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USAAVLABS TECHNICAL REPORT 69-35

FIELD APPLICATION STUDY AND ENVIRONMENTAL AND BALLISTICS EVALUATION OF VITHANE SEALING MATERIALS

By

Edwin J. Koski

April 1969

U. S. ARMY AVIATION MATERIEL LABORATORIES FORT EUSTIS, VIRGINIA

CONTRACT DAAJ02-68-C-0020
THE GOODYEAR TIRE & RUBBER COMPANY
AKRON, OHIO

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This report was prepared by the Goodyear Tire and Rubber Company, Akron, Ohio, under the terms of Contract DAAJ02-68-C-0020. The purpose of this effort was to conduct a feasibility study to determine the field application of Vithane materials to fluid-containing aircraft components for protection against .30 and .50 caliber ballistic impacts.

The results contained herein are believed to be valid by this Command.

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FIELD APPLICATION STUDY AND ENVIRONMENTAL AND BALLISTICS EVALUATION OF VITHANE SEALING MATERIALS

Final Report

Goodyear Tire & Rubber Company GTR-19-596

By

Edwin J. Koski

Prepared by

The Goodyear Tire & Rubber Company
Akron, Ohio

for

U.S. ARMY AVIATION MATERIEL LABORATORIES
FORT EUSTIS, VIRGINIA

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ABSTRACT

This report presents the results of the environmental and ballistics study of Vithane sealing materials subjected to various environmental and ballistic conditions. Work was also conducted in testing two adhesive systems. This evaluation resulted in recommendations to limit the use of these materials to certain environmental conditions.

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VITHANE COATINGS AND TEST PROCEDURE

GENERAL

Vithane coatings were developed by The Goodyear Tire & Rubber Company to provide self sealing of critical fuel lines, fuel filters, oil tanks, and transmission cases from penetration by projectiles up to .50 caliber.

The original Vithane coatings developed by The Goodyear Tire & Rubber Company were designated FLC-1 and FLC-2. Both are self-sealing coverings devised to seal wounds in aircraft liquid containers inflicted by enemy gunfire. FLC-1 differs from FLC-2 in that a reinforcing fabric and a sealant are encapsulated in Vithane, where FLC-2 encapsulates the liquid container with Vithane only.

A third construction designated FLC-4 was later developed. Its composition is similar to that of FLC-1 except that it eliminates the need for tooling such as molds since the materials are applied manually using only simple hand tools.

An environmental and ballistic evaluation of Vithane sealing materials bonded to aluminum and magnesium with two adhesive systems was authorized by USAAVLABS. The requirements of this study were that the test panels be subjected to environmental conditions, detailed in MIL-STD-810A, Environmental Test Methods for Aerospace Group Equipment, at various elevated temperatures. Further, these samples were to be vibration tested and gunfired under specified conditions.

DESCRIPTION OF SAMPLES AND TESTS

Three panels of Vithane self-sealing coating FLC-1, FLC-2, and FLC-4 (6 in. by 18 in.) were applied to each of 38 aluminum panels (24 in. by 24 in. by 0.032 in.; 6061-T6). See Figure 1 for a diagram. Eighteen were built with 2398-C and 2379-C adhesive systems and were serial numbered B-1 through B-18. Eighteen were built with the 80C10 adhesive system and were serial numbered U-1 through U-18. Two control aluminum panels numbered Original 1 and Original 2 were constructed using the same sealing materials and two adhesive systems. Original 1 panel was made using the 80C10 adhesive system and Original 2 panel was made using the 2379-C and 2398-C adhesive system. These panels were not subjected to any environmental testing; they were, however, gunfired.

Four magnesium panels (6 in. by 12 in. by 1/2 in.) numbered Mag 1 through Mag 4 were built using FLC-4 construction and 80C10 adhesive system. See Figure 2.

The samples were subjected to environmental testing in accordance with MIL-STD-810A for fungus, salt fog, dust and sand, and modified humidity and temperature cycling.

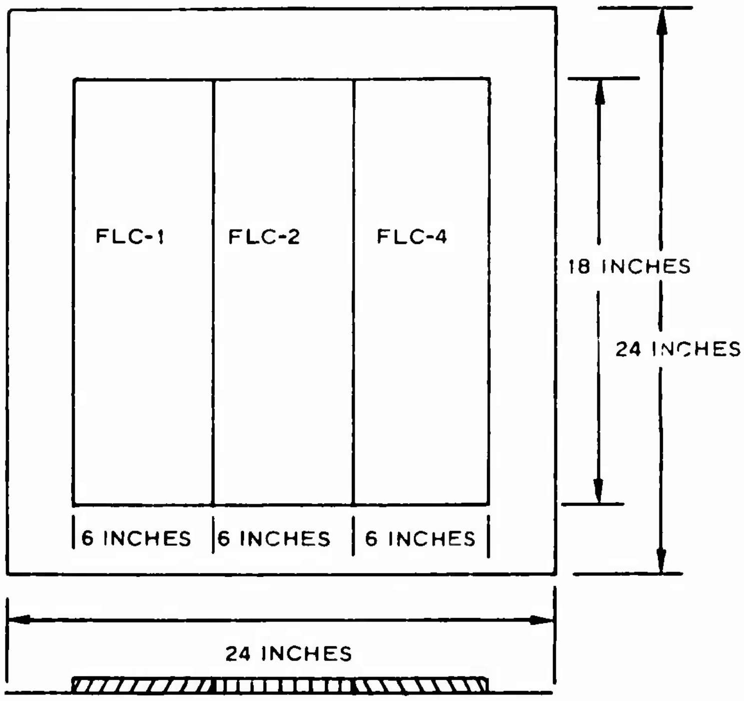

Figure 1. Aluminum Test Panel.

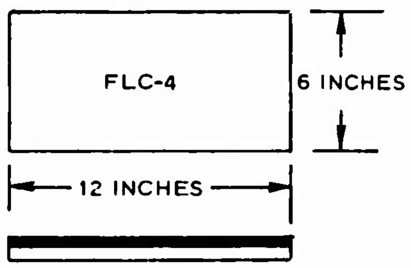

Figure 2. Magnesium Test Panel.

A fungus test per MIL-STD-810A, Method 508.1, was performed on panels B-1 through B-11, U-1 through U-11, and Mag 1 through Mag 4.

A salt fog test per MIL-STD-810A, Method 509.1, was performed on panels B-2 through B-12, U-2 through U-12, and Mag 1 through Mag 4.

A sand and dust test per MIL-STD-810A, Method 510.1, was performed on panels B-3 through B-11, U-3 through U-11, B-13 and U-13, and Mag 1 through Mag 4.

The temperature and humidity test was performed according to the following procedure on each of the named panels at the temperature noted.

1. Start at 70°F and 95 percent RH.
2. Increase temperature to X°F in 10 min.
3. Hold at X°F for 3.5 hr.
4. Decrease temperature to 150°F in 30 min.
5. Hold at 150°F for 1 hr.
6. Repeat steps 2 through 5, three times.
7. Decrease temperature to 70°F in 20 min.
8. Hold at 70°F and 95 percent RH for 3 hr.
9. Repeat steps 1 through 8, 75 times.

Temperature X referred to in steps 2 and 3 had four values:

1. X = 225°F
2. X = 250°F
3. X = 300°F
4. X = 350°F

Panels B-4 and U-4, B-8 and U-8, B-14 and U-14, and Mag 1 were tested at temperature X = 225°F.

Panels B-5 and U-5, B-9 and U-9, B-15 and U-15, and Mag 2 were tested at temperature X = 250°F.

Panels B-6 and U-6, B-10 and U-10, B-16 and U-16, and Mag 3 were tested at temperature X = 300°F.

Panels B-7 and U-7, B-11 and U-11, B-17 and U-17, and Mag 4 were tested at temperature X = 350°F.

Vibration tests were conducted on eight panels at the following conditions:

1. Displacement, 0.032 + 0.010 - 0.000 in.
2. Speed, 1050 ± 100 rpm
3. Time, 80 hr
4. Temperature, ambient

The test panels were attached to the gunfire test cube, and the cube was fastened to the table of the vibration tester. The vibration tester is shown in Figure 3.

