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13-DEVELOPMENT OF IMPROVED H.E. ADHESIVE SYSTEMS

Adhesive System Studies: A continuous survey of commercially available adhesives and bonding methods for their properties and adaptability to production.

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ABSTRACT

A heat ageing study in which tensile specimens (aluminum-to-aluminum and aluminum-to-LX-04-1 with Aerobond H-7) were heated to 165°F. and aged up to three months has been completed. Aerobond H-7 showed no signs of deterioration when treated in this manner.

Butyl glycidyl ether and benzene were tested as diluents for Aerobond H-7; butyl glycidyl ether is an effective diluent but benzene appeared to promote an exotherm.

Water permeabilities were remeasured for Adiprene, Aerobond H-7, and Estane to resolve the questionable data gathered earlier. Kel-F, Perm-A-Lon, and Aerobond H-7 are by far the most impermeable to water.

The disc extrudability test was run on the new lot of LX-02-1, A-335, both milled and unmilled materials.

PREVIOUS APPLICABLE WORK

Viscosity adjustment studies were made with allyl glycidyl ether; several mixtures were tested for strength and its effectiveness in reducing viscosity. Although 20 pph of A.G.E. will reduce Aerobond's viscosity from 600 to 105 cps at 165°F., the most effective mix is 10 pph A.G.E. which will reduce Aerobond's viscosity to 450 cps at 76°F. but will not drastically reduce its strength.

Thin, smooth, dimple-free films of Adiprene, Perm-A-Lon, Kel-F, and Estane have been prepared and their water permeabilities were measured. Kel-F, Perm-A-Lon,

and Estane are impermeable to moisture, but being thermoplastics require evaporation of a solvent to set, and, therefore, cannot be used in closed quarters where the surface is not exposed to the atmosphere. Adiprene may be applied easily and will set in closed quarters, but it is permeable to moisture. Aerobond's water permeability was measured by spraying it on a filter paper and measuring the water loss through both; it is impermeable to moisture.

The Dillon Tester was installed last quarter and preliminary peel strength tests were run. Rubber was bonded to aluminum with Aerobond H-7 and Adiprene and their peel strengths measured 14 pounds/inch of width for Aerobond, and 12 pounds/inch of width for Adiprene.

The disc extrudability test was set up last quarter and the test was run for three lots of LX-02-1 on different surfaces. All tests were made at ambient temperature (50°C.). LX-02-1, Lots A-186 and A-188, were milled on the rubber roll mill and yielded values compared to those obtained at LRL. Lot A-187, which was tested as received from the vendor, yielded slightly lower values than the other two lots.

DISCUSSION

AEROBOND H-7

A heat ageing study was designed to study Aerobond H-7's physical properties at elevated temperatures for a prolonged period of time. Tensile specimens, both aluminum-to-aluminum and aluminum-to-LX-04-1, were bonded with a 2-mil film of Aerobond H-7, then stored at 165°F. for one, two, and three months, and cooled to ambient for testing. The results are shown in Table I.

Table I

Heat Ageing of Aerobond H-7
Tensile Strength
(psi)

Tested at Ambient Temperature and 0.005 in/min.

<u>Control</u>		<u>30 Days @ 165°F.</u>	
<u>Al-to-Al</u>	<u>Al-to-LX-04-1</u>	<u>Al-to-Al</u>	<u>Al-to-LX-04-1</u>
1920	336	3680	384
1808	290	3886	328
1660	360	3460	357
1352	400	3580	350
1992	372	3000	352
1272	350	3360	375
1667	352	3493	358
720	110	886	56
		Avg.	
		Spread	
<u>60 Days @ 165°F.</u>		<u>90 Days @ 165°F.</u>	
<u>Al-to-Al</u>	<u>Al-to-LX-04-1</u>	<u>Al-to-Al</u>	<u>Al-to-LX-04-1</u>
3420	362	4016	362
5520	377	4596	302
4940	356	2888	336
4260	227	3724	344
4100	308	3812	350
3280	319	2952	344
4253	325	3665	340
2240	150	1644	60
		Avg.	
		Spread	

It appears that Aerobond H-7 has not deteriorated when subjected to hot temperatures that might be encountered by the explosive.

Some work has been done with allyl glycidyl ether as a diluent for Aerobond H-7, primarily for its usage as a patch material, also for applications requiring good

sprayability. Two new diluents were checked, butyl glycidyl ether (B.G.E.) and benzene. Benzene, when mixed with Aerobond H-7, was very highly exothermic. Its pot life was only nine minutes and it set as a hard, rigid material overnight. Butyl glycidyl ether reacted somewhat like allyl glycidyl ether, except that after an overnight set period, the material was somewhat flexible. B.G.E. also was more detrimental to Aerobond's strength than A.G.E. Its pot life was approximately 16 minutes.

Chromatograms, viscosities, and torsional shear strengths were measured for various mixes of both diluents; the chromatogram data are listed in Table II, the strength-viscosity data in Figure 1.

Table II

Gas Chromatograph Test Results
22 Hours @ 120°C.

