 °C [113 °F] | 180 min |
| Full Cure @65 °C [149 °F] | 60 min |
| Full Cure @80 °C [176 °F] | 14 min |

a) Pot life for 100 g and room temperature.

b) Shelf life assumes the product is tightly capped and kept below 45 °C.

c) Minimal service cure at 25 °C [77 °F]

TEMPERATURE SERVICE RANGE

| Properties | Value |
|---|--|
| Constant Service Temperature | -65 °C to 165 °C [-40 °F to 302 °F] |
| Maximum Withstand Temperature ^{d)} | -70 °C to 200 °C [-40 °F to 302 °F] |
| Storage Temperature of Unmixed Parts | 22 to 27 °C [72 to 81 °F] |

d) Withstand temperatures the temperature extremes that can be withstood for a short period of times.

PRODUCT AVAILABILITY

| Cat. No. | Form | Net Volume | | Net Weight | | Shipping Weight | |
|---------------|-------|------------|------------|------------|---------|---------------------|----------------------|
| 8329TCM-6ML | Paste | 6 mL | 0.20 fl oz | 15 g | 0.47 oz | 400 g ^{a)} | 0.9 lb ^{a)} |
| 8329TCM-50ML | Paste | 50 mL | 1.7 fl oz | 121 g | 3.9 lb | 2 kg ^{a)} | 4.4 lb ^{a)} |
| 8329TCM-200ML | Paste | 200 mL | 6.8 fl oz | 486 g | 15.6 lb | 550 kg | 1.2 lb |

a) Pack of ten.

ENVIRONMENT

- ✓ RoHS
- ✓ REACH compliant

SPECIFICATIONS

| Physical Properties | Method | Value ^{a)} |
|---|---------------------|---|
| Color | Visual | Dark Grey |
| Density @ 26 °C [79 °C] | | 2.30 g/cm ³ |
| Hardness | (Shore D durometer) | 76D |
| Tensile Strength | ASTM D 638 | 10 N/mm ² [1,400 lb/in ²] |
| Young's Modulus | " | — |
| Elongation | " | 1.8% |
| Compression Strength | ASTM D 695 | 34 N/mm ² [4,900 lb/in ²] |
| Lap Shear Strength (Aluminum 5052) | " | 8.2 N/mm ² [1,200 lb/in ²] |
| Water Absorption | ASTM D 570 | 0.35% |
| Outgassing (Total Mass Loss) @ 24 h | ASTM E 595 | 3.34% |
| Water Vapor Release (WVR) | " | 0.15% |
| Collectable Volatile Condensable Material | " | 0.18% |

Note: Specifications are for epoxy samples that were cured at 65 °C for 20 min. Additional curing time at room temperature was given to allow for optimum curing.

a) N/mm² = MPa; lb/in² = psi

| Electric Properties | Method | Value |
|--|-----------------------------|---|
| Breakdown Voltage @4.491 mm | ASTM D 149 | 29.0 kV |
| Dielectric Strength @4.491 mm | " | 6.5 kV/mm [164 V/mil] |
| Breakdown Voltage @3.175 mm [1/8"] | Reference fit ^{b)} | 24.3 kV |
| Dielectric Strength @3.175 mm [1/8"] | | 7.7 kV/mm [195 V/mil] |
| Volume Resistivity | ASTM D 257 | 9 x10 ¹² Ω cm |
| Dielectric Dissipation & Constant @1 kHz | ASTM D 150-98 | dissipation, D constant, k' 0.025 5.43 |
| Insulating | | Yes |
| Conductive | | No |

| Thermal Properties | Method | Value |
|--|---------------|----------------|
| Thermal Conductivity @25 °C | ASTM E 1461 | 1.36 W/(m·K) |
| @50 °C | " | 1.34 W/(m·K) |
| @100 °C | " | 1.28 W/(m·K) |
| Heat Deflection Temperature | ASTM D 648 | 42 °C [115 °F] |
| Glass Transition Temperature (T _g) | ASTM D 3418 | 46 °C [108 °F] |
| CTE ^{b)} After T _g | ASTM E 831 | 71 ppm/°C |
| CTE ^{b)} After T _g | ASTM E 831 | 131 ppm/°C |
| Specific Heat @25 °C [77 °F] | | 0.907 J/(g·K) |

a) Calculated value based on measures densities of each part

b) Brookfield viscometer at 3 rpm for part A and 0.6 rpm for part B with spindle 7

COMPATIBILITY

Chemical—Once cured, the epoxy adhesive is inert under normal conditions. It will resist water and salt exposure.