Panels that were vibration tested were: B-8 and U-8, B-9 and U-9, B-18 and U-18, and Mag 1 and Mag 2.

The gunfire test was conducted on each of the three self-sealing constructions on aluminum panels using two rounds of .30-caliber and two rounds of .50-caliber AP ammunition. One .30-caliber round and one .50-caliber round were fired at a zero degree angle of obliquity. The second .30-caliber and .50-caliber rounds were fired at a 45-deg angle of obliquity into each FLC-1, FLC-2, and FLC-4 panel. The firing distance was 75 ft. The aluminum test panels were attached to the gunfire test cube shown in Figure 4. The test cube was two-thirds filled with JP-4 aviation fuel to detect a leak or seal after the cube was ruptured.

The panels gunfired were B-1 and U-1, B-2 and U-2, B-3 and U-3, B-12 and U-12, B-13 and U-13, B-18 and U-18, U-4 and U-14, and Orig 1 and Orig 2. The gunfired panels are shown in Figures 5, 6, 7, and 8. Magnesium panel 1 was gunfired with two rounds of .30 caliber and two rounds of .50 caliber. One round of each was fired at the coated side of the panel, and one round of each was fired at the uncoated side of the panel. The panel was gunfired dry without being attached to a liquid container.

The fungus, salt fog, sand and dust, and humidity and temperature tests were performed at General Testing Laboratories, Inc., Moonachie, New Jersey, and the results are shown in Appendix I.

The vibration and gunfire tests were conducted at the Goodyear Tire & Rubber Test Facility, Akron, Ohio. A summary of the environmental and ballistics tests related to the serial-numbered panels is shown in Table I.

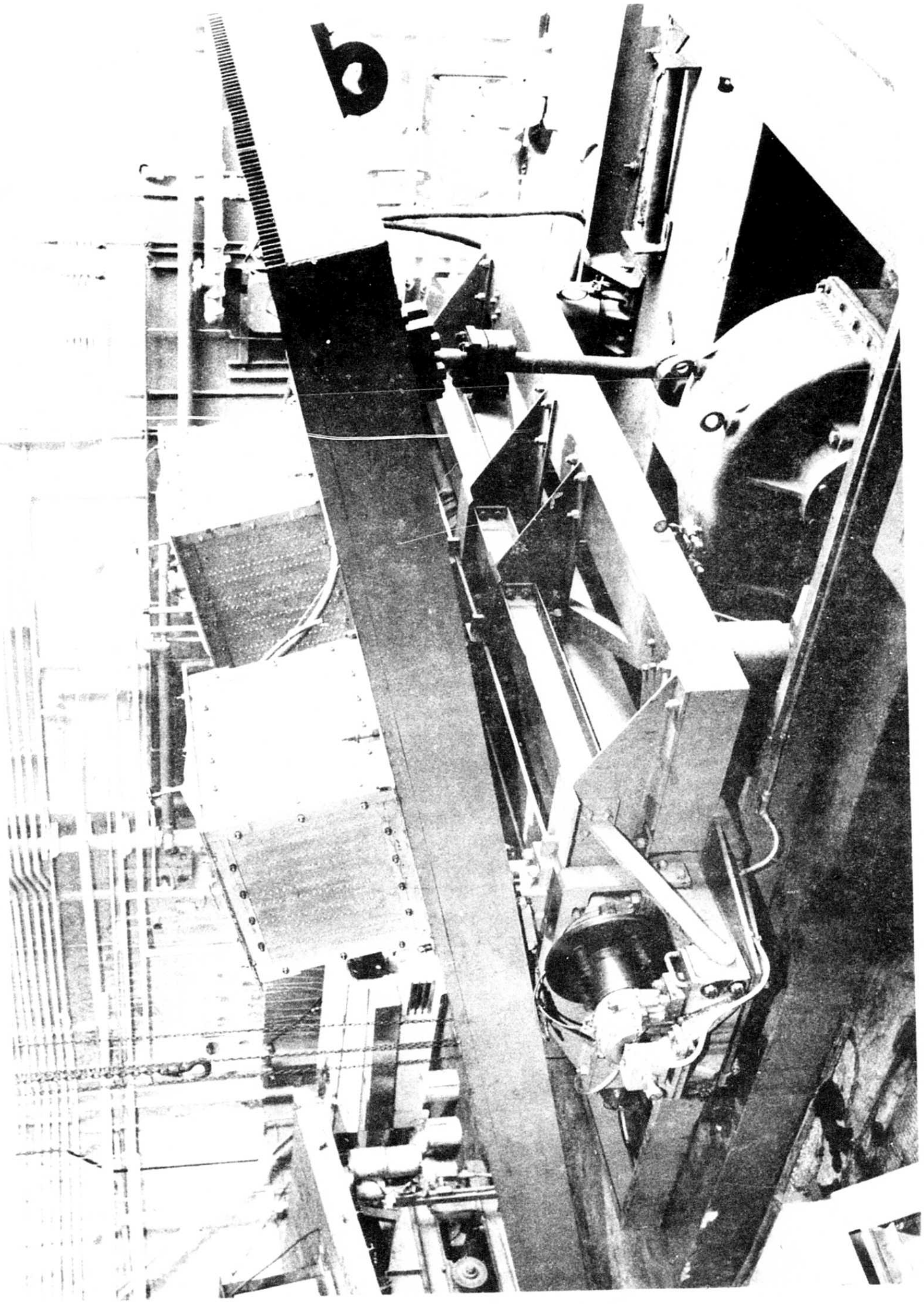

Figure 3. Vibration Tester.

