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NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND



TECHNICAL MEMORANDUM

REPORT NO: NAWCADPAX/TM-2008/124

DURABILITY TESTING OF POLYMER D MATERIAL

by

**Dr. Matthew Tillman
Mr. William Koegel
Mr. Michael Bosak
Dr. David John Barrett**

16 September 2008

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SUMMARY

Viscoelastic damping materials are used to control resonant vibrations in mechanical and structural systems. Before these materials can be applied to a naval air application, they must demonstrate an ability to survive the aggressive marine operating environment. This report documents the results of a laboratory investigation into the durability of the Polymer D damping material. In general, Polymer D was found to have adequate durability as long as it is shielded from excessive exposure to operational fluids.

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INTRODUCTION

BACKGROUND

1. Viscoelastic materials reduce vibrations in structural and mechanical systems by converting kinetic energy to heat (references 1 and 2). Viscoelastic damping treatments have been employed by the Navy to solve problems associated with resonant vibrations and high cycle fatigue (reference 3). Before a viscoelastic material can be applied in a naval repair or a vibration control design, its in-service environmental durability must be evaluated.

PURPOSE

2. The objective of the work reported here was to perform a laboratory assessment of the durability of Polymer D. Polymer D is a commercially available viscoelastic material that is manufactured by the Soundcoat Corporation.

METHODS

MATERIAL EXPOSURE

3. The Navy operates and maintains its carrier-based aircraft under austere conditions. The salt spray marine environment, coupled with the cramped industrial conditions on the flight and hanger decks, presents aggressive chemical and corrosive hazards to aircraft structure. Any repairs or improvements to aircraft structure must be designed to reliably maintain function under these conditions.

4. Durability tests are typically performed to ensure that a damping treatment would be suitable for sea-based operations. Since damping materials are not like typical structural adhesives, the durability tests for qualifying these materials for in-service application are patterned on the approaches taken for appliqué and pressure sensitive adhesive materials. A simple lap shear test suffices for establishing the mechanical properties and durability behavior. The single lap shear strength of Polymer D was measured under the following test conditions:

- a. Room temperature (70°F, baseline)
- b. Elevated temperature (testing performed at 120°F, 150°F, 180°F, and 200°F)
- c. Hot/Wet/RT (exposed 28 days to 140°F and 95% relative humidity, tested at 70°F)
- d. Hot/Wet/Hot (exposed 28 days to 140°F and 95% relative humidity, tested at 180°F)
- e. Fuel (exposed 7 days to JP-5 at 140°F, tested at 70°F)

- f. Hydraulic fluid (exposed 24 hr to MIL-H-5606F fluid at 150°F, tested at 70°F)
- g. Lubrication oil (exposed 24 hr to MIL-PRF-23699F oil at 150°F, tested at 70°F)
- h. Cold temperature (exposed to and tested at -65°F)
- i. Neutral salt fog (exposed 28 days to ASTM B117 salt spray, tested at 70°F)
- j. Acidified salt fog (exposed 7 days to ASTM G85 Annex 4 SO₂ salt spray, tested at 70°F)

LAP SHEAR TESTING

5. The single lap shear test specimens consisted of two 1-in. wide 7075-T6 aluminum plates bonded together at one end by the damping material. Prior to assembly, the plates were phosphoric acid anodized per ASTM D3933 and coated with BR-127 primer (Cytec Engineered Materials). The overlap length in the bond area was 1 in. A clamping load of approximately 2 psi was applied for 48 hr to the spliced area to enhance the bond. The specimens were stored in a desiccator until removed for exposure and testing. The durability tests were performed in the Materials Engineering Laboratory at the Patuxent River Naval Air Station. The testing was performed per ASTM D1002 using a crosshead speed of 0.05 in./min. Five replicates were performed for each type of environmental test.

DISCUSSION

6. The peak load and shear stress data for each of the tested specimens is shown in tables 1 and 2. Figures 1 and 2 are graphical depictions of this data.

