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### General Considerations

To correctly prepare the surface to be joined, all grease, oil and foreign particles should be removed. With most high performance adhesives this step is critical, since for good wetting, the adherend should have a higher surface tension than the adhesive. Even a thumbprint on an otherwise clean surface can prevent the adhesive from spontaneously wetting and spreading.

Organic contaminants are removed by degreasing, while loose deposits are dislodged by scraping or washing with acids, alkali solutions or other such chemicals. Metals are best cleaned by vapor degreasing with trichloroethane, followed by sandblasting or, preferably, by chemical etching. Chemical treatments may be confined to the bonding areas, but degreasing should be done to the entire assembly. A cleaned assembly should be bonded as soon after the cleaning operation as possible or an adhesive primer should be applied. However, if storage is necessary, special precautions should be taken so that the assembly does not become contaminated. All parts should be tightly wrapped or placed in airtight and oil-free containers. Etched surfaces must never be touched with bare hands – even wiping the surface with a clean cloth can affect the bond. Handlers should wear clean cotton gloves and use clean tools.

Nonmetallic, nonporous materials should be degreased with a detergent solution, rinsed thoroughly with clean water, and then dried. Clean solvent may be substituted for detergent. The surfaces are then hand-sanded or sandblasted to give them a rough texture. With organic polymers, plasma or corona treatments are frequently being used to increase the surface activity and thus increase surface wetting and the strength of adhesive bonds.

Water is often used to test a metal surface for cleanness. A small portion is placed on the surface. If the water distributes evenly then the metal should wet well with an adhesive. But if it beads or crawls then the surface should be cleaned again and the test repeated.

Bonding should be performed in a room separate from other manufacturing operations. When bonding is done in the same area as plastic or rubber molding, a physical barrier should be erected between the two operations to prevent airborne mold lubricants from depositing on the metal. Similar hazards are presented by spray painting, electroplating, etching, and machining with coolants. Storage and assembly areas should be enclosed, and air to these areas filtered and under slight pressure.

Numerous studies are underway to find surface treatment methods that minimize or eliminate use of toxic materials or polluting substances. Some progress is being made, but replacement of such degreasing solvents as trichloroethane and such toxic materials as the dichromates will take time. For polymeric surfaces, plasma or corona discharge treatments are receiving much attention.

## Degreasing Metals

To degrease metal surfaces with a degreasing unit, suspend the metals in a stabilized trichloroethane vapor bath for about 30 seconds. Check the bath frequently for accumulated contaminants. If a degreasing unit is not available, clean the surface with a white cotton rag or pieces of absorbent cotton dampened with trichloroethane. Rags should be changed frequently. Let the surface stand several minutes while the chemical evaporates. Although non-flammable, this solvent is toxic in both liquid and vapor forms, so the working areas should be well ventilated. Gloves should be worn when handling this solvent, and smoking should not be allowed.

## Degreasing Non-Metals

Solvents or detergent solutions can be used to remove mold-release agents or waxes from plastics. Such commercial detergents as represented by “Sprex” (DuBois Chemical Co., 1120 West Front, Cincinnati, Ohio) are suitable. Acetone or methyl alcohol are effective solvents, depending on the type of plastic to be cleaned. The adverse effect of solvents on some polymeric materials should be checked before their use.

## Surface Abrasion

Smooth surfaces can be improved for bonding by roughening with abrasives such as medium-grit emery paper. Abrasion should always be followed by degreasing to remove contaminants and loose particles.

Blasting with a fine grit is the best method for removing surface deposits – oxide films, tarnish, rust, mill scale and other contaminants – from metals. This method should be used only on structures thick enough to resist distortion. With thinner materials, contaminants should be removed by vapor honing. This method is similar to grit blasting but uses high-velocity water or steam instead of air. If neither method is appropriate, abrasive discs, belts, cloth, medium-grit emery paper, or wire brushes can be used. Plastics should be roughened with abrasive discs, belts, cloth or emery paper to remove mold release agents. Medium-grit emery paper will give the best results.