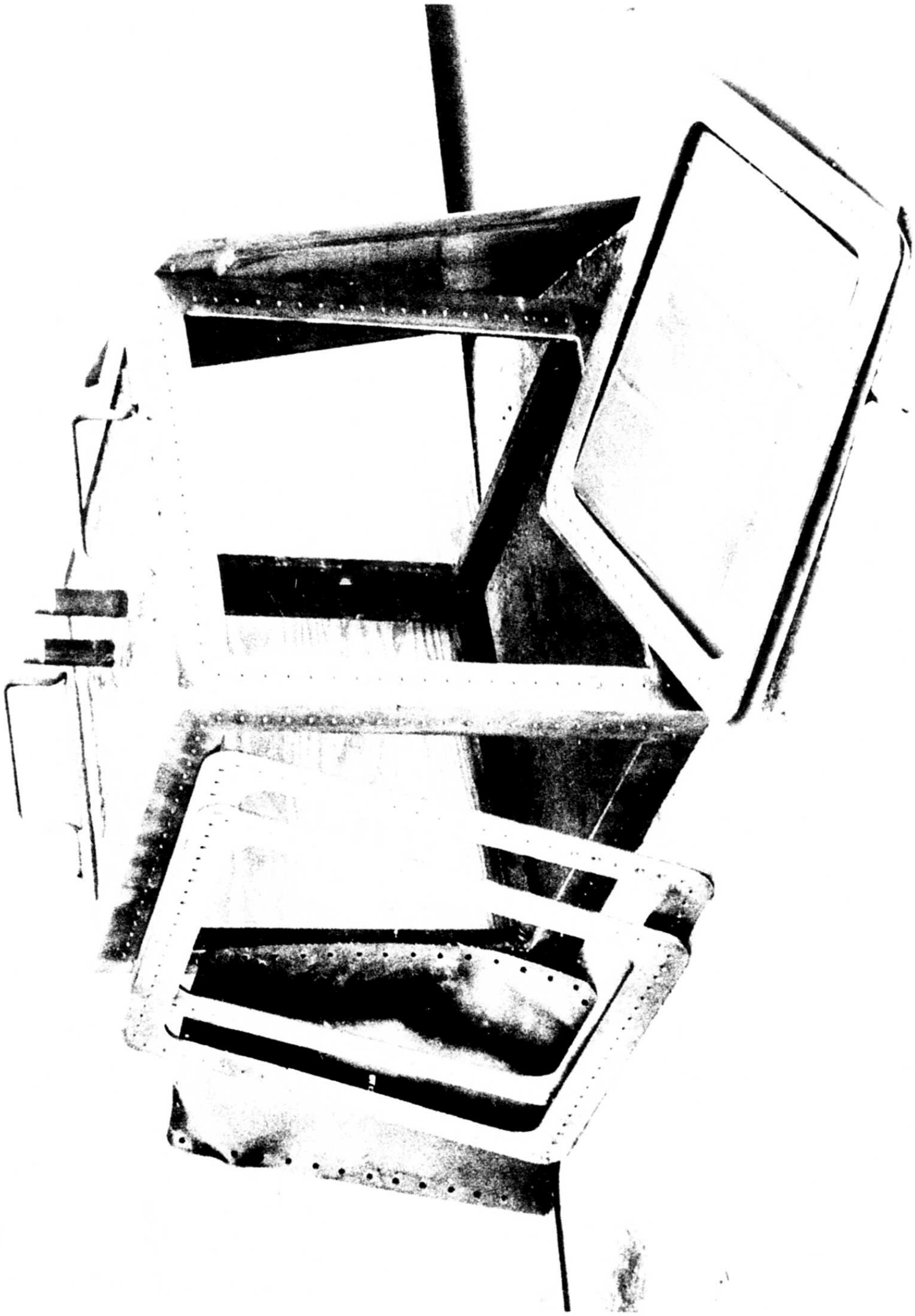

Figure 4. Gunfire Test Cube.

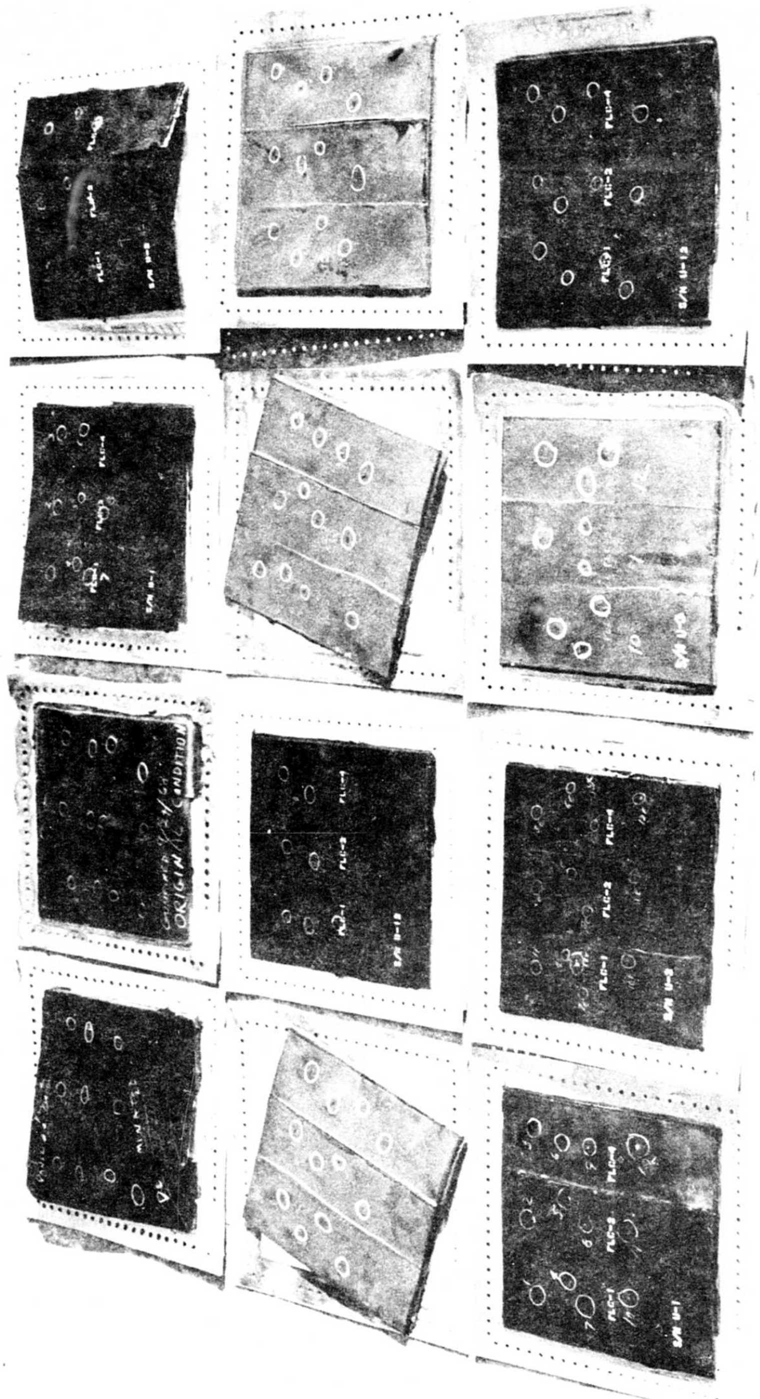

Figure 5. Gunfired Test Panels (Coated Side).

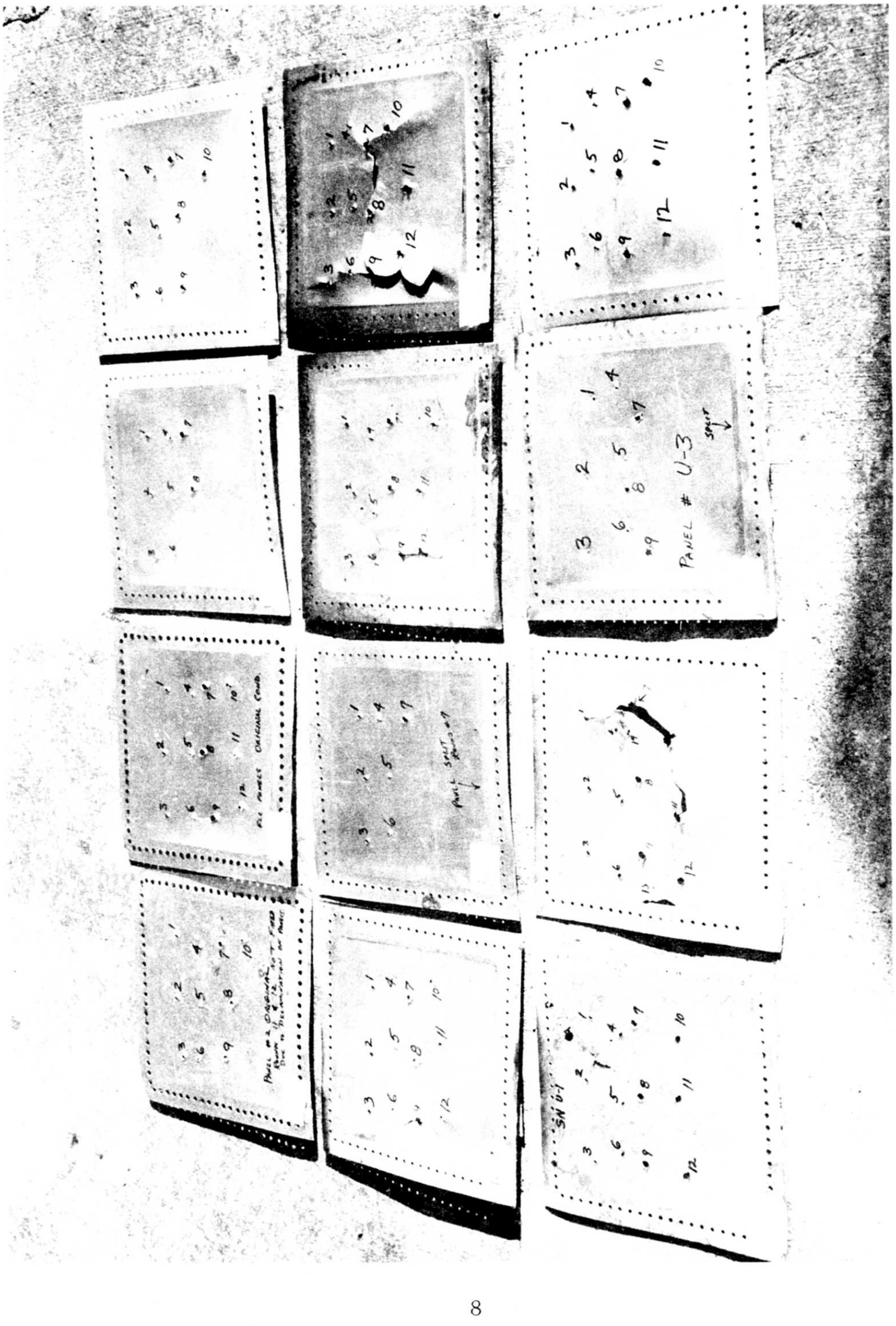

Figure 6. Gunfired Test Panels (Aluminum Side).