It is expected to resist short term exposures to fuels or similar non-polar organic solvents, but it is not suitable for prolonged exposures. Avoid use with strong acids, strong bases, or strong oxidizers.

Adhesion—As seen in the substrate adhesion table, the 8329TCM epoxy adheres to many materials found on printed circuit assemblies; however, contaminants like water, oil, and greasy flux residues may affect adhesion. If contamination is present, clean the printed circuit assembly with electronic cleaner such as MG Chemicals 4050 Safety Wash, 406B Superwash, or 824 Isopropyl Alcohol.

For substrate substances with weak adhesion strengths, surface preparation such as sanding or pre-coating with a suitable primer may improve adhesion.

PROPERTIES OF UNCURED 8329TCS

| Mixed Property | Mixture (1A:1B) |
|---------------------------|------------------------|
| Color | Dark Grey |
| Density ^{a)} | 2.43 g/mL |
| Mix Ratio by Volume (A:B) | 1:00:1.00 |
| Mix Ratio by Weight (A:B) | 1.93:1.00 |
| Solids Content (w/w) | 100% |

| Unmixed Property | Part A | Part B |
|-------------------------|---------------------------|---------------------------|
| Color | Silver Grey | Silver Grey |
| Density | 2.48 g/mL | 2.38 g/mL |
| Flash Point | >149 °C [300 °F] | >148 °C [298 °F] |
| Viscosity ^{b)} | 1 300 000 cP [1 300 Pa s] | 6 000 000 cP [6 000 Pa s] |

PRINCIPLES COMPONENTS

Name

Part A: Bis-A Epoxide Resin

Aluminum Oxide

Zinc Oxide

Boron Nitride

Part B: tris-2,4,6-(dimethylaminomethyl) phenol

Mercaptan mixture

Aluminum Oxide

Zinc Oxide

Boron Nitride

CAS Number

25068-38-6

1344-28-1

1314-13-2

110043-11-5

90-72-2

proprietary

1344-28-1

1314-13-2

110043-11-5

SUBSTRATE ADHESION IN DECREASING ORDER

| Physical Properties | Adhesion |
|-----------------------------|-----------------|
| Steel | Stronger |
| Aluminum | |
| Copper/Bronze | |
| Fiberglass | |
| Wood | |
| Paper, Fiber | |
| Glass | |
| Rubber | |
| Acrylic | |
| Polycarbonate | |
| Polypropylene ^{a)} | |
| Teflon ^{a)} | Weaker |

a) Does not bond to polypropylene or teflon

THERMALLY CONDUCTIVE ADHESIVES

SLOW CURE THERMAL CONDUCTIVE ADHESIVE (4 HR. WORKING TIME)

DESCRIPTION

The 8329TCS Slow Cure Thermal Conductive Epoxy Adhesive is an electronically insulating epoxy that combines long working time and high conductivity with ease of use. It has a convenient 1-to-1 mix ratio and 4 hours work life. Due to this long work life, the mixed adhesive essentially behaves like a 1-part adhesive for the duration of a work shift. However, unlike 1-part adhesives, it doesn't require temperatures as high as 130 and 170 °C, and it will cure at a more moderate 80 °C in less than 1 hour. The cured adhesive bonds very well to most substrates used in electronic assemblies; and resists thermal and mechanical shocks.

APPLICATIONS & USAGES

The 8329TCS epoxy has many uses. The excellent conductivity improves thermal management for modern high-powered devices, such as high-powered electronics and LEDs, increasing their long term reliability. It is used for thermal management situations requiring superior bonding strengths and good thermal transfers.