Surface abrasion can also remove other surface contaminants as well as weak, low molecular weight components which can be concentrated at the surface due to their exclusion during solidification or crystallization of some polymers.<sup>2</sup> Also during solidification of both thermoplastic and thermoset materials, there is often an orientation of the more polar groups towards the interior, leaving a concentration of lower polarity, lower energy groups on the surface.<sup>3</sup> Abrasion can open up access to the more energetic polymer interior.

## Chemical Treatment

Chemical or electrolytic pretreatments of a bonding surface can greatly increase the strength of the bond. Pretreating can etch the surface of a metal, and form a highly adherent oxide. Environmental resistance can often be greatly increased by such treatment. Etching solutions should be prepared in glass, porcelain, polyethylene, polypropylene or tetrafluoroethylene fluorocarbon laboratory ware and stirred with rods of the same material. Metals other than those to be etched should not touch the solutions. For solutions containing hydrofluoric acid or fluorides, TFE fluorocarbon should be used. Solutions in plastic trays can be heated by immersion in hot water baths; hot plates or infrared heaters can be used for glass and porcelain trays. See Caution section below for safe procedures.

## Caution

The Occupational Safety and Health Administration of the Department of Labor has defined some of the following chemicals and substrates to be hazardous to health in varying degrees. Some are even extremely hazardous. You should familiarize yourself with the substrates and needed chemicals and know the safe handling procedures to be used before preparing the surfaces for adhesive bonding. Also, many of the solvents, degreasing solvents and etch bath chemicals are toxic or can be dangerous if not mixed and handled properly. Materials such as hydrofluoric acid and the chromates need very careful handling. Care should be taken in preparing such chemical solutions, not only because the wrong proportions can seriously weaken a bond but also because the chemicals can be harmful to the skin. Many are strong acids and bases. Remember that solutions containing concentrated sulfuric acid must be prepared by adding acid to water with stirring, and not vice versa. A violent reaction can occur if this is not observed. Use rubber gloves, aprons, face shields, etc.

While the information contained in this article is believed to be reliable, surface treating methods have been selected from many sources, substrates can vary considerably from source to source, and bonding conditions can vary with location and the experience of the operator. Therefore, all recommendations are made without guarantee and those following such listed procedures should become familiar with the general requirements of adhesive bonding and run controls with specific materials and processes before proceeding with the preparation of critical bonded structures.

## Surface Treatment Tables

A number of abbreviations have been used on the surface treatment tables to reduce their length. These include the following: Parts by weight – pbw; distilled or deionized water – DI water; minutes – min.; hours – hr.; chemical names – chemical symbols, i.e., hydrofluoric acid – HF, hydrochloric acid -- HCl, sulfuric acid – H<sub>2</sub>SO<sub>4</sub>, sodium dichromate – Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, sodium hydroxide – NaOH, etc.