Figure 7. Gunfired Test Panels (Vibration Tested).

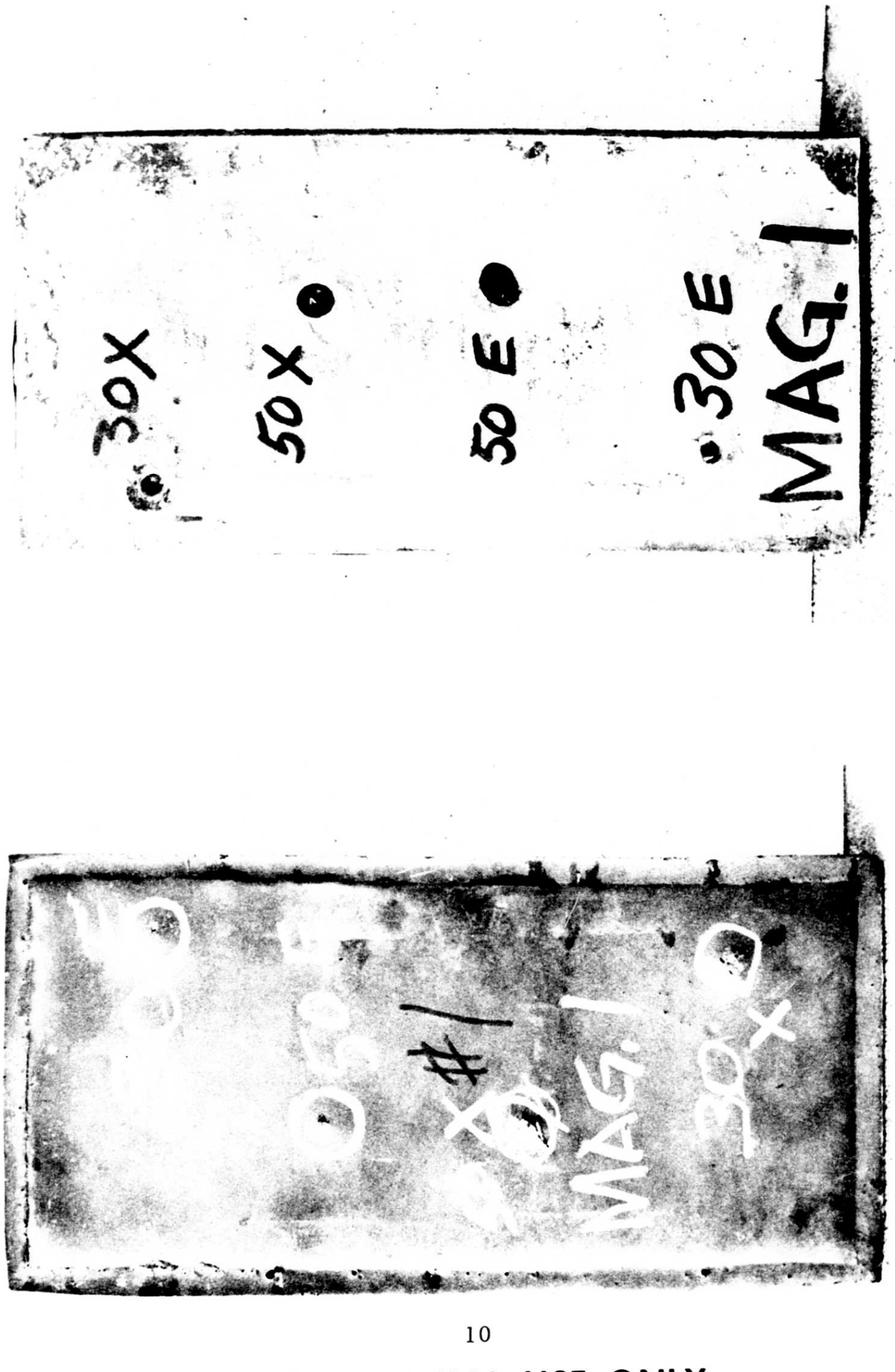

Figure 8. Gunfired Test Panel (Magnesium).

TABLE I. SUMMARY OF ENVIRONMENTAL AND BALLISTICS TESTS

Serial No.		Fungus	Salt Fog	Sand Dust	Temperature (F) 225°	250°	300°	350°	Vibration	Gunfire*	
B-1	U-1	X	-	-	-	-	-	-	-	X**	X***
B-2	U-2	X	X	-	-	-	-	-	-	X	X
B-3	U-3	X	X	X	-	-	-	-	-	X	X
B-4	U-4	X	X	X	X	-	-	-	-	-	X
B-5	U-5	X	X	X	-	X	-	-	-	-	-
B-6	U-6	X	X	X	-	-	X	-	-	-	-
B-7	U-7	X	X	X	-	-	-	X	-	-	-
B-8	U-8	X	X	X	X	-	-	-	X	-	-
B-9	U-9	X	X	X	-	X	-	-	X	-	-
B-10	U-10	X	X	X	-	-	X	-	-	-	-
B-11	U-11	X	X	X	-	-	-	X	-	-	-
B-12	U-12	-	X	-	-	-	-	-	-	X	X
B-13	U-13	-	-	X	-	-	-	-	-	X	X
B-14	U-14	-	-	-	X	-	-	-	-	-	X
B-15	U-15	-	-	-	-	X	-	-	-	-	-
B-16	U-16	-	-	-	-	-	X	-	-	-	-
B-17	U-17	-	-	-	-	-	-	X	-	-	-
B-18	U-18	-	-	-	-	-	-	-	X	X	X
Mag 1		X	X	X	X	-	-	-	X	-	-
Mag 2		X	X	X	-	X	-	-	X	-	-
Mag 3		X	X	X	-	-	X	-	-	-	-
Mag 4		X	X	X	-	-	-	X	-	-	-
Orig 1		-	-	-	-	-	-	-	-	-	X
Orig 2		-	-	-	-	-	-	-	-	-	X

X denotes tests performed on panels.

*.30 and .50 caliber.

**B series panels.

***U series panels.

RESULTS

The results of the fungus test show that there were no visible traces of fungus growth.

The panels were examined, and there was no evidence of deterioration or corrosion due to the salt fog test.

The sand and dust test indicated that there was no evidence of deterioration or corrosion on the Vithane sealing materials.

The panels in the humidity and temperature test, groups 3 and 4 (the two higher temperature test groups), were blistered and melted after 11 hr of the first cycle, and testing was stopped at this time. Photographs are shown in Figures 9, 10, 11, and 12. The panels in groups 1 and 2 (the two lower temperature test groups) completed the 75 cycles of testing. The results are shown in Figures 13 and 14 and noted in Table II.

The results of the vibration test show that there was no loss of adhesion or ply separation or looseness in any of the bonded panels due to the vibration testing.

The results of the gunfire tests are presented in Table III.

Figure 9. Panels After 11-Hr Exposure to 350°F.

Figure 10. Panels After 11-Hr Exposure to 300°F.

Figure 11. All Panels Exposed to 350°F for 11 Hr.