Gas Evolved in μ liters @ S.T.P.
0.250 g. of Explosive, 0.25 g. of Other Material

	<u>N₂ + O₂</u>	<u>NO + CO</u>	<u>N₂O</u>	<u>CO₂</u>	<u>Total</u>
HMX	38	0	12	4	54
Aerobond H-7	22	0	0	2	24
H-7/B.G.E.	13	0	0	9	22
H-7/B.G.E. + HMX	11	6	46	14	77
H-7/Benzene	12	0	0	14	26
H-7/Benzene + HMX	27	5	0	48	80

(All tests after set up of the mix)

Figure 1
Effect of Butyl Glycidyl Ether Upon
Strength & Viscosity of Aerobond H-7

H.E. COATING

The study to evaluate materials for coatings for H.E. surfaces is continuing in an attempt to find one impermeable to moisture, and fairly resistant to abrasion. Several materials have been tested, primarily for water permeability. Water permeabilities of Adiprene, Aerobond H-7, Perm-A-Lon, Kel-F, and Estane have been measured previously, but some of the data have not been conclusive. The varying values, particularly for Adiprene and Estane, may have been due to poor quality films, small voids (especially in those films sprayed on filter paper, which cannot be inspected), and possibly to the test itself. It appears that the test is sensitive to atmospheric conditions.

The water permeability of Aerobond H-7 has been measured, but only for a film that was sprayed on filter paper, for which there is no method of inspecting. Aerobond's water permeability, along with those of Adiprene, Kel-F, and Estane, was measured during one time period to eliminate the effect of temperature and humidity changes. The results are shown in Table III.

Table III

Water Permeability
(mg/cm²/hr)

<u>Aerobond H-7</u>	<u>Adiprene</u>	<u>Kel-F</u>	<u>Estane</u>
0.093	0.868	0.108	0.403
0.108	1.162	0.062	0.418
<u>0.124</u>	<u>1.224</u>	-	<u>0.512</u>
Avg. 0.105	1.085	0.085	0.444

Aerobond appears to be a much better water barrier than Adiprene, and is comparable to Kel-F and Perm-A-Lon. Estane is somewhat better than Adiprene, but Kel-F and

Perm-A-Lon are better moisture barriers. Aerobond appears to be the most promising material as it is a thermosetting plastic and does not require evaporation of a solvent for curing; whereas, Kel-F and Perm-A-Lon are thermoplastics.

DISC TEST

The disc extrudability test (putty test) was set up in order to measure the relative extrudability of LX-02-1 and other paste explosives, and to measure lot-to-lot variations in LX-02-1. Last quarter preliminary tests were made on three lots of LX-02-1, one of which (Lot A-187) had not been milled prior to testing; its results were somewhat lower than the other two lots which had been milled. This quarter it was intended to recheck the values for milled material from Lot A-187, also to compare milled and unmilled material from a new lot, A-335.

It has been hoped that a large number of samples could be run for each lot and surface material to get a feeling for the reproducibility of the test. Due to a lack of time, only three samples were run for each condition, except for unmilled Lot A-335 in which ten were run. The standard deviations for all four surfaces were less than 0.1 cm, indicating rather good reproducibility.

Table IV

Disc Test

<u>Surface</u>	Disc Diameters of LX-02-1 (cm)			
	<u>Lot A-187</u>		<u>Lot A-335</u>	
	<u>Unmilled†</u>	<u>Milled</u>	<u>Unmilled</u>	<u>Milled</u>
Mylar	6.8	9.4	6.4	8.7
Plexiglas	7.0	7.9	6.4	7.6
Polyvinylchloride	-	8.5	6.3	7.6
Steel	6.8	7.6	6.2	7.4

†Values from last quarter's report.

It is quite evident from the results listed above that milling LX-02-1 increased its extrudability significantly. This was also apparent in other work, when both milled and unmilled material was placed into grooves. Unmilled LX-02-1 was spongy and sticky and pulled out of the groove easily.

FUTURE WORK; COMMENTS; CONCLUSIONS

The Dillon Tester was installed last quarter, and preliminary peel strength tests were made for Aerobond H-7 and Adiprene using a hard rubber backing material. This rubber backing material stretched during the test, thereby varying the actual speed of stripping and changing the test conditions. A sample of polyurethane, SEILON UR-29E¹, was tried and appears to stretch very little, possibly not enough to hurt the accuracy of the test, and bonds very well with Aerobond and Adiprene, the two materials tested. More of this material has been ordered and preliminary tests can be made as soon as it is available.

Our Tinius-Olsen Plastics Impact Tester has been installed and is being checked out now with standard Charpy and Izod impact specimens. One use for the tester is measuring the brittleness temperature of plastics by impact. Changes are being made now to adapt the machine to a test patterned after ASTM D746-57T, in which the brittleness temperature is that at which plastics exhibit brittle fracture under specified impact conditions. A method of molding the test specimens is also being considered.

Butyl glycidyl ether may prove to be more useful as a diluent for Aerobond H-7 than allyl glycidyl ether. B.G.E. is slightly more effective in reducing viscosity, but its apparent flexibilizing effect on Aerobond may prove to be more useful.

Thermal shock tests should show much more about its value in this area.

¹Seiberling Rubber Company.