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## Metals

Adherend Material	Cleaning	Abrasion or Chemical Treatment	Method
<b>Aluminum and Alloys</b>	Degrease in vapor bath with appropriate solvent or alkaline cleaner.  (See ASTM D2651 for general information. See Ref 4 for chromate-free P2 etch.)	(A) Chromic Acid Etch DI water 1 liter H <sub>2</sub> SO <sub>4</sub> (conc.) 300g Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O 60g 2024 Bare Aluminum 1.5g Dissolve the 20 mil aluminum sheet to “seed” the bath.  (B) Phosphoric Acid Anodizing (Boeing Co. Patent Appl.) (for improved environmental resistance) (ASTM D3933-80) Prepare anodizing bath. H <sub>3</sub> PO <sub>4</sub> (75% conc.) 454g DI water 3.7l Add acid to water with stirring. Use titanium racks and a stainless steel cathode.	(A) • Etch metal in bath for 12-15 minutes at 150-160°F (66-71°C). • <b>Do not delay rinse!</b> Spray in tap water for 5 min. Follow with DI water soak rinse. • Dry thoroughly at 120-140°F max. (49-60°C). • Prime or bond within 16 hours. (B) • Prepare etched metal as above in A. • Anodize at 65-85°F (18-30°C). • Slowly raise voltage to 10-11 volts for 20-25 minutes. • Disconnect current, immediately remove parts and rinse in running water (DI or <150ppm solids tap-water) for 10-15 min. • Dry at 160°F (71°C) max. • Don’t touch surface. • Prime or bond within 16 hours.
<b>Aluminum Honeycomb Core</b>	Degrease.	Not used.	• After degreasing, let stand for 2 hrs. at room temp. or 15 min. at 200°F (93°C).
<b>Beryllium (highly toxic)</b>	Degrease.	Dissolve NaOH in equal weight of DI water, then add water to reduce concentration to 20%W.	• Immerse in conc. (20%W) NaOH soln. 3 min. at 180°F (82°C). • Rinse thoroughly in cold running DI water. • Finally, dry in oven for 10-15 min. at 300-350°F (149-177°C).
<b>Cadmium</b>	Degrease.	Abrade with emery paper. Preferable electroplate with silver or nickel for bonding.	• Repeat degreasing step.
<b>Copper and Alloys Brass, Bronze</b>	Degrease.  (Also see Ref 4 and ASTM D2651-79)	(A) For medium strength bonds, abrade with emery paper. (B) For high bond strengths etch metal surface in: 42% Aqueous FeCl <sub>2</sub> soln. 15 pbw Conc. HNO <sub>3</sub> (s.g. 1.41) 30 pbw DI water 197 pbw	(A) • Repeat degreasing step. (B) • Immerse for 1-2 min. at 77°F (25°C). • Rinse in cold running DI water. • Dry immediately with pressurized air at R.T.
<b>Gold</b>	Degrease with vapor bath or clean rag and solvent.	None.	• Degreasing only treatment.
<b>Iron Cast Iron (Alloys under Steel)</b>	Degrease.	Grit blast or abrade with emery paper.	• Repeat degreasing step.
<b>Lead and Alloys, Pewter</b>	Degrease.	Abrade with medium-grit emery paper.	• Repeat degreasing step.

**Metals – cont.**

Adherend Material	Cleaning	Abrasion or Chemical Treatment	Method