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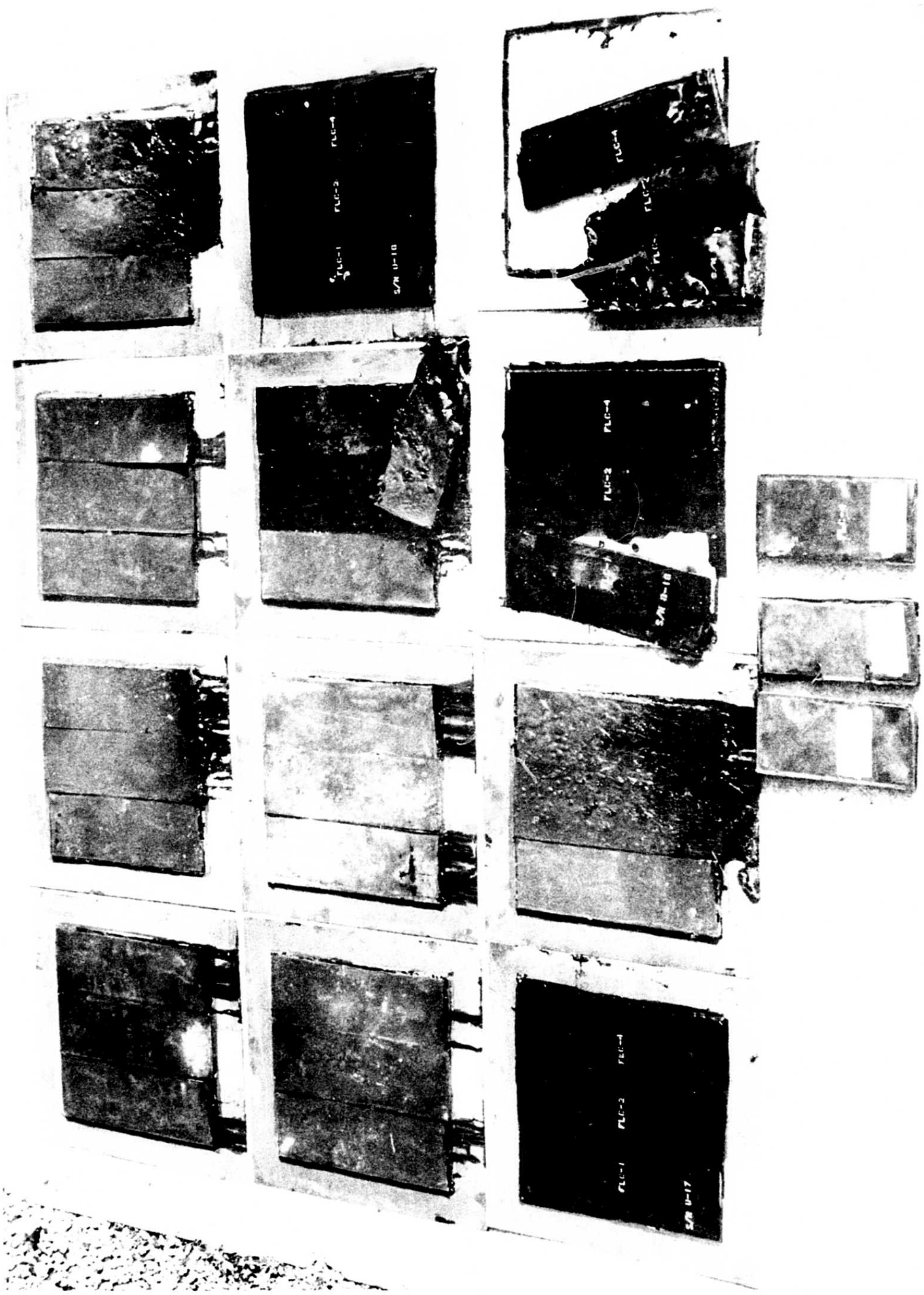

Figure 12. Two Higher Temperature Test Group Panels.

Figure 13. Panels After 75 Cycles at 225°F (U-4, U-8, U-14 in Upper Row);
Panels After 75 Cycles at 250°F (U-5, U-9, U-15 in Lower Row).

Figure 14. Panels After 75 Cycles at 250°F (B-5, B-9, B-15 in Upper Row); Panels After 75 Cycles at 225°F (B-4, B-8, B-14 in Lower Row).

TABLE II. CONDITION OF PANELS AFTER TEMPERATURE AND HUMIDITY CYCLING

Serial No.	FLC-1 Loss of Adhesion (Percent)	FLC-1 Ply Separation (Percent)	FLC-1 Blistering (Percent)	FLC-2 Loss of Adhesion (Percent)	FLC-2 Comments	FLC-2 Blistering (Percent)	FLC-4 Loss of Adhesion (Percent)	FLC-4 Ply Separation (Percent)	FLC-4 Blistering (Percent)	Temperature (F)
B-4	95	×	×	100	-	×	20	×	-	225
U-4	-	-	-	-	-	-	-	×	×	
B-8	75	75	-	90	-	-	-	×	×	
U-8	-	10	-	-	-	-	-	×	×	
B-14	100	×	-	100	-	-	10	×	-	
U-14	-	×	-	-	-	-	-	×	-	
Mag 1	-	-	-	-	-	-	-	×	-	
B-5	90	50	-	90	-	×	-	×	-	250
U-5	-	50	-	-	(Crack in long direction)	-	-	30	-	
B-9	75	50	-	100	(Spongy)	-	-	-	20	
U-9	-	50	-	-	(Chunking out)	×	-	-	-	
B-15	100	20	-	100	-	-	20	30	-	
U-15	-	25	-	-	(Crack in short dimension)	-	-	×	75	
Mag 2	-	-	-	-	-	-	-	50	-	

× denotes less than 10 percent.

CONCLUSIONS AND RECOMMENDATIONS

The sealing qualities of the gunfired panels exposed to the fungus, salt fog, sand and dust, and temperature aging at 225°F are not adversely affected.

Large leaks in splits at the edge fastening area of the aluminum panels are caused by .30 and .50 caliber gunfire.

The sealing materials mounted on both aluminum and magnesium deteriorate at high temperature. Therefore, these materials should not be used in an atmosphere above 250°F.

The application of 80C10 adhesive performs more satisfactorily on aluminum and magnesium than the 2379-C/2398-C systems. Vibration has no effect on adhesion.

FLC-4 construction dry seals after penetration by .30 and .50 caliber rounds at 0° or 45° obliquities.

Goodyear recommends that Vithane sealing materials be limited to use in an atmosphere of 225°F maximum. It has been shown that in-field application of Vithane sealing materials is feasible. Goodyear further recommends that a personnel training program be established relative to the application of Vithane materials.

TABLE III. COMPARISON OF SEA

Gunfired Round	Caliber	Angle of Obliquity (deg)	Construction	B-1	U-1	B-2	U-2	B-3	U-3	B-12	Seri U-1
1	.30	0	FLC-1	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	V.S.S.	Dry s
2	.30	0	FLC-2	1/32-in. str to F.S.	S.S. to V.S.S - 10 min	F.S. to seep - 1/2 min	S.S.	S.S. to V.S.S. - 1 min	S.S.	Dry seal	S.S.
3	.30	0	FLC-4	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry s
4	.30	45	FLC-1	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	S.S.	Dry s
5	.30	45	FLC-2	Seep	Seep	Seep	S.S.	S.S. to V.S.S. - 1/2 min	V.S.S.	Dry seal	Seep
6	.30	45	FLC-4	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry s
7	.50	0	FLC-1	Seep to dry seal 1/2 min	V.S.S. to dry seal - 1/2 min	Seep to wet seep 1/4 min	Wet to dry seal 1/2 min	Wet to dry seal	Dry seal	Dry seal alum	V.S. to dr seal 1/4 r
8	.50	0	FLC-2	Alum split	1/16-in. str	1/16-in. str	1/16-in. str	1/16-in. str	1/16-in. str	Panel split	1/16- str
9	.50	0	FLC-4	Stop test	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal alum	Stop test	Dry s
10	.50	45	FLC-1	-	Dry seal	Dry seal panel	Dry seal	Dry seal	Panel split stop	-	Wet t dry s 10 se
11	.50	45	FLC-2	-	1/16-in. str	Delam stop	1/16-in. str	F.S.	Test	-	F.S.
12	.50	45	FLC-4	-	Dry seal	Test	Dry seal	Dry seal	-	-	Dry s
13	.30	0	FLC-2	-	-	-	1/16-in. str, 2/3 tumble	-	-	-	-
14	.50	0	FLC-1	-	-	-	1/4-in. tumble at fuel storage	-	-	-	-

ABBREVIATIONS:

Alum - aluminum.
Delam - delaminated.
Fixt - fixture.
F.S. - fast seep.
RD - gunfired round.
S.S. - slow seep.
Str - constant stream.
V.S.S. - very slow seep.

