Chapter 16

Acetal Resin

Heated Tool Welding

Cadillac Plastic and Chemical Company: Cadco

Cadco acetal parts can be joined to achieve strong, permanent, leak free, pressure tight joints by rapid fusion-type welding. To accomplish the weld, the joint surfaces of the parts are held lightly against a hot metal surface that is a mirror image of the surface of the unwelded joint. The surface temperature of the hot plate is 288°C (550°F) and the contact time is 2-20 seconds, depending on joint geometry. When surface melting occurs, the heating tool is removed and the surfaces to be welded are quickly brought together and held under light pressure. This procedure can be used for welds up to 12.7 mm (0.5 in) wide. Wider joints should be sheared across each other during the contacting movement to prevent air entrapment and to ensure good weld strength.

In general, lap-joints are preferred over butt joints. A small uniform bead of flash around the joint indicates that weld quality is good. When necessary, flash can be avoided by using an open flange on the joint perimeter to accomodate melted material expelled from the joint. Flash can also be trimmed by mechanical means. A heating tool made of aluminum will be light, corrosion resistant and possess high thermal conductivity. Tool surfaces should be coated with a layer of Teflon non-stick finish to prevent stringing and sticking to molten resin.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Hot Gas Welding

Cadillac Plastic and Chemical Company: Cadco

Heavy sections of Cadco acetal can be joined by hot gas welding. A hot nitrogen welding gun, pressure regulator, filler rods of acetal and appropriate jigs and fixtures are needed for this technique. Use of a nitrogen "blanket" is recommended to avoid oxidation leading to low weld strength. The outlet temperature of the welding gun should be approximately 332°C (630°F). For maximum joint strength, both of the parts to be welded and the filler rod should be heated so that all surfaces to be joined are melted.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Spin Welding

Cadillac Plastic and Chemical Company: Cadco

When properly performed, spin welding quickly produces strong, permanent and leak-free welds. Spin welds are made by rotating the part surfaces to be welded at high speeds relative to each other. When a film of melted acetal forms, relative motion is stopped, and the weld is allowed to solidify under pressure. The spin welding operation can be performed in 1-2 seconds while production assembly rates for small parts may be as high as 60 pieces per minute through the use of automatic part handling equipment.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Ultrasonic Welding

Cadillac Plastic and Chemical Company: Cadco

Parts made from Cadco acetal can be successfully welded using conventional ultrasonic welding equipment. A vibration frequency of about 20,000 cycles per second is transmitted to the part surfaces to be joined by means of a special tool called a horn. The vibrations cause a thin film of material to melt at the joint surface. Solidification and a subsequent weld occur under pressure after the vibrations stop.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

DuPont: Delrin

Delrin acetal is a highly crystalline plastic with a high, sharp melting point, high strength, hardness and stiffness at elevated temperatures. Of the three flow grades of Delrin, parts of Delrin 500 and 900 ultrasonically weld easier than parts of the higher melt viscosity Delrin 100. The difference is very slight with the shear joint but more pronounced with the butt type joints. Delrin 570, a glass filled composition, may also be ultrasonically welded. Atmospheric moisture does not appear to influence the welding of parts made from Delrin.

Lubricants and pigments negatively influence welding. With welding equipment set at conditions which produce quality welds in unpigmented parts, the quality of welds in pigmented parts may be markedly lower - reflected in welds of lower strength and greater brittleness. The presence of pigments appears to influence the means of heat generation at the joint. Often lower weld quality may be offset by welding pigmented parts at longer weld times than for unpigmented parts. However, these longer weld times may produce undesirable effects such as the formation of excess weld flash and marring under the welding horn. Use of dye coloring systems, which do not significantly affect ultrasonic welding, may offer an alternative solution.

The adverse effects on ultrasonic weldability caused by pigments also apply to the welding of materials with externally or internally compounded lubricants and mold release agents. Relatively small quantities of such materials appear to adversely affect the means of heat generation in the joint during welding. If spray-on mold release agents are used in molding of otherwise unlubricated molding material, these parts should be thoroughly cleaned prior to welding.

Reference: *Ultrasonic Welding of Delrin Acetal Resin, Zytel Nylon Resin, Lucite Acrylic Resin,* supplier technical report (171) - DuPont Company, 1972.