<b>Magnesium and Alloys</b>	See ASTM D2651-79.	(A) For medium strength bond, abrade with medium-grit emery paper.  (B) For high strength bonds, use etch procedure (ASTM D2651, Method A) Bath 1: Sodium Metasilicate 2.5 pbw Tetrasodium Pyrophosphate 1.1 pbw Sodium Hydroxide 1.1 pbw Nacconol® NR (Allied Chem Corp) 0.3 pbw DI water 95 pbw Bath 2: Chromium Trioxide 1 pbw DI water 4 pbw	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> <li>Dry in forced draft oven at 150-200°F (66-93°C).</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse metal for 10 min. in Bath 1 at 140-160°F (60-71°C).</li> <li>Rinse thoroughly in water.</li> <li>Immerse metal for 10 min. in Bath 2 kept at 140-190°F (60-88°C).</li> <li>Wash in cold running DI water.</li> <li>Dry in forced draft oven at &lt;140°F (60°C).</li> <li>When cool, immediately apply adhesive.</li> </ul>
<b>Nickel</b>	Degrease.	(A) For medium strength bond, abrade with medium-grit emery paper. (B) For higher bond strengths, conc. HNO <sub>3</sub> (s.g. 1.41) (Ref 4).	(A) <ul style="list-style-type: none"> <li>Repeat the degreasing step.</li> </ul> (B) <ul style="list-style-type: none"> <li>For stronger bond, immerse in metal for 5 seconds in conc. HNO<sub>3</sub> solution at room temp 77°F (25°C).</li> <li>Rinse etched metal thoroughly in cold running DI water.</li> <li>Air dry at 104°F (40°C).</li> </ul>
<b>Platinum</b>	Degrease.	No other treatment needed.	
<b>Silver</b>	Degrease.	Using fine-grit emery paper, remove any tarnish from bonding area.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
<b>Steel and Iron Alloys (except Stainless Steel)</b>	Degrease.	(A) Sandblast or abrade with medium-grit emery paper. (B) If cannot sandblast or abrade Acid Bath 1: Conc. Orthophosphoric Acid (Sig 1.73) 1 pbw Ethyl Alcohol (denatured) 1 pbw or Acid Bath 2: Conc. HCl 1 pbw DI water 1 pbw	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse for 10 min. in acid Bath 1 at 140°F (60°C) or 5-10 min. in Bath 2 at 68°F (20°C).</li> <li>Remove black residue with stiff brush under running DI water.</li> <li>Dry at 250°F for 1 hour.</li> </ul> If cannot be stored at less than 30% R.H., bond prepared surfaces in short time.
<b>Steel, Ferrous Alloys</b>	Degrease.	(A) Gritblast if possible  (B) If cannot abrade Conc. HCl 1 pt/wt DI water 1 pt/wt	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul> (B) <ul style="list-style-type: none"> <li>If cannot abrade, immerse for 3-10 min. at 77°F (25°C) in HCl bath.</li> <li>Rinse thoroughly in cold running DI water.</li> <li>Oven dry at 150°F (66°C) for 10 min.</li> </ul>
<b>Stainless Steel</b>	Degrease. (See Ref 6 for alternate procedures. Also see ASTM D2651.)	Remove surface deposits with non-metallic agent – alumina grit paper.  (A) General Purpose Treatment Bath 1: See under Magnesium and Alloys.	<ul style="list-style-type: none"> <li>Repeat degreasing.</li> <li>Vapor degrease for 30 seconds.</li> </ul> (A) <ul style="list-style-type: none"> <li>Immerse in Bath 1 for 10 min. at 160-180°F (71-82°C).</li> <li>Rinse thoroughly in running tapwater, then cold DI water.</li> <li>Oven dry at 200°F (93°C) for 10 min.</li> <li>Bond as soon as possible.</li> </ul>