BENEFITS AND FEATURES

- **Excellent 1.44 W/(m·K) thermal conductivity**
- **Easy 1:1 mix ratio**
- **Adheres to most electronic substrates**
- **Stores and ships at room temperature**—no freezing or dry ice required
- **Very long shelf life of at least three years**—even when stored at room temperature
- **Strong water and chemical resistance** to brine, acids, bases, and aliphatic hydrocarbons

CURING & WORK SCHEDULE

| <i>Properties</i> | <i>Value</i> |
|----------------------------|---------------------|
| Working Life ^{a)} | 240 min |
| Shelf Life | ≥3 y |
| Full Cure @25 °C [77 °F] | 96 h |
| Full Cure @80 °C [176 °F] | 1 h |

a) Pot life at temperature.

TEMPERATURE SERVICE RANGE

| <i>Properties</i> | <i>Value</i> |
|---|--|
| Constant Service Temperature | -65 °C to 165 °C [-40 °F to 302 °F] |
| Maximum Withstand Temperature ^{b)} | -70 °C to 200 °C [-40 °F to 302 °F] |
| Storage Temperature of Unmixed Parts | 22 to 27 °C [72 to 81 °F] |

b) Withstand temperatures the temperature extremes that can be withstood for a short period of times.

ENVIRONMENT

- ✓ RoHS
- ✓ REACH compliant

PRODUCT AVAILABILITY

| <i>Cat. No.</i> | <i>Form</i> | <i>Net Volume</i> | | <i>Net Weight</i> | | <i>Shipping Weight</i> | |
|------------------------|--------------------|--------------------------|------------|--------------------------|---------|-------------------------------|----------------------|
| 8329TCS-6ML | Paste | 6 mL | 0.20 fl oz | 14 g | 0.45 oz | 400 g ^{a)} | 0.9 lb ^{a)} |
| 8329TCS-50ML | Paste | 50 mL | 1.7 fl oz | 113 g | 3.64 oz | 1.5 kg ^{a)} | 3.3 lb ^{a)} |
| 8329TCS-200ML | Paste | 207 mL | 7.01 fl oz | 469 g | 15.1 oz | 250 g | 0.6 lb |

a) Pack of ten

SPECIFICATIONS

| Physical Properties | Method | Value ^{a)} |
|---|---------------------|--|
| Color | Visual | Dark Grey |
| Density @ 22 °C [71 °F] | | 2.17 g/cm ³ |
| Hardness | (Shore D durometer) | 62D |
| Tensile Strength | ASTM D 638 | 11.4 N/mm ² [1,650 lb/in ²] |
| Young's Modulus | " | 310 N/mm ² [45,500 lb/in ²] |
| Elongation | " | 7.0% |
| Compression Strength | ASTM D 695 | 43 N/mm ² [6,200 lb/in ²] |
| Lap Shear Strength (Aluminum 5052) | " | 7.7 N/mm ² [1,200 lb/in ²] |
| Water Absorption | ASTM D 570 | 0.23% |
| Outgassing (Total Mass Loss) @ 24 h | ASTM E 595 | 0.80% |
| Water Vapor Release (WVR) | " | 0.13% |
| Collectable Volatile Condensable Material | " | 0.07% |

Note: Specifications are for epoxy samples that were cured at 65 °C for 1 hr. Additional curing time at room temperature was given to allow for optimum curing.

