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<p>SUMMARY</p> <p>"Teflon" film, applied as a fused coating to metal molds and gluing fixtures, can act as a release medium without adhering to an epoxy resin surface such as Hysol 13-009. This mold release capability of "Teflon" is useful when contamination of a resin surface cannot be tolerated. "Teflon" and Ram 225 (Silicone) are compared as release agents. They are about equal in terms of the force required to separate a mold from its resin casting. "Teflon" is superior in its resin casting cleanliness, but its film is susceptible to mechanical damage. Considering these qualities, "Teflon" can be a useful material, but its application must be chosen with care.</p> <p>* Du Pont trade-mark</p>		
KEY WORDS		

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MOLD RELEASE CAPABILITY OF "TEFLON" FILMS FUSED ONTO METALLIC MOLDS

INTRODUCTION

In various designs that the Neutron Devices Department (NDD) is required to build, two-stage potting operations create an interface such as resin-to-resin, foam-to-foam, or conductive epoxy-to-ceramic. This interface has been subject to electrical and mechanical failures; contamination of the interface is suspected as the cause.

More specifically, when an encapsulated assembly is removed from a mold, or an adhered part is removed from its gluing fixture, mold release such as Ram 225 (Silicone) adheres to the resin surface. If this assembly is to be encapsulated again as part of a larger unit, the mold release must be removed to prevent failure at the interface. Normally a sandblasting or vaporhoning cleaning of the resin surface is performed to remove silicone mold release. These cleaning methods introduce contamination such as sand into the surface.

This investigation was undertaken to find a material which possessed good releasing qualities but which would not adhere to the casting resin or adhesives. "Teflon" and Ram 225 films were applied onto metallic mold parts and their mold release properties were compared.

PROCEDURE AND RESULTS

Two configurations were designed to test the releasing properties of "Teflon" films. One placed the "Teflon" to-resin interface in compression, the other placed it under tension. For these configurations, NDD selected steel cylindrical molds (2.25-inch diameter by 4-inch length) and stainless steel rods (3/4-inch diameter by 5-inch length) for "Teflon" coatings. The casting resin has a greater coefficient of expansion than that of the metal mold. Therefore, when cooled to room temperature from cure temperature (160°F), the interface in the cylindrical mold is in tension and the interface of the rod configuration is in compression.

The surfaces of the steel molds and stainless steel rods were prepared for 'Teflon' coating by vaporhoning with a 140 'aluminum oxide' grit slurry, followed by ultrasonic cleaning in water and alcohol. These surfaces were then spray coated with a 'Teflon' pigmented surface primer No. 851-204. A single coat thickness of 0.3 to 1.5 mils is recommended for this primer; thicknesses greater than 1.5 mils cause 'mud cracking' on subsequent operations. To set the primer, 10 to 20 minutes at 125 to 150°F was required. Routine inspection of the coated piece parts was made at this time to ensure that 'mud cracking' had not occurred. If it had, a water wash removed the primer, which could then be reapplied.

After the initial set of the primer, the piece parts were placed in a 450 to 500°F circulating oven for 30 to 45 minutes. Multiple applications of the primer were avoided, since additional applications apparently weaken the bond of primer to metallic substrate, resulting in primer separation.

A top coating of 'Teflon' 852-201 clear finish was applied to the primed metallic surface of the piece parts to promote full release from cured Hysol 13-009 epoxy resin. This clear finish was applied in the same manner as the primer, except for the final bake temperature—one hour at 725 to 775°F. Contrary to the behavior of primer, multiple coatings of clear finish increased releasing quality as well as durability of the overall coatings. For the piece parts mentioned, three coats of 852-201 were applied.

"TEFLON" FILM VERSUS RAM 225

Table I shows comparative test results obtained in removing cast Hysol 13-009 resin samples from cylindrical molds coated with either 'Teflon' or Ram 225 mold release. Test values were obtained using an Instron tensile tester at a crosshead speed of two inches per minute. Figure 1 shows the cylindrical mold, mounting fixture, and a cast sample being removed by the Instron tester. In the Figure 1 configuration, casting resin cure shrinkage, and large differences in coefficient of expansion between the resin and the mold cause the resin-to-release medium interface to be in tension. With the resin-to-release agent in tension, Table I values show that the releasing qualities of the respective coatings are about equal.