**Metals – cont.**

Adherend Material	Cleaning	Abrasion or Chemical Treatment	Method
<b>Stainless Steel (cont.)</b>		(B) For high temperature use, further treat the metal. Bath 2: Oxalic Acid 1 pbw Conc. H <sub>2</sub> SO <sub>4</sub> (s.g. 1.86) 1 pbw DI water 8 pbw Dissolve oxalic acid before stirring in the H <sub>2</sub> SO <sub>4</sub> .  (C) For resistance to high peel stresses, further treat metal from (A). (Do not combine B & C treatments.) Bath 3: Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·2H <sub>2</sub> O 3.5 pbw DI water 3.5 pbw Conc. H <sub>2</sub> SO <sub>4</sub> (s.g. 1.86) 200 pbw	(B) <ul style="list-style-type: none"> <li>Immerse metal for 10 min. in Bath 2 at 185-195°F (85-90°C).</li> <li>Under cold running water, scrub away any black residue with clean, stiff bristle brush.</li> <li>Rinse in DI water.</li> <li>Dry in oven at 200°F (93°C) for 10-15 min</li> </ul> (C) <ul style="list-style-type: none"> <li>Immerse in Bath 3 at 140-160°F (60-71°C) for 15 min.</li> <li>Scrub under cold running water with stiff bristle brush.</li> <li>Rinse in DI water.</li> <li>Dry in oven at 200°F (93°C) for 10-15 min</li> </ul>
<b>Tungsten and Alloys</b>	Degrease.	(A) Abrade using medium-grit emery paper. (B) For maximum strength, also use a chemical etch. Conc. HCl 30 pbw DI water 15 pbw HF 5 pbw Conc. H <sub>2</sub> SO <sub>4</sub> 50 pbw Hydrogen peroxide few drops Add HCl and HF to the water, stir in the H <sub>2</sub> SO <sub>4</sub> then add the hydrogen peroxide.	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse for 1-5 min. at 77°F (25°C).</li> <li>Rinse thoroughly in cold running DI water.</li> <li>Dry for 10-15 min. in a 160-180°F (71-82°C) oven.</li> </ul>
<b>Zinc, Alloys, Galvanized Metals</b>	Degrease.	(A) Abrade using medium-grit emery paper. (B) For maximum strength Conc. HCl 20 pbw DI water 80 pbw	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse for 2-4 min. with the solution at 77°F (25°C).</li> <li>Rinse thoroughly in cold running DI water.</li> <li>Dry for 20-30 min. in a 150-160°F (66-71°C) oven.</li> <li>Apply adhesive as soon as possible.</li> </ul>
<b>Tin</b>	Degrease.	Abrade with medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing.</li> </ul>
<b>Titanium and Alloys</b> (Many procedures in literature, also see ASTM D2651.)	Vapor degrease with trichloroethane. Remove surface deposits with non-metallic abrasive.	(A) Bath 1: Sodium Metasilicate Soln. (See Magnesium) (B) For stronger bonds Bath 2: (Polyethylene vessel) Sodium Fluoride 10 pbw Chromium trioxide 5 pbw DI water 250 pbw Conc. H <sub>2</sub> SO <sub>4</sub> (add with last stirring) 50 pbw (C) Alternate Treatment (ASTM D2651) Bath 3: Alkaline-clean Oakite HD 126 1.5 oz DI water to 1 gal Bath 4: Acid Pickle HF (70%) 2-3 oz (fl) Na <sub>2</sub> SO <sub>4</sub> (anhyd.) 3 oz HNO <sub>3</sub> (70%) 40-50 oz DI water to 1 gal	(A) <ul style="list-style-type: none"> <li>Immerse at 160-180°F (71-82°C) for 10 min</li> <li>Rinse in cold, running DI water.</li> <li>Dry in oven at 150-200°F (66-93°C) for 10-15 min.</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse in Bath 2 at R.T. for 5-10 min.</li> <li>Rinse in cold, running DI water.</li> <li>Dry in oven at 160-180°F (71-82°C) for 10-15 min.</li> </ul> (C) <ul style="list-style-type: none"> <li>Immerse in Bath 3 for 3-5 min at 150°F (66°C).</li> <li>Rinse in running tapwater at 105°F (40°C) for 2 min.</li> <li>Immerse in Bath 4 for 2 min. at R.T.</li> <li>Rinse in cold water.</li> </ul> (continued next page)

**Metals – cont.**

Adherend Material	Cleaning	Abrasion or Chemical Treatment	Method
<b>Titanium and Alloys (cont.)</b>		Bath 5: Etch Bath Trisodium Phosphate            6.5-7 oz Potassium Fluoride            2.5 oz HF (70%)                            2.2-2.5 oz DI water                              to 1 gal	<ul style="list-style-type: none"> <li>Immerse in Bath 5 for 2 min at R.T.</li> <li>Rinse in DI water at 150°F (66°C) for 15 min.</li> <li>Repeat rinse.</li> <li>Dry at 140°F (60°C) for 30 min. in air circulating oven.</li> <li>Wrap in clean Kraft paper.</li> </ul>