Table 1: Lap Shear Test Data for Polymer D

No. 1 Room Temperature

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	None	70	90	169	
2	“	“	68	118	
3	“	“	76	138	
4	“	“	76	137	
5	“	“	78	141	
		Average	78	141	
		Std. Deviation	8	18	

No. 2 Elevated Temperature

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	None	180	6	11	
2	“	“	9	17	
3	“	“	7	14	
4	“	“	15	30	
5	“	“	13	26	
		Average	10	20	
		Std. Deviation	4	8	

Table 1: (Cont'd)

No. 3 Hot/Wet

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	28 days at 95% RH/140°F	70	84	163	
2	“	“	94	182	
3	“	“	87	170	
4	“	“	75	145	
5	“	“	73	140	
		Average	83	160	
		Std. Deviation	9	17	

No. 4 Hot/Wet Elevated Temperature

Specimen No.	Exposure	Temperature (F°)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	28 days at 95% RH/140°F	180	23	43	
2	“	“	16	29	
3	“	“	13	24	
4	“	“	21	40	
5	“	“	22	43	
		Average	19	36	
		Std. Deviation	4	9	

Table 1: (Cont'd)

No. 5 Fuel Exposure

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	7 days at 140°F in JP-5	70	0	0	Specimen fell apart after fuel soak.
2	“	“	11	21	
3	“	“	10	19	
4	“	“	16	30	
5	“	“	9	18	
		Average	9	17	
		Std. Deviation	6	11	

No. 6 Hydraulic Fluid Exposure

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	24 hr at 150°F in H fluid	70	38	70	
2	“	“	43	82	
3	“	“	41	78	
4	“	“	63	119	
5	“	“	53	98	
		Average	47	90	
		Std. Deviation	10	20	

Table 1: (Cont'd)

No. 7 Lubrication Oil Exposure

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	24 hr at 150°F in lube oil	70	12	22	
2	“	“	95	185	
3	“	“	4	8	
4	“	“	96	186	
5	“	“	84	157	
		Average	58	112	
		Std. Deviation	46	89	

No. 8 Cold Temperature

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	None	-65	534	1,040	
2	“	“	802	1,554	
3	“	“	697	1,377	
4	“	“	745	1,428	
5	“	“	-	-	Test was interrupted before completion.
		Average	695	1,350	
		Std. Deviation	115	220	

Table 1: (Cont'd)

No. 9 Neutral Salt Fog

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	28 day Salt Spray	70	78	146	
2	“	“	77	146	
3	“	“	59	110	
4	“	“	80	155	
5	“	“	76	148	
		Average	74	141	
		Std. Deviation	9	18	

No. 10 Acidified Salt Fog

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	7 day SO ₂ Salt Spray	70	62	119	
2	“	“	33	65	
3	“	“	76	148	
4	“	“	41	80	
5	“	“	81	157	
		Average	59	114	
		Std. Deviation	21	40	

Table 1: (Cont'd)

120°F

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	None	120	20	39	
2	“	“	16	31	
3	“	“	27	52	
4	“	“	33	64	
5	“	“	36	69	
		Average	26	51	
		Std. Deviation	8	16	

150°F

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	None	150	13	25	
2	“	“	8	16	
3	“	“	23	45	
4	“	“	27	54	
5			23	43	
		Average	19	37	
		Std. Deviation	8	16	

Table 1: (Cont'd)

200°F

Specimen No.	Exposure	Temperature (°F)	Peak Load (lb)	Peak Stress (psi)	Failure Mode/Comments
1	None	200	13	25	
2	“	“	12	24	
3	“	“	12	23	
4	“	“	14	27	
5	“	“	13	26	
		Average	13	25	
		Std. Deviation	1	1	