Table I
FORCES REQUIRED TO SEPARATE SAMPLE
FROM CYLINDRICAL SHELL*

Ram 225 - Coated Molds	"Teflon" - Coated Molds
Separating Shear Stress (psi)	Separating Shear Stress (psi)
0.36	1.07
3.32	2.79
4.28	2.46
10.06	6.79
1.78	5.29
0.56	5.61
4.65	3.04
0.43	6.24
6.79	0.86
5.55	1.96
<u>4.65</u>	<u>2.07</u>
Average 3.86	Average 3.47
σ 3.01	σ 2.12

* Sample: Hysol 13-009 epoxy resin, vacuum potted and cured 16 to 24 hours at $130 \pm 5^\circ\text{F}$, followed by 16 to 24 hours at $160 \pm 5^\circ\text{F}$. Surface area of sample: 28 square inches.

Note: Samples at $74 \pm 2^\circ\text{F}$ at time of testing.

Two sets of rods, one set coated with "Teflon," the other with Ram 225, were cast in 6-ounce containers. The resin completely surrounded the rod to a depth of four inches. With this design, the epoxy-to-coating interface is in compression, Figure 2. To facilitate removal of the rod from cured resin, vent holes were drilled into the bottom of the casting. Test results were obtained at 160°F and at room temperature. Table II shows that the "Teflon" requires approximately one-third less force than Ram 225 at room temperature. However, at 160°F the values appear to be about equal.

Figure 1. Instron Tensile Tester Separating Tension Sample

Table II
FORCES REQUIRED TO SEPARATE EMBEDDED ROD
FROM CASTING*

Ram 225 - Coated Sample		"Teflon" - Coated Sample	
Tested at $74 \pm 2^\circ\text{F}$	Tested at $160 \pm 5^\circ\text{F}$	Tested at $74 \pm 2^\circ\text{F}$	Tested at $160 \pm 5^\circ\text{F}$
Separating Shear Stress (psi)	Separating Shear Stress (psi)	Separating Shear Stress (psi)	Separating Shear Stress (psi)
47.75	0.53	6.58	1.29
50.93	0.34	5.33	3.82
48.28	2.34	31.83	1.01
30.63	1.90	1.93	1.09
6.19	1.37	0.67	1.01
8.23	1.08	0.21	0.32
1.27	1.27	11.46	0.32
11.49	--	6.86	2.02
0.95	--	4.46	0.53
--	--	19.37	1.25
Avg 22.86	Avg 1.26	Avg 8.87	Avg 1.27
σ 21.45	σ 0.71	σ 9.86	σ 1.09

* Sample: Stainless steel rods: 0.75-inch diameter by 6-inch length.
Average "Teflon" build on rods: 0.3 mil.

DISCUSSION AND RECOMMENDATIONS

Because of probable contaminating effects, the use of silicone mold releases such as Ram 225 is undesirable if the molded plastic part will later be overcast with resin. Results indicate that baked "Teflon" coatings will eliminate both resin contamination and the need for additional release agents. However, the susceptibility of "Teflon" to mar, scratch, and abrade compared to hardened mold released tooling indicates that "Teflon" coatings on tooling should be limited to areas where mold release contamination cannot be tolerated.

Figure 2. Instron TensileTester Separating Compression Sample

Where application of a "Teflon" coating is preferred to silicone mold release as a release agent, the substrate surface design should be carefully considered. If possible, sharp radii (less than 1/16 in.) and small or blind holes (less than 1/8 in.) should be avoided as they tend to cover nonuniformly.

"Teflon" films wear longer by using soft metallic substrates. Therefore, it is recommended that aluminum or soft steel be used as a substrate. Copper is undesirable as a substrate due to its tendency to form an oxide rapidly at the 725 to 775°F bake temperature. Furthermore, the bond to the oxide is considerably weaker than the "Teflon" bond to other metals.