**Thermoplastics**

<b>ABS (Ref 4)</b>	Degrease in acetone. (Alcohol is probably better to use.)	(A) Abrade with medium-grit sandpaper.  (B) Etch Solution Conc. H <sub>2</sub> SO <sub>4</sub> 26 pbw K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> 3 pbw DI water                                    11 pbw (Add acid to stirred water)  (C) Plasma or Corona Treatment (Ref 10)	(A) <ul style="list-style-type: none"> <li>Wipe free of dust.</li> <li>Prime with Dow Corning A-4094 or G.E. SS-4101.</li> </ul> (B) <ul style="list-style-type: none"> <li>Etch at room temp. for 20 min.</li> <li>Rinse in tapwater.</li> <li>Rinse in DI water.</li> <li>Dry in warm air.</li> </ul>
<b>Cellulose Plastics</b>	Degrease with methyl alcohol or isopropyl alcohol.	Abrade using fine-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> <li>Heat to 200°F (93°C) for 1 hr. and apply adhesive while hot.</li> </ul>
<b>Diallylphthalate</b>	Degrease with acetone or MEK.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
<b>Fluorocarbons</b> Polymonochloro-trifluoroethylene Polytetrafluoroethylene Tetrafluoroethylene Polyvinyl fluoride	Degrease with acetone or MEK. (Also see Ref 4, Flame Treatment, Corona Discharge and plasma treatments are also being increasingly used. See Ref 10.)	Use chemical etch. Sodium metal                            23 g Naphthalene                              128 g Tetrahydrofuran                        1L Prepare under anhydrous conditions. (Dry solvents, closed flask, stirrer, drying tube.) Add naphthalene to the THF, carefully add 1/4" to 1/2" cubes of sodium, one at a time while stirring. Let soln. stand 16 hrs. at R.T., then stir 2 hrs. Store in bottles with glass stoppers—keep free from air and moisture. Use near exhaust ventilator.	<ul style="list-style-type: none"> <li>Immerse in the solution for 15 min. at 77°F (25°C).</li> <li>Wash in acetone or MEK then in cold DI water.</li> <li>Dry thoroughly.</li> <li>Proprietary solutions may be used. "Bondaid" W.S. Shambrand Co. "Fluorobond" Joclin Mfg. Co.</li> </ul>
<b>Nylon</b>	Degrease with acetone or MEK.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
<b>Polycarbonate or Polymethyl-methacrylate or Polystyrene</b>	Degrease with methyl alcohol.	Abrade using medium-grit emery paper.  (Also plasma or Corona treatment. Ref 10)	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
<b>Polyether (chlorinated) or Polyethylene or Polypropylene or Polyformaldehyde</b>	Degrease with acetone or MEK. (See Ref 5 for alternate procedures. Flame or plasma treatment may also be used. See Refs 4 and 10.)	Chemical pretreatment is necessary. K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> 75 pbw DI water                                    120 pbw Conc. H <sub>2</sub> SO <sub>4</sub> 1500 pbw Dissolve the K <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> in water and stir in the H <sub>2</sub> SO <sub>4</sub> .	(A) <ul style="list-style-type: none"> <li>Immerse in the chromic acid solution as follows:               <ul style="list-style-type: none"> <li>Chlorinated Polyether – 5 min at 160°F (71°C).</li> <li>Polyethylene and Polypropylene – 60 min. at 77°F (25°C).</li> <li>Polyformaldehyde – 10 sec. at 77°F (25°C).</li> </ul> </li> <li>Rinse in cold running DI water.</li> <li>Dry at R.T.</li> <li>Flame or plasma treatments may be used also.</li> </ul>



**Thermoplastics – cont.**

Adherend Material	Cleaning	Abrasion or Chemical Treatment	Method
<b>Polyethylene-terephthalate or Linear Polyesters</b>	Degrease with methyl alcohol.  (See Ref 4, plasma treatments also used.) (Ref 10)	(A) Abrade using medium-grit emery paper. (B) For a stronger bond use chemical etch. Sodium hydroxide soln. (20%W)	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse for 2-10 min. at 160-200°F (71-93°C).</li> <li>Wash thoroughly in cold running DI water.</li> <li>Dry with hot air.</li> </ul>
<b>Polyvinyl-chloride rigid</b>	Degrease with methanol or trichloroethane.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>

