Chapter 34

Polyphthalamide

Welding

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

Components produced from Amodel resins can be readily joined using hot-plate, vibration, spin, or ultrasonic welding.

Acceptable welds can be achieved using all of these welding techniques. Ultrasonic welding does require near-field energy appplication for strong welds. In general, absorbed moisture does not interfere with welding, but best results are obtained using samples that contain "normal" amounts of moisture (1.8%) or less.

Reference: *Amodel PPA Resins Engineering Data,* supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Heated Tool Welding

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

Tests were conducted to determine the hot plate weldiing characteristics of Amodel polypthalamide. The hot plate welding machine used was a Bielomatic HV 4806 welding machine manufactured in 1986 by Leuze GMBH. The specimens used were bars 4 inches (102 mm) long, 1 inch (25 mm) wide, and 0.250 inch (6 mm) thick. The welding machine was set up to provide a nominal lap shear weld of 0.5 by 1 inch (13 by 25 mm).

Best results were obtained using a hot plate temperature of 626°F (330°C), a clamping pressure of 30 psi (207 KPa), a welding time of 40 seconds, and a hold time of 20 seconds. The strength of the bond produced was comparable to the strength of the material itself, i.e., the majority of the specimens failed at points other than the joint.

Test plaques occasionally stuck to the hot plate unless a silicone mold release was applied and the hot plate allowed to return to thermal equilibrium. Tests showed that the use of mold release did not reduce weld strength. Absorbed moisture did not significantly affect weld strength at dry (0%) and normal (1.8%) levels, but it did reduce weld strength at the saturated (3.8%) condition. Moisture levels (0%, 1.8%, 3.8%) correspond to Amodel AS-1133 HS resin that reached equilibrium in air with relative humidities of 0, 50, and 100%, respectively.

Reference: *Amodel PPA Resins Engineering Data,* supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Vibration Welding

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

In vibrational welding, friction is used to generate heat. One part is held stationary while the mating part vibrates 0.030 to 0.060 inches (0.8 to 1.5 mm) in a linear fashion at 100 to 400 Hz. Vibration welding is limited to flat parts.

The vibration welding machine used to weld Amodel AS1133HS resin was a Vinton Hydroweld vibration welding machine. This machine operates at a nominal frequency of 240 Hz. The specimens used were 4 inches (102 mm) long, by 1 inch (25 mm) wide, by one-fourth inch (6 mm) thick, and they were welded in a 1 by 0.5 inch (25 by 13 mm) lap shear configuration.

This method was very effective and welds as strong as the parent material were easily obtained. This technique proved relatively insensitive to welding conditions, giving good results at weld times as short as 0.6 seconds and pressures as low as 320 psig (2.2 MPa). Best results were obtained using specimens containing a normal (1.8%) amount of moisture, corresponding to equilibrium moisture content at 50% relative humidity.

Reference: *Amodel PPA Resins Engineering Data*, supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Spin Welding

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

The spin welding method uses frictional heat to join two cylindrical or spherical mating parts. While one half is held stationary in a nest fixture, the mating part is spun rapidly against it. Friction at the interface raises the temperature of the material to the melt point. At that point, the spinning action is stopped, and the parts are held under pressure for cooling.

The spin welding machine used to weld Amodel AS-1133 HS resin was a Mechasonic KLN Omega machine, model SPN-063. Typically the important parameters are angular speed in revolutions per minute, normal force, and welding time. Because this machine is an inertia-type, the energy available for spinning the sample is limited to that stored in a flywheel. So instead of adjusting speed per se, the energy stored in the flywheel is controlled.

The specimens used for spin welding were injection molded cups. This style has an interference joint configuration. Excellent weld strength was obtained using this method.

Because welding condition settings are machine specific, they are not generally useful in setting a starting point. Rather it was observed that as forge pressure and angular velocity were increased, weld strength increased up to a maximum and then decreased when an excessive amount of either pressure or velocity was applied. The explanation for this observation is that when a weld was made with too high a forge pressure, the spinning motion was stopped nearly instantaneously and not enough polymer melted and flowed. In the other extreme, a high angular velocity and a low forge pressure, the top part essentially sat on top of the bottom part and freely rotated without being forged into the interference fit. Thus, to assure a good joint, a welding condition must be found so both melting and forging occurs.