Snap Fit Assemblies

Cadillac Plastic and Chemical Company: Cadco

Snap fitting is a quick, simple and economical method of assembling Cadco acetal parts to other plastic materials or metals. In general, a machined undercut on one part engages a mating lip on the other to retain the assembly. Although a snap fit is strong, it's usually not pressure tight unless other features such as o-rings are incorporated in the joint design.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Press Fit Assemblies

Cadillac Plastic and Chemical Company: Cadco

Press fitting Cadco Acetal parts to other plastics or metals provides joints of high strength at minimum cost. In general, suggested interferences are larger between parts of Cadco acetal than between metal parts since the elastic modulus of acetal is lower than that of metals. Use of large rather than small interferences can result in production economy because of greater latitude with production tolerances.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Staking

Cadillac Plastic and Chemical Company: Cadco

Heading (staking) is useful in forming low cost, strong, permanent, mechanical joints between Cadco acetal parts or between Cadco acetal and other materials. Heading involves permanent deformation of a rivet, stud or similar part. Cold heading is accomplished by compressing the end of a rivet while holding and containing the rivet body at room temperature. When the compressive load exceeds acetal's yield point, the rivet end is formed into a head. Less heading force is required when hot heading. Heading at the maximum suggested temperature of 149°C (300°F) results in minimum recovery of the head (with low heading force).

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Tapping and Self-Tapping Screws

Cadillac Plastic and Chemical Company: Cadco

Using self-tapping screws to join Cadco acetal parts may provide substantial cost savings by simplifying machined parts and reducing assembly costs. A self-tapping screw cuts or forms thread as it is inserted so a separate tapping operation is not required.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Adhesive and Solvent Bonding

Cadillac Plastic and Chemical Company: Cadco

The non-stick and/ or solvent resistant nature of Cadco acetal requires that part surfaces be specially prepared before adhesive bonding can occur. The surfaces can then adhere to like substrates or others such as wood, steel and aluminum.

Roughing techniques such as "satinizing" and sanding with a 280A grit emery cloth have been successful with Cadco acetal surfaces. "Satinizing" is a chemical etching process developed by DuPont for Delrin acetal. In the process, a mildly acidic solution produces uniform anchor points on the surface. Finishes or cements bond mechanically to these anchor points so that strong adhesion is possible.

Reference: *Cadco Engineering Plastics,* supplier design guide (CP-200-92) - Cadillac Plastic and Chemical Company, 1992.

Cadillac Plastic and Chemical Company: Cadco

Cadco BA-410 cement is suitable for joining Cadco acetal stock shapes.

Reference: *Cadco Acetal,* supplier technical report - Cadillac Plastic and Chemical Company.

Adhesive Bonding

DuPont: Delrin 100

A study was conducted to test for bond strength on a representative matrix of commonly used plastics and the adhesives best suited to them. For many of the plastics evaluated, the effect of polymer composition on bond strength was evaluated by compounding plastic formulations with each of the most commonly used additives and fillers for that plastic; common grades were used for the remaining resins. The effect of each additive and filler was determined by comparing the bond strength achieved with the specially compounded formulations to that of the neat plastic. In addition, the effect of surface roughening and chemical treatment of the plastic surface on bond strength was examined.

The block-shear (ASTM D 4501) test was chosen as the test method because it places the load on a thicker section of the test specimen that can withstand higher loads before experiencing substrate failure. In addition, the geometry of the test specimens and the block-shear fixture helps minimize peel and cleavage forces in the joint. How well the block-shear test method reflects the stresses that an adhesively bonded joint will experience in real world applications should be considered. Also, limitations on the data due to the variety of additives and fillers used by different companies should not be ignored.

Prism 401, when used in conjunction with Prism Primer 770, achieved the highest bond strengths on all of the acetal formulations that were evaluated. Prism 401 and Super Bonder 414, both cyanoacrylate adhesives, achieved the second highest bond strengths, followed by Loctite 3105, a light curing acrylic adhesive. Black Max 380, a rubber toughened cyanoacrylate adhesive, and Depend 330, a two-part no-mix adhesive, achieved the lowest bond strengths on acetal polymers. The addition of an antistatic additive to acetal homopolymer resulted in a large, statistically significant increase in the bond strengths achieved when using Prism 401 or Super Bonder 414.

