Chapter 41

Polyimide

Welding

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Kinel formulae cannot be welded because they are thermosets.

Reference: *Kinel Polyimide Compounds - Part Design, Processing,* supplier design guide (ST/AN/0187/008) - Rhone Poulenc.

Mechanical Fastening

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Screw flights should not be too fine - pitch (P) >= 1 mm; they can be tapered (S1) or round with a pitch of 2.5 to 4 mm. The flight should begin below the the edge and end a distance of P/2 above the base.

Metal inserts cause no problems with KINEL 5514 - 5504, 3515 and 4525. They can be pressed in after molding (self-drilling) or molded in. The latter is preferable.

Example: ring with a knurled steel insert diameter of 35 mm:

	Extraction torque
-molded in	>500 Nm
-0.2 mm compression on diameter	300-350 Nm
-0.3 to 0.5 mm compression on diameter	500 Nm

Self-drilling or self-tapping inserts must be strong enough to withstand distortion (e.g. warping of the inside thread) when they are inserted into the KINEL, which is very hard. Brass and light alloys should not be used. Steel is preferable.

Example: for a self-tapping screw diameter of 4.75 mm (thread root diameter of 3.3 mm), a preliminary hole diameter of 4.4 mm must be drilled, otherwise the plastic will chip.

Molded-in inserts can be anchored in the plastic by means of:

-diagonal knurling
-lengthwise knurling and hexagonal or square graining,
-radial holes around the edge.

Inserts should have a cylindrical shoulder to hold them in the mould and withstand the force of the plastic flow.

Reference: *Kinel Polyimide Compounds - Part Design, Processing,* supplier design guide (ST/AN/0187/008) - Rhone Poulenc.

Riveting

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Riveting is possible, but riveting conditions must be adapted to the Kinel formula used.

Reference: *Kinel Polyimide Compounds - Part Design, Processing,* supplier design guide (ST/AN/0187/008) - Rhone Poulenc.

Adhesive Bonding

DuPont: Kapton (note: cast with solvent evaporation to form a thermoplastic); **Vespel** (note: precipitated to form a "pseudo thermoplastic" which thermally degrades before its Tg but is not crosslinked)

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 and Super Bonder 414, both cyanoacrylate adhesives, achieved the highest bond strengths on the Vespel polyimide. Black Max 380, a rubber toughened cyanoacrylate adhesive, achieved the second highest bond strengths. Depend 330, a two-part no-mix acrylic adhesive, and Loctite 3105, a light curing acrylic adhesive, achieved the lowest bond strengths on Vespel. Black Max 380, Prism 401, Super Bonder 414, Depend 330, and Loctite 3105 all achieved substrate failure on the 5 mil (0.005 in) thick Kapton films.

Surface Treatments
The use of Prism Primer 770, in conjunction with Prism 401, resulted in either no effect or a statistically significant decrease in the bondability of polyimide.

Other Information
When bonding polyimide films, an accelerator may be necessary to speed the cure of cyanoacrylates. Polyimide is compatible with all Loctite adhesives, sealants, primers, and activators. Recommended surface cleaners are isopropyl alcohol and Loctite ODC Free Cleaner 7070.

Table 41.1: Shear strengths of polyimide to polyimide adhesive bonds made using adhesives available from Loctite Corporation. Values are given in psi and (MPa).[d,e]

Plastic Material Composition (DuPont Polymers Vespel and Kapton)		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)
Vespel SP-1	unfilled	1550 (10.7)	2200 (15.2)	350 (2.4)	1650 (11.4)	1150 (7.9)	800 (5.5)
Vespel SP-21	15% graphite	1400 (9.7)	2250 (15.5)	850 (5.9)	2350 (16.2)	550 (3.8)	1000 (6.9)
Vespel SP-22	40% graphite 10% PTFE	550 (3.8)	850 (5.9)	400 (2.8)	1000 (6.9)	500 (3.5)	250 (1.7)
Vespel SP-211	15% graphite 10% PTFE	400 (2.8)	550 (3.8)	600 (4.1)	700 (4.8)	200 (1.4)	200 (1.4)
Kapton HN	5 mil thick 500 gauge film	>800[a,b,c] (>5.5)[a,b,c]	>800[a,c] (>5.5)[a,c]	650[c] (4.5)[c]	>800[a,c] (>5.5)[a,c]	>800[a,c] (>5.5)[a,c]	>800[a,c] (>5.5)a,c
Kapton HPP-ST	5 mil thick 500 gauge film	>800.[b,c] (>5.5)[a,b,c]	>800[a,c] (>5.5)[a,c]	600[c] (4.1)[c]	>800[a,c] (>5.5)[a,c]	>800[a,c] (>5.5)[a,c]	>800[a,c] (>5.5)[a,c]
Kapton HPP-FST	5 mil thick 500 gauge film	>800[a,b,c] (>5.5)[a,b,c]	>800[a,c] (>5.5)[a,c]	450[c] (3.1)[c]	>800[a,c] (>5.5)[a,c]	>800[a,c] (>5.5)[a,c]	>800[a,c] (>5.5)[a,c]

[a] The force applied to the test specimens exceeded the strength of the material resulting in substrate failure before the actual bond strength achieved by the adhesive could be determined.
[b]TAK PAK 7452 Accelerator was used in conjunction with Black Max 380.
[c]The Kapton films were bonded to aluminum lap shears prior to evaluation.
[d] All testing was done according to the block shear method (ASTM D4501).
[e] 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.

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Articles made of Kinel can be assembled with the following adhesives, most of which are epoxy. These references are given as examples. Their resistance to high temperatures should however be checked according to the application:

Adhesive	Use temperature
-Loctite 620	240°C
-Loctitie 648	175°C
-Eccobond 104 (Cummings)	290°C
-Metlbond 388 (Narmco)	190°C
-9309 (Ciba-Geigy)	
-Eccobond 45 and Catalyst 15	

Reference: *Kinel Polyimide Compounds - Part Design, Processing,* supplier design guide (ST/AN/0187/008) - Rhone Poulenc.