Moisture content did not significantly affect weld strength.

Reference: *Amodel PPA Resins Engineering Data*, supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Ultrasonic Welding

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

The ultrasonic welding machine used to weld Amodel AS-1133 HS resin was a Branson Model 910 M, microprocessor controlled machine. With this unit it is possible to dial in the amount of energy that will be applied to the sample. The output from the booster was fed to near and far field horns. The samples used were injection molded cups. Aluminum fixturing held the parts in a butt joint configuration.

Welds produced using a near field horn to joint distance [defined as 1/4 inch (6 mm) or less] were excellent. Welds made using the far field horn position were weak (one-third of the strength achieved at near field) and are probably not useful. The conditions that gave acceptable strength were weld energy of 750 J and pressure of 617 psi (4.3 MPa). The recommended interference at the shear joint should be at least 0.008 inch (0.2 mm).

Reference: *Amodel PPA Resins Engineering Data,* supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Snap Fit Assemblies

Amoco Performance Products: Amodel A1230L (material compostion: 30% mineral filler); **Amodel AS1133HS** (material compostion: 33% glass fiber reinforcement); **Amodel ET1000HS** (features: lubricated, impact modified, heat stabilized)

Table 34.1: Maximum strain recommendations for cantilever snap fits made from several grades of Amodel resins.

Amodel PPA grade	maximum strain, %
ET-1000HS	1.0
A-1230L	0.5
AS-1133HS	1.0

Reference: *Amodel PPA Resins Engineering Data,* supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Threaded Fasteners

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

When threaded metal fasteners are used to retain or secure plastic parts to an assembly, and the assembly is subjected to changes in temperature, the difference between the thermal expansion coefficients of the metal and the plastic can cause problems. When a threaded fastener is tightened, the fastener is elongated slightly and a compressive stress is generated on the substrate. This compressive stress maintains the tightness of the bolt.

When the assembly is heated, both the plastic part and the metal fastener will expand. The plastic part, however, is constrained by the metal fastener, and cannot expand. This results in increased compressive stresses in the plastic and a corresponding increased tendency for compressive creep or stress relaxation to occur. The relaxation of the compressive stress will result in reduced torque retention in the bolts.

To evaluate this tendency, 0.250 in. (6.4 mm) thick plaques of Amodel AS-1133 HS resin, 33% glass reinforced nylon 66 and 35% glass reinforced nylon 46 were bolted to a metal surface with steel machine bolts tightened to 60 in-lbs (6.8 N•m) of torque with a torque wrench compressing the plastic plaque under the bolt face. The temperature of the bolted assemblies was then raised to indicated temperatures, held for one hour, and then cooled to room temperature. The torque required to loosen the bolts was then measured.

The coefficient of thermal expansion of Amodel resin is lower than those of the other materials tested, and therefore closer to that of the steel. The smaller difference in thermal expansion results in lower induced stress due to the compressive strain caused by the thermal excursion in the constrained part. This translates to lower creep and therefore better torque retention for such bolted assemblies.

Reference: *Amodel PPA Resins Engineering Data*, supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Threaded Inserts

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

The figure depicts the recommended insert and boss designs for use with Amodel PPA resin.

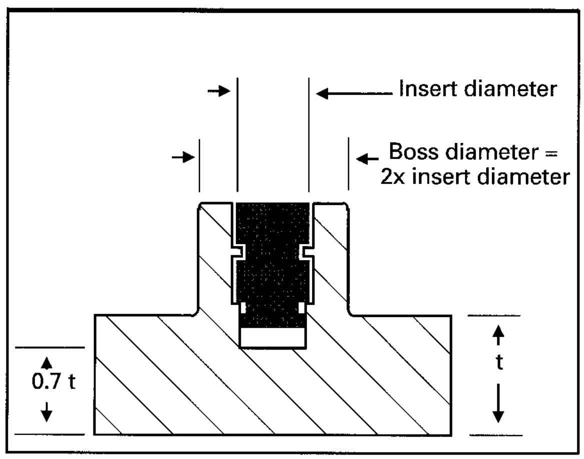

Figure 34.1: Boss design for ultrasonic inserts in Amodel PPA resin.