LE III. COMPARISON OF SEALING QUALITIES

			Serial Number								
3	U-3	B-12	U-12	B-13	U-13	Orig 1	Orig 2	B-18	U-18	U-4	U-14
seal	Dry seal	V.S.S.	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Seep	Dry seal
to S. - n	S.S.	Dry seal	S.S.	Seep to S.S. - 1 min	S.S.	S.S.	Dry seal	1/32-in. str	1/32-in. str	F.S.	F.S.
seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal
seal	Dry seal	S.S.	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal
to S. - min	V.S.S.	Dry seal	Seep	S.S.	S.S.	S.S.	V.S.S.	F.S.	F.S.	F.S.	F.S.
seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal
to seal	Dry seal	Dry seal alum	V.S.S. to dry seal - 1/4 min	S.S. to dry seal 1/4 min	V.S.S. to dry seal - 1/4 min	Dry seal	Dry seal	S.S.	V.S.S. to wet seal - 1/2 min	V.S.S. to wet seal - 1/2 min	Dry seal
-in.	1/16-in. str	Panel split	1/16-in. str	1/16-in. str	1/16-in. str	1/16-in. str	1/32-in. str	1/8-in. str	1/8-in. str	1/8-in. str	1/8-in. str
seal	Dry seal alum	Stop test	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal	Dry seal test	Dry seal	Dry seal	Dry seal alum
seal	Panel split stop	-	Wet to dry seal 10 sec	RD 12 dry seal	Dry seal	Dry seal	Dry seal	Fixt bent stop	Dry seal	Damp seal	Panel split stop
	Test	-	F.S.	F.S.	1/16-in. str	F.S.	FLC-2 panel	Test	1/16-in. str	1/8-in. str	Test
seal	-	-	Dry seal	RD 10 dry	Dry seal	Dry seal	Delam stop	-	Bent test	Dry seal	-
-	-	-	-	-	-	-	Test	-	Fixt stop test	-	-
-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX I
ENVIRONMENTAL TESTING OF VITHANE PANELS

PERTINENT DATA

Purpose of Test:	To subject panels to environmental tests as specified in The Goodyear Tire & Rubber Company RFQ dated April 29, 1968.
Manufacturer:	The Goodyear Tire & Rubber Company, Akron, Ohio 44316
Manufacturer's Type or Model No.:	2378-C and 2379-C
Drawing, Specification, or Exhibit:	MIL-STD-810A and Purchase Order No. 495901
Quantity of Items Tested:	Thirty-eight Serial Nos., B-1 through B-17, U-1 through U-17 and 1 through 4
Security Classification of Items:	Unclassified
Date Test Completed:	October 8, 1968
Test Conducted By:	General Testing Laboratories, Inc.
Disposition of Specimens:	Returned to The Goodyear Tire & Rubber Company

ABSTRACT

Fungus Test	There were no visible traces of fungus growth.
Salt Fog Test	The panels were examined, and there was no evidence of deterioration or corrosion due to the salt fog test.
Sand and Dust Test	There was no evidence of deterioration or corrosion due to the sand and dust test.
Humidity and Temperature Test	The panels in Groups 3 and 4 were blistered and melted after 11 hours of the first cycle. Testing was stopped on these groups at this time.
	The panels in Groups 1 and 2 completed the 75 cycles with the following results:

Group 1

Serial No. U-14 - Minor peeling and melting
Serial No. B-14 - Major peeling
Serial No. U-4 - Slight warping
Serial No. U-8 - Slight peeling and melting
Serial No. B-8 - Major peeling
Serial No. B-4 - Major peeling
Serial No. 1 - Slight peeling

Group 2

Serial No. B-5 - Minor blistering, peeling, melting, and cracking along back section
Serial No. U-5 - Minor peeling, cracking, and melting
Serial No. B-15 - Major peeling and warping
Serial No. U-9 - Major blistering and minor peeling
Serial No. B-9 - Major peeling
Serial No. U-15 - Minor blistering and cracking
Serial No. 2 - Minor blistering and peeling

SEQUENCE OF TESTS AND PANELS DESIGNATED FOR EACH TEST

Fungus	B-1 through B-11 U-1 through U-11 1 through 4
Salt Fog	B-2 through B-12 U-2 through U-12 1 through 4
Sand and Dust	B-3 through B-11 and B-13 U-3 through U-11 and U-13 1 through 4
Temperature and Humidity	Group 1 - B-4, B-8, B-14, U-4, U-8, U-14 and 1 Group 2 - B-5, B-9, B-15, U-5, U-9, U-15 and 2 Group 3 - B-6, B-10, B-16, U-6, U-10, U-16 and 3 Group 4 - B-7, B-11, B-17, U-7, U-11, U-17 and 4

FUNGUS TEST

Test Procedure

The test was conducted at the United States Testing Company facility in Hoboken, New Jersey.

The panels were tested in accordance with MIL-STD-810A, Method 508.1.

Test Organisms:

A composite spore suspension of:

Chaetomium globosum	6205
Memnoniella echinata	9597
Aspergillus flavus	10836
Penicillium citrinum	9849

Incubation Period - Twenty-eight days at 30°C, ±2 C°and a relative humidity of 95, ±5 percent.

Test Results

There were no visible traces of fungus growth.

SALT FOG TEST

Test Equipment

Salt spray chamber, Model CA-3; Standard Cabinet Company

Test Procedure

The panels were subjected to the salf fog test as specified in MIL-STD-810A, Method 509.1. The panels were suspended in the test chamber and subjected to a salt fog test consisting of 95 parts distilled water and 5 parts sodium chloride, by weight. The pH of the salt solution was maintained between 6.5 and 7.2.

The chamber temperature was raised to and maintained at 35°C.

The duration of the exposure was 48 hours.

Test Results

The panels were examined, and there was no evidence of deterioration or corrosion due to the salt fog test.

SAND AND DUST TEST

Test Equipment

Sand and dust chamber, Serial No. 1088; Standard Cabinet Company.

Test Procedure

The panels were subjected to the sand and dust test as specified in MIL-STD-810, Method 510.1.

The panels were placed in the test chamber, which conformed to MIL-C-9436. The sand and dust density was raised and maintained between 0.1 and 0.25 gram per cubic foot. The relative humidity was less than 30 percent. The internal temperature was maintained at 25°C for 2 hr. At the end of the 2-hr period, the chamber temperature was raised to and maintained at 71°C for 2 hr.

The air velocity throughout the test was between 100 and 500 fpm.

Test Results

The panels were examined, and there was no evidence of deterioration or corrosion due to the sand and dust test.

HUMIDITY AND TEMPERATURE TEST (LONG-TERM HEAT AGING)

Test Equipment

Four temperature chambers, Model 333; Grieve Corporation
Temperature humidity chamber, GTL 537; Standard Cabinet Company

Test Procedure

The panels were subjected to the aging test in accordance with the procedure listed below.

Step 1 - Stabilize at 70°F and 95 percent relative humidity.

Step 2 - The temperature was held at X°F for 10 min.

Step 3 - The temperature was held at X°F for 3.5 hr.

Step 4 - The temperature was decreased to 150°F in 30 min.

Step 5 - The temperature was held at 150°F for 1 hr.

Step 6 - Steps 2 through 5 were immediately repeated three times.

Step 7 - The temperature was decreased to 70°F in 20 min.

Step 8 - The temperature was held at 70°F and 95 percent relative humidity for 3 hr.

Step 9 - Steps 1 through 8 above were repeated 75 times.