**Engineering Thermoplastics (Examples of Representative Commercial Materials)**

<b>Polyarylate (Ardel®, U.C.) (Ref 4) or Polyaryl Sulfone (Astrel® 360, 3M) (Ref 4)</b>	(A) Ultrasonic clean in alkaline-etching solution.	(A) Using alkaline-etching solution. Sandblast with 150 mesh silica sand. (B) Acid Etch Solution Na <sub>2</sub> Cr <sub>2</sub> O <sub>7</sub> ·12H <sub>2</sub> O 3.4% Conc. H <sub>2</sub> SO <sub>4</sub> 96.96% (C) Plasma or Corona Treatment (Ref 10, 11).	(A) <ul style="list-style-type: none"> <li>Water wash.</li> <li>Alcohol wash.</li> <li>Dry with dry nitrogen.</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse 15 min. at 150-160°F (66-71°C).</li> <li>Cold water wash.</li> <li>Dry at 150°F (66°C) in an air circulating oven.</li> </ul>
<b>Polyether-etherketone (PEEK, ICI) (Ref 4)</b>	Degrease with isopropyl alcohol.	(A) Abrade. (B) Flame Treatment Blue oxidizing flame. (C) Chromic Acid Etch Bath composition not given in Ref. 4. (D) Plasma or Corona Treatment (Ref 10, 11).	(A) <ul style="list-style-type: none"> <li>Repeat degrease.</li> </ul> (B) <ul style="list-style-type: none"> <li>Abrade.</li> <li>Degrease.</li> <li>Flame treat (blue oxidizing flame).</li> </ul> (C) <ul style="list-style-type: none"> <li>Abrade.</li> <li>Degrease.</li> <li>Chromic acid etch.</li> <li>Water wash.</li> </ul>
<b>Polyphenylene-sulfide (Ryton®, Phillips) (Ref 4)</b>	(A) Degrease with acetone. (B) Wipe surface with ethyl alcohol soaked paper.	(A) Sandblast. (B) Sand with 1220-grit sandpaper. (C) Plasma or Corona Treatment (Ref 10, 11).	(A) <ul style="list-style-type: none"> <li>Repeat degreasing.</li> </ul> (B) <ul style="list-style-type: none"> <li>Clean off dust with stiff bristle brush.</li> </ul>
<b>Polysulfone (Udel®, U.C.) (Ref 4)</b>	Degrease in alcohol.	(A) Grit-blast with 27-50 micron aluminum oxide. (B) Etch in sodium dichromate-sulfuric acid soln. (C) Plasma or Corona Treatment (Ref 10).	(A) <ul style="list-style-type: none"> <li>Clean in ultrasonic cleaner in Neutra-Clean (Shibley Co., Inc.)</li> <li>Rinse in tap and then DI water.</li> <li>Rinse in IPA for 30 sec.</li> <li>Flush with dry N<sub>2</sub>.</li> <li>Dry in air at 150°F (66°C).</li> </ul> (B) See Polyaryl Sulfone treatment.

### Thermosets

Adherend Material	Cleaning	Abrasion or Chemical Treatment	Method
Epoxy, Epoxide Resins	Degrease with acetone or MEK.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
Furane Resins	Degrease with acetone or MEK.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
Melamine Formaldehyde Plastics (Formica)	Degrease with acetone or MEK.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
Phenolics Polyester Polyurethane Resins	Degrease with acetone or MEK.	Abrade using medium-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
Polyimide (Vespel®, DuPont) (Ref 4)	(A) Degrease. (B) Degrease in acetone.	(A) Abrade with dry or wet abrasive blast. (B) Etch Solution Sodium Hydroxide 5 pbw Water 95 pbw (C) Plasma or Corona Treatment (Ref 10).	(A) <ul style="list-style-type: none"> <li>Repeat degreasing.</li> <li>Dry.</li> </ul> (B) <ul style="list-style-type: none"> <li>Etch for 1 min. at 140-194°F (60-90°C).</li> <li>Rinse in cold water.</li> <li>Dry in hot air.</li> </ul>

### Carbon and Carbon Fiber and Glass Fiber Composites

Carbon	Degrease with acetone or MEK.	Abrade using fine-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> <li>Allow solvent to evaporate.</li> </ul>
Glass Reinforced Laminates	Degrease with acetone or MEK.	Abrade using fine-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> </ul>
Graphite	Degrease with acetone or MEK.	Abrade using fine-grit emery paper.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> <li>Allow solvent to evaporate.</li> </ul>
Carbon Fiber Epoxy Composites (Ref. 4)	(A) Solvent wipe (MEK, toluene, etc.) (B) Use peel ply during initial curing. (C) See Ref 6 for the effect of abrasion procedures. See also Refs 7 and 9.	(A) Lightly abrade with medium-grit emery paper. Avoid exposing the reinforcing fibers.	(A) <ul style="list-style-type: none"> <li>Wipe with solvent.</li> <li>Check surface by water break test. Repeat if necessary.</li> </ul>
Carbon Fiber Polyether-etherketone (PEEK)	Solvent wipe with MEK.	Abrade lightly with Scotch-brite – Bon Ami. Good strengths require A or B treatment. (A) Chromic Acid Etch Exact composition of etch solution not defined in Ref 9. (B) Plasma Treatment Gave good bond strengths also. (Ref 11) See Ref 10 for general plasma treatments.	<ul style="list-style-type: none"> <li>Rinse in tap water and DI water.</li> <li>Air dry.</li> </ul> (A) <ul style="list-style-type: none"> <li>Immerse for 15 min. at R.T.</li> <li>Rinse in tap and then DI water.</li> <li>Dry at 200°F (93°C) for 30 min.</li> </ul>