Table 2: Lap Shear Test Data for Polymer D

Summary		
Temperature (°F)	Average Peak Load (No.)	Average Peak Stress (psi)
75	78	141
120	26	151
150	19	37
180	10	20
200	13	25

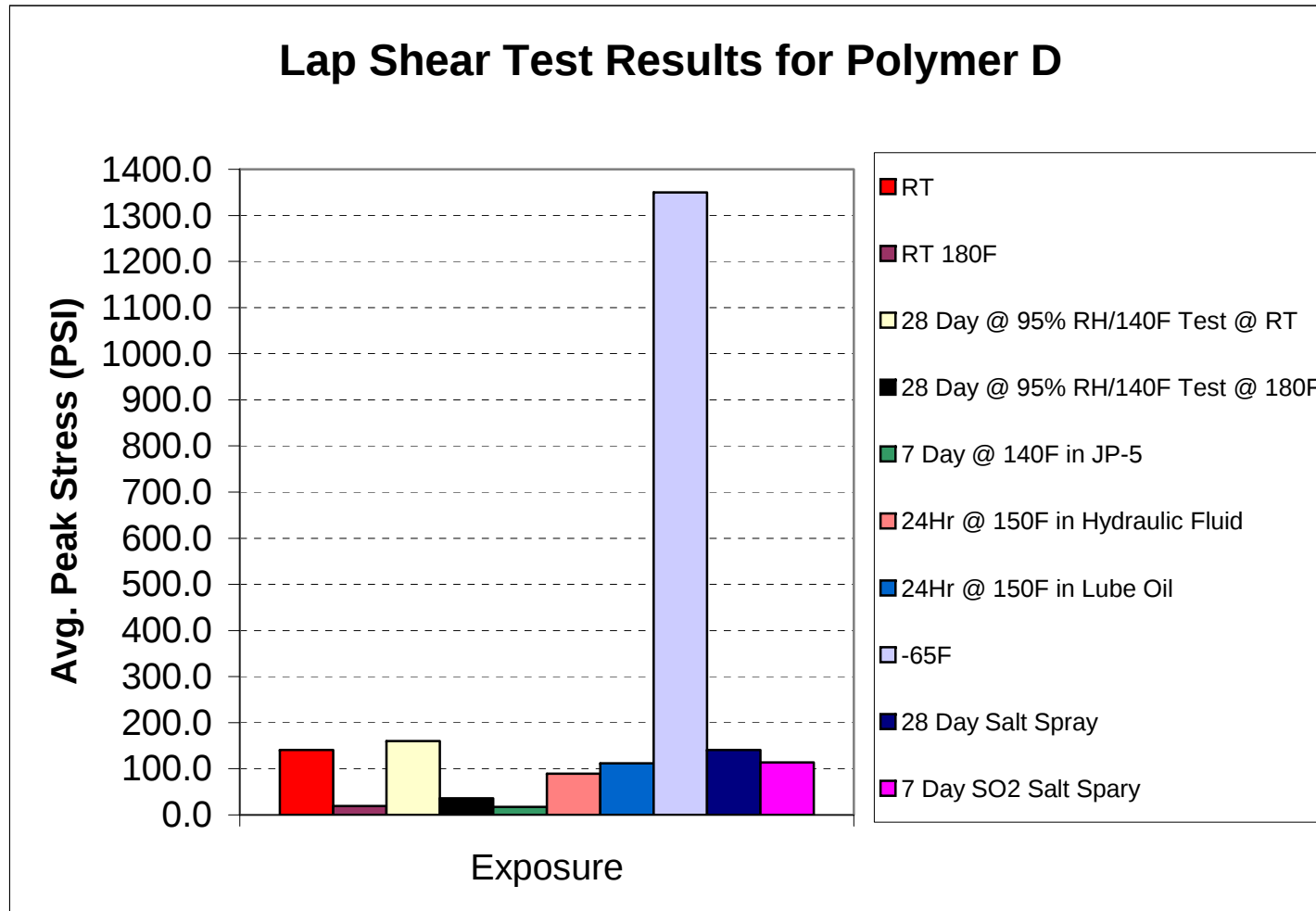


Figure 1: Average Peak Stress for Single Lap Shear Tests, Polymer D

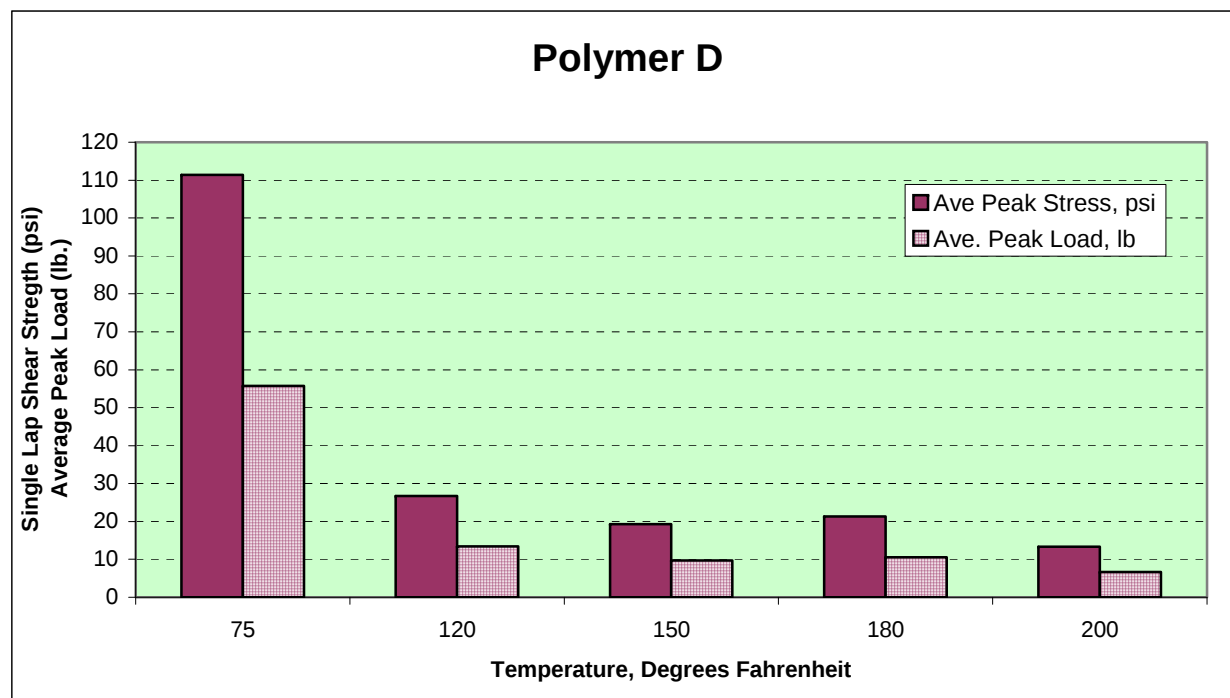


Figure 2: The Effects of Temperature on the Single Lap Shear Strength of Polymer D

CONCLUSIONS

Polymer D performed well for the elevated temperature, cold soak, and salt fog tests. However, under the aggressive fluid exposure tests, the fluids leached into the bond line and affected the strength of the joint. In the long term, this absorption would cause irreversible damage as the fuel attacks the chemical structure of the damping material.

In previous work on appliqué and damping materials, a lap shear strength of 2 lb/in. width has been used by the Navy when applications were not in the airstream. Polymer D satisfied this criterion for all of the tested conditions except for the JP-5 fuel soak test.

Based on the test data, it is concluded that there will be no durability and integrity concerns with the use of Polymer D as long as it is shielded from excessive fluid exposure and unusual shear loads. Under these conditions, a damping treatment employing Polymer D should remain in place and will be able to withstand the operational environment.

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