Surface Treatments
Surface roughening either caused no effect or a statistically significant increase in bond strength achieved on acetal homopolymer. The use of Prism Primer 770, in conjunction with Prism 401, caused a statistically significant increase in the bondability of both acetal homopolymer and copolymer.

Other Information
The surface of acetals tends to be very dry, so an accelerator may be necessary to speed the cure of cyanoacrylates. Acetal homopolymers are compatible with all Loctite adhesives, sealants, primers, and activators. Recommended surface cleaners are isopropyl alcohol and Loctite ODC Free Cleaner 7070.

Table 16.1: Shear strengths of acetal to acetal adhesive bonds made using adhesives available from Loctite Corporation. Values are given in psi and (MPa).[a,b]

Plastic Material Composition (Du Pont Delrin 100)		Loctite Adhesive					
		Black Max 380 rubber toughened cyanoacrylate (200 cP)	**Prism 401** surface insensitive ethyl cyanoacrylate (100 cP)	**Prism 401/ Prism Primer 770** polyolefin primer for cyanoacrylate	**Super Bonder 414** general purpose cyanoacrylate (110 cP)	**Depend 330** two-part no-mix acrylic	**Loctite 3105** light cure acrylic (300 cP)
Unfilled Resin	30 rms	100 (0.7)	200 (1.4)	1700 (11.7)	500 (3.5)	50 (0.3)	250 (1.7)
Roughened	47 rms	150 (1.0)	600 (4.1)	1700 (11.7)	500 (3.5)	100 (0.7)	250 (1.7)
Antioxidant	0.2% Irganox 1010	100 (0.7)	400 (2.8)	1700 (11.7)	500 (3.5)	50 (0.3)	250 (1.7)
UV stabilizer	0.2% Tinuvin 328 0.4% Tinuvin 770	100 (0.7)	900 (6.2)	1700 (11.7)	500 (3.5)	50 (0.3)	300 (2.1)
Impact Modifier	30% Estane 5708F1	100 (0.7)	350 (2.4)	1700 (11.7)	500 (3.5)	50 (0.3)	350 (2.4)
Lubricant	0.88% N,N'-Ethylene bisstearamide wax	100 (0.7)	350 (2.4)	1700 (11.7)	900 (6.2)	50 (0.3)	450 (3.1)
Glass filler	20% type 3090 glass fiber	100 (0.7)	1100 (7.6)	2800 (11.7)	1100 (7.6)	50 (0.3)	300 (2.1)
PTFE filler	15% PTFE MP1300	100 (0.7)	200 (1.4)	1700 (11.7)	100 (0.7)	50 (0.3)	250 (1.7)
Colorant	4% 3972 colorant	100 (0.7)	200 (1.4)	1700 (11.7)	500 (3.5)	50 (0.3)	250 (1.7)
Antistatic	1.5% Markstat AL12	150 (1.0)	1750 (12.1)	1700 (11.7)	1100 (7.6)	50 (0.3)	250 (1.7)
Acetal copolymer	Celcon courtesy of Hoechst Celanese	50 (0.3)	100 (0.7)	300 (2.1)	100 (0.7)	200 (1.4)	200 (1.4)

[a] All testing was done according to the block shear method (ASTM D4501).
[b] For more information on data presented in this table, contact Loctite Corporation at 800-562-8483 (1-800-LOCTITE). Request the "Design Guide for Bonding Plastics."

Reference: *The Loctite Design Guide for Bonding Plastics,* supplier design guide (LT-2197) - Loctite Corporation.

DuPont: Delrin

The adhesive joining of Delrin acetal resin is generally limited to prototype models with low shear forces. This is because the shear strength achieved with most adhesives is only 2 to 10% of the available shear strength of Delrin acetal resin. The best adhesion requires a special roughening step such as "Satinizing" or sanding with 280 grit emery cloth. The "Satinizing" technique gives the best joints.

Reference: *Delrin Design Handbook For Du Pont Engineering Plastics,* supplier design guide (E-62619) - Du Pont Company, 1987.