a) N/mm² = MPa; lb/in² = psi

b) Coefficient of Thermal Expansion (CTE) units are in ppm/°C = in/in/°C × 10⁻⁶ = unit/unit/°C × 10⁻⁶

| Electrical Properties | Method | Value |
|--------------------------------------|-----------------------------|-----------------------------|
| Breakdown Voltage @3.967 mm | ASTM D 149 | 26.3 kV |
| Dielectric Strength @3.967 mm | " | 6.6 kV/mm [168 V/mil] |
| Breakdown Voltage @3.175 mm [1/8"] | Reference fit ^{b)} | 23.9 kV |
| Dielectric Strength @3.175 mm [1/8"] | | 7.5 kV/mm [165 V/mil] |
| Volume Resistivity | ASTM D 257 | 2 x10 ¹³ Ω·cm |
| Dielectric Dissipation & Constant | | dissipation, D constant, k' |
| Dissipation & Constant @1 kHz | ASTM D 150-98 | 0.024 5.48 |
| Insulating | | Yes |
| Conductive | | No |

| Thermal Properties | Method | Value |
|--|-------------|---------------|
| Thermal Conductivity @25 °C | ASTM E 1461 | 1.44 W/(m·K) |
| Thermal Conductivity @50 °C | " | 1.41 W/(m·K) |
| Thermal Conductivity @100 °C | " | 1.27 W/(m·K) |
| Heat Deflection Temperature | ASTM D 648 | 30 °C [86 °F] |
| Glass Transition Temperature (T _g) | ASTM D 3418 | 20 °C [68 °F] |
| CTE ^{b)} Prior T _g | ASTM E 831 | 53 ppm/°C |
| CTE ^{b)} After T _g | ASTM E 831 | 137 ppm/°C |
| Specific Heat @25 °C [77 °F] | | 0.922 J/(g·K) |

a) Calculated value based on measures densities of each part

COMPATIBILITY

Chemical—Once cured, the epoxy adhesive is inert under normal conditions. It will resist water and salt exposure.

It is expected to resist short term exposures to fuels or similar non-polar organic solvents, but it is not suitable for prolonged exposures. Avoid use with strong acids, strong bases, or strong oxidizers.

Adhesion—As seen in the substrate adhesion table, the 8329TCS epoxy adheres to many materials found on printed circuit assemblies; however, contaminants like water, oil, and greasy flux residues may affect adhesion. If contamination is present, clean the printed circuit assembly with electronic cleaner such as MG Chemicals 4050 Safety Wash, 406B Superwash, or 824 Isopropyl Alcohol.

For substrate substances with weak adhesion strengths, surface preparation such as sanding or precoating with a suitable primer may improve adhesion.

PROPERTIES OF UNCURED 8329TCS

| Mixed Property | Mixture (1A:1B) |
|---------------------------|-----------------|
| Color | Dark Grey |
| Density ^{a)} | 2.27 g/mL |
| Mix Ratio by Volume (A:B) | 1:00:1.00 |
| Mix Ratio by Weight (A:B) | 1.95:1.00 |
| Solids Content (w/w) | 100% |

| Unmixed Property | Part A | Part B |
|------------------|------------------|------------------|
| Density | 2.25 g/mL | 2.28 g/mL |
| Flash Point | >149 °C [300 °F] | >148 °C [298 °F] |

PRINCIPLES COMPONENTS

| Name | CAS Number |
|---|-----------------------|
| Part A: Aluminum Oxide | 1344-28-1 |
| Zinc Oxide | 1314-13-2 |
| 4,4'-Methylenebis[N,N-bis(2-oxiranylmethyl)aniline] | 28768-32-3 |
| Epoxy Phenol Novolak Resin | 28064-14-4 |
| Boron Nitride | 110043-11-5 |
| Part B: Aluminum Oxide | 1344-28-1 |
| Zinc Oxide | 1314-13-2 |
| Fatty acids, C18-unsatd., dimer, polymers | 68541-13-9+68082-29-1 |
| Boron Nitride | 110043-11-5 |

SUBSTRATE ADHESION IN DECREASING ORDER

| Physical Properties | Adhesion |
|-----------------------------|----------|
| Steel | Stronger |
| Aluminum | |
| Copper/Bronze | |
| Fiberglass | |
| Wood | |
| Paper, Fiber | |
| Glass | |
| Rubber | |
| Acrylic | |
| Polycarbonate | |
| Polypropylene ^{a)} | |
| Teflon ^{a)} | Weaker |

a) Does not bond to polypropylene or teflon

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