The panels for this test were divided into 4 groups as follows:

Group 1 - X°F equal to 225°F
Group 2 - X°F equal to 250°F
Group 3 - X°F equal to 300°F
Group 4 - X°F equal to 350°F

Test Results

The panels in Groups 3 and 4 were blistered and melted after 11 hr of the first cycle. Testing was stopped on these groups at this time.

The panels in Groups 1 and 2 completed the 75 cycles with the following results:

Group 1 - S/N U-14 - Minor peeling and melting
S/N B-14 - Major peeling
S/N U-4 - Slight warping
S/N U-8 - Slight peeling and melting
S/N B-8 - Major peeling
S/N B-4 - Major peeling
S/N 1 - Slight peeling

Group 2 - S/N B-5 - Minor blistering and peeling; minor melting and cracking along back section
S/N U-5 - Minor peeling, cracking, and melting
S/N B-15 - Major peeling and warping
S/N U-9 - Major blistering and minor peeling
S/N B-9 - Major peeling
S/N U-15 - Minor blistering and cracking
S/N 2 - Minor blistering and peeling

APPENDIX II
FEASIBILITY OF APPLYING VITHANE SEALING MATERIAL UNDER FIELD CONDITIONS

INTRODUCTION

This study was authorized by USAAVLABS for the feasibility of application of the coatings under field conditions, specifically those environmental conditions found in Southeast Asia (SEA). A review of the Operation of Materiel Under Extreme Meteorological Conditions of Southeast Asia along with a technical assistance program undertaken by The Goodyear Tire & Rubber Company for the U.S. Air Force for the inspection and repair of collapsible tanks now in use in Southeast Asia, indicates that Vithane coatings can be applied under field conditions with proper care.

DISCUSSION

Self-sealing coverings are applied generally to vulnerable areas in fuel, hydraulic, or lubricating systems in military aircraft. Liquid containers in these areas may be pressurized or unpressurized and must be sealed after rupture to a reasonable extent. The FLC-1 and FLC-2 covering require molds in their construction. Molding a uniformly thick covering around a prefabricated metal part presents problems because of slight inconsistencies inherent in the manufacture of metal parts. Rigid fuel lines, oil lines, or hydraulic lines are formed in bending fixtures to fit specific locations in aircraft. The nature of the bending operation lends itself to slight differences from one part to another. Similar problems also are encountered in fabricating metal liquid containers having several inlet and outlet fittings. The fittings can be misaligned or mislocated slightly from one vessel to another, causing a mismatch to the urethane casting mold that will produce an undesirable variance in coating thickness. It was for this reason that a third construction designated FLC-4 was developed.

The FLC-4 construction eliminates the need for such tooling as molds since the materials are applied by hand, using only simple hand tools. The sealing materials can be cut to shape and applied directly to the part and cemented in place without the use of any special fixtures or equipment unless a rapid turnover is desired. For volume production and efficient use of production space, equipment such as drum heaters and power mixers is required.

A sketch of FLC-2 and FLC-4 is shown in Figure 15.

Environmental Conditions

Temperature, relative humidity, atmospheric pressure, winds, and rainfall are all factors requiring consideration in a feasibility study of application of Vithane materials.

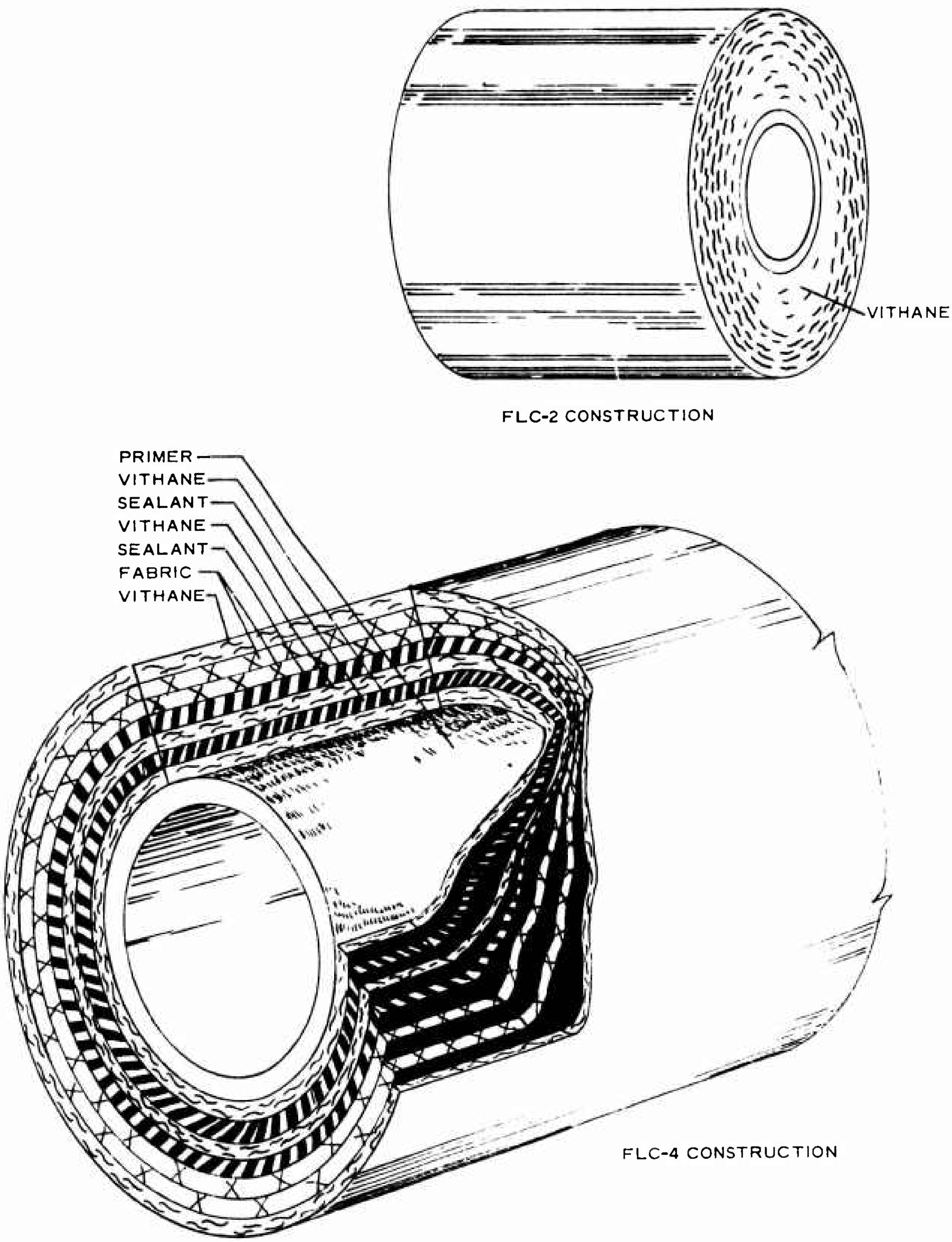

Figure 15. FLC-2 and FLC-4 Construction.

A study of Operation of Materiel Under Extreme Meteorological Conditions of Southeast Asia suggests that existing environmental conditions would not prevent the use of Vithane materials suggested for in-field applications. Further, the technical assistance program for the repair and maintenance of collapsible rubber containers in Southeast Asia performed early in 1968 by The Goodyear Tire & Rubber Company personnel showed that in-field application of Vithane materials can be accomplished successfully in SEA environmental conditions. It should be noted, however, that the interpretation of in-field application is the same as that used for the repair of fuel cells used in SEA aircraft. The unit to be coated or repaired is removed from the aircraft to a covered area away from possible contamination from sand and dust and direct rainfall. Although high humidity adversely affects certain ingredients of Vithane materials, procedures can be used in their storage and handling to control this factor, as noted below under "General Handling Precautions."

Effort Level and Equipment Requirements

It is suggested that in-field application of Vithane coatings be accomplished at the same facility level as that of self-sealing fuel cells, bladder fuel cells, and pillow tank major repairs. The personnel performing fuel cell repair should be capable of applying Vithane coatings since many Goodyear pillow tanks in SEA are manufactured from Vithane.