### Rubbers

Rubber, Natural and Rubber, Synthetic Chloroprene Neoprene	Degrease with methyl alcohol.	For maximum strength use – Chemical etch: Bath 1, concentrated sulfuric acid. Neutralizing solution: Bath 2, 0.2% soln. of caustic.	<ul style="list-style-type: none"> <li>Immerse for 5-10 min. in conc. sulfuric acid at 77°F (25°C). (Bath 1)</li> <li>Wash thoroughly in cold DI water.</li> <li>Neutralize by immersing for 5-10 min. at R.T. in Bath 2.</li> <li>Rinse with cold running DI water.</li> <li>Dry.</li> </ul>
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### Ceramics, Glass, etc.

Adherent Material	Cleaning	Abrasion or Chemical Treatment	Method
Ceramics, Porcelain, Glazed China	Degrease with MEK.	Abrade using emery paper or sandblasting.	<ul style="list-style-type: none"> <li>Repeat degreasing step.</li> <li>Evaporate the solvent.</li> </ul>
Glass, Quartz, nonoptical	Degrease with MEK.	(A) Abrade using carborundum powder and water or fine-grit paper. (B) For maximum strength, continue abrading and use chemical etch. Chromium trioxide                      1 pbw DI water                                      4 pbw	(A) <ul style="list-style-type: none"> <li>Repeat degreasing step.</li> <li>Dry for 30 min. at 210°F (100°C).</li> </ul> (B) <ul style="list-style-type: none"> <li>Immerse for 10-15 min. at 77°F (25°C).</li> <li>Dry for 30 min. at 210°F (100°C).</li> <li>Apply adhesive while still hot.</li> </ul>
Glass, optical	Degrease in an ultrasonically agitated detergent bath.		<ul style="list-style-type: none"> <li>Rinse thoroughly.</li> <li>Dry &lt;100°F (38°C).</li> </ul>
Jewels	Degrease with MEK.		<ul style="list-style-type: none"> <li>Dry at R.T.</li> </ul>

### Construction Materials

Bricks, fired Nonglazed Building Mat'ls	Degrease in acetone or MEK.	Abrade using a wire brush.	<ul style="list-style-type: none"> <li>Remove all contaminants.</li> </ul>
Concrete	Decontaminate with a detergent solution.	Clean by one of these procedures: (A) Sandblast about 1/16" from bonding surface. (B) Remove 1/8" by mechanical scarification. (C) Chemical etch. Hydrochloric acid soln. (15% by wt.).	<ul style="list-style-type: none"> <li>Wash thoroughly with water.</li> <li>Remove all dust.</li> </ul> (C) <ul style="list-style-type: none"> <li>Spread solution with a stiff bristle broom.</li> <li>Remove sludge with water from high pressure hose.</li> <li>Check with litmus paper for residual acid.</li> <li>If present, rinse with 1% ammonia.</li> <li>Flush with water.</li> <li>Allow to dry.</li> </ul>
Stonework	Dry thoroughly.	Abrade using a wire brush.	<ul style="list-style-type: none"> <li>Remove all contaminants.</li> </ul>
Wood	Dry thoroughly.	Decontaminate with a sander, plane, smooth with sandpaper.	<ul style="list-style-type: none"> <li>Remove all contaminants.</li> </ul>

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