Reference: *Amodel PPA Resins Engineering Data*, supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.

Adhesive Bonding

Amoco Performance Products: Amodel AS1133HS (material compostion: 33% glass fiber reinforcement)

Injection molded samples of Amodel A-1133 HS resin were bonded with Fusor 305-1/-2 (two part epoxy) and Tyrite 7500 A/C (two part urethane) adhesives. Both adhesives were supplied by Lord Corporation.

To prepare the test specimens, a cure cycle of 30 minutes at 250°F (120°C) followed by conditioning at room temperature for 72 hours was used when the adhesive was Fusor 305-1/-2 adhesive. When the adhesive was the Tyrite 7500 A/C adhesive, the cure cycle used was 10 minutes at 200°F (90°C) followed by conditioning at room temperature for 72 hours.

Bond strengths were tested at low temperature, room temperature, and an elevated temperature. To evaluate the effect of humid aging, specimens were conditioned for 14 days at 100°F (38°C) and 100% relative humidity. Some specimens were tested immediately after conditioning; others were tested 24 hours after conditioning.

Impact performance was determined with a side impact tester according to GM 9751P. Lap shear values were measured on an Instron testing machine at 0.5 inch/minute according to ASTM D 1002. In general, the epoxy adhesive performed slightly better than the urethane. Acrylic adhesives are not recommended for use with Amodel resins.

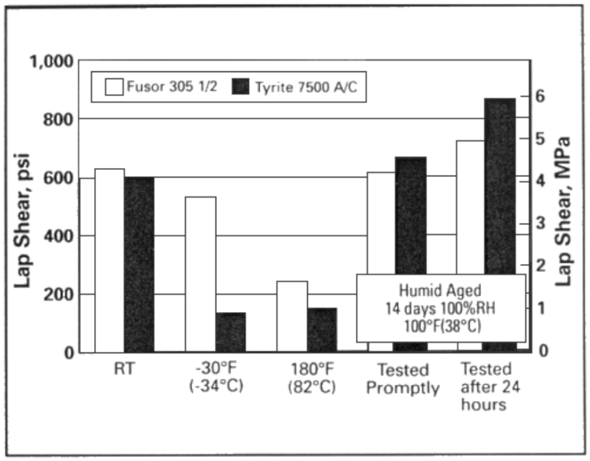

Figure 34.2: Lap shear bond strengths for Amoco Amodel AS1133HS 33% glass fiber reinforced PPA resin. (Fusor 305-1/-2 is a two part epoxy adhesive. Tyrite 7500 A/C is a two part urethane adhesive. Both adhesives are supplied by Lord Corporation).

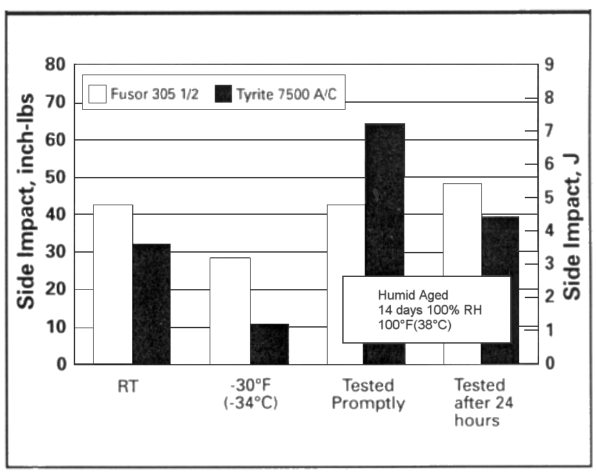

Figure 34.3: Side impact bond strengths for Amoco Amodel AS1133HS 33% glass fiber reinforced PPA resin. (Fusor 305-1/-2 is a two part epoxy adhesive. Tyrite 7500 A/C is a two part urethane adhesive. Both adhesives are supplied by Lord Corporation).

Reference: *Amodel PPA Resins Engineering Data*, supplier design guide (AM-F-50060) - Amoco Performance Products, Inc.