Equipment requirements for in-field application of Vithane materials will vary in accordance with the level of effort expended. Simple lower level application can be made in a temporary shelter with basic hand tools and materials premeasured and packaged in kit form, usually 1-qt size.

Higher level or semiproduction type application requires extensive equipment and trained personnel in a permanent location. A typical facility for coating 15 to 30 average-size fuel lines per day would be located in a permanent building with approximately 1,600 sq ft of floor area. The building should be well ventilated with filtered air and adequately lighted. A drum heater would be necessary to keep the prepolymer at a low viscosity for ease of pouring and mixing. A power-driven mixer would be needed to mix quantities of Vithane of 1 gal or more. Various other items would be necessary to fill out equipment requirements. Where bulk quantities (5- to 50-gal containers) of Vithane ingredients are used, laboratory equipment and trained personnel would be required to perform control tests on these components that make up the Vithane sealing material. This is necessary to assure the quality level of the ingredients that have a marked effect on the quality of the mixed Vithane material.

Procedures for application of FLC-1, FLC-2, and FLC-4 are given in Appendix III. Equipment requirements are listed in Appendix IV.

General Handling Precautions

Vithanes may contain a trace of volatile Isocyanate, which is an irritant to skin and mucous membranes. Therefore, good ventilation is required in areas where large quantities of the polymer are being used. S· ne persons have unusually sensitive skin and should avoid prolonged contact with the material and should wash thoroughly after contact.

The polymer should be stored in clean dry containers and kept out of direct sunlight. Large containers (5 gal or more) must be equipped with drying tubes (anhydrous calcium sulfate) to remove moisture from the air, which replaces the polymer as it is withdrawn for use. Smaller containers should be kept sealed until mixed with the accelerator. High humidity and high temperature accelerate the cure of Vithane so that the pot life of the mixed Vithane is decreased.

The polymer freezes at temperatures of 65°F or below. Freezing is a reversible process that does no damage, but does present handling problems.

APPENDIX III
REPAIR PROCEDURES FOR SELF-SEALING VITHANE COATINGS FLC-1, FLC-2, AND FLC-4

CLASSIFICATION OF INJURIES

The following repair procedure is recommended for field repair of metal fuel and oil containers and lines that have been coated with Goodyear Vithane constructions FLC-1, FLC-2, and FLC-4. Injuries are classified as follows:

1. Field Repairable Injuries

    a. Mechanical damage to the coating where the metal container is not damaged

    b. Mechanical damage to the coating where the metal container is punctured, provided damage to metal can be repaired by process not employing or generating heat

2. Injuries Not Repairable

    a. Damage resulting from fire or chemicals

    b. Damage where the metal container cannot be restored

REPAIR PROCEDURE

The curing conditions for repairs should be made at temperatures of 75°F or higher so that the repair compounds will cure.

PREPARATION FOR REPAIR

1. If possible, remove container from aircraft. Drain fuel and purge the interior.

2. Remove the damaged portion of the Vithane construction with a sharp knife, using water as a cutting lubricant. If the metal container is punctured, remove enough material so that at least 1-in. of metal will be exposed all around the wound.

3. Check the sealant layer (brown color) at the exposed edges for activation. If the sealant appears to be activated, remove the outer layer of Vithane, fabric plies, and sealant until all activated sealant is removed.

CONTAINER REPAIR

Repair the metal container using the procedures recommended by the container manufacturer provided these procedures do not employ or generate any heat.

In the event such procedures do not exist, use the following method.

1. Clean the metal surface of the container around the wound with a piece of abrasive cloth until bare metal is exposed.

2. Remove dust and traces of fuel with a cloth dampened with methyl ethyl ketone solvent.

3. Cut out three pieces of aluminum sheet approximately 1/2 in. larger all around than the wound.

4. Clean both sides of the aluminum patch with abrasive cloth and solvent.

5. Prepare a mixture of air-curing epoxy cement, following the directions in the kit.

6. Apply a coat of epoxy cement to the clean metal surface around the wound and a coat to one side of the aluminum patch.

7. Position the patch and press in place over the wound.

8. Cover the metal patch and surface of the container with a coat of epoxy cement.

9. Allow cement to cure until firm before making further repairs.

FLC-1 REPAIR

1. Cut out a patch of 1/8-in.-thick Vithane sheet slightly smaller than the removed area of Vithane (inside).

2. Cut out a patch of FT-179 slightly smaller than the removed area of rubber sealant and nylon fabric.

3. Cut out a patch of 1/8-in.-thick Vithane sheet slightly smaller than the removed area of Vithane (outside).

4. Mix a quantity of Vithane repair cement, which is composed of 2373-C (amber color) and 80C32 (purple color). Pour the 80C32 in the 2373-C and stir slowly to avoid trapping air. Mix at least 3 min.

NOTE: If the wound cannot be repaired in a horizontal position, pour the mixed Vithane repair cement into a paper cup and add Pig 371 filler material as required to make a stiff paste.

5. Apply one coat of the Vithane repair cement to the exposed epoxy and metal surfaces. Also, coat the exposed edges of the Vithane FLC-1 coating.

6. Apply a coat of Vithane repair cement to one side of the 1/8-in.-thick Vithane patch. Position the patch in place being careful not to trap air. Press down firmly against the container to squeeze out any excess cement.

7. Apply a coat of Vithane repair cement to one side of the FT-179 patch and to the exposed surface of the Vithane patch.

8. Place cemented side of FT-179 down on top of the Vithane patch. Press firmly in place to squeeze out any excess cement.

9. Apply a coat of Vithane repair cement to the exposed surface of the FT-179 and to one side of the second Vithane patch.

10. Place the Vithane patch in position, cemented side down, and press firmly in place. Probe edges of patch to remove trapped air.

11. Apply a coat of Vithane repair cement over the top of the patch to build up the repair area flush with or higher than the surface of the original coating.

12. Cover the patch with a piece of polyethylene, using masking tape to hold it in place.

13. Allow repair to cure 4 hours before removing the polyethylene.

14. Reinstall container. Full cure of the repair will take a minimum of 5 days at 75°F or higher.

REPAIR WHERE DAMAGE IS ONLY TO PART OF FLC-1 COATING

In the event that the damage extends only to the outside layers of the FLC-1 coating, remove the damaged areas only and use the applicable procedures under FLC-1 repair.

NOTE: FLC-2 and FLC-4 repairs are made in the same manner as FLC-1.

APPENDIX IV
MATERIAL AND EQUIPMENT
NECESSARY FOR APPLICATIONS OF VITHANE

Material and equipment necessary for lower level in-field applications of Vithane are listed below:

Description	Quantity	Amount
Epoxy resin	2	1/2 fl oz tubes
Epoxy hardener	2	1/2 fl oz tubes
Alum sheet (5052-0)	2	6 in. × 6 in. × 0.025 in. to 0.030 in.
2373-C Vithane prepolymer	4	4 oz btls, 70 gm ea
80C32 accelerator	4	2 oz btls, 26 gm ea
Vithane sheet	4	6 in. × 6 in. × 1/8 in.
FT-179	2	6 in. × 6 in.
Polyethylene film	4	6 in. × 6 in.
Methyl ethyl ketone (MEK)	1	Pt can w/lid
Paper cups	4	
Abrasive cloth	2	4 in. × 6 in., 120 grit
Pig 371, filler	1	Pt can/w/lid
Wooden mixing spoons	4	
Sharp knife		
Spatula		
Scissors		
Paper towels or clean rags		
Small-diameter narrow-wheel roller		

Material and equipment necessary for semiproduction or higher level application of Vithane self-sealing materials are listed below:

Balance - 5 kg cap

Hot plate - electric

Paint shaker - Red Devil, Cat. 30 - 1/4 hp or equivalent

Drum heater - for 55-gallon drum - sufficient to keep contents at 120°F, 220 v

Mixer - 1 hp air motor - approx 420 rpm - 24-in. shaft with 6-in. ship blade type propeller - Cleveland Mixer Co., Cleveland, Ohio, or equivalent

Polyethylene container - round - 8 qt cap

Vithane sheet - 1/8 in. thick

FT-179 fabric

Polyethlene film

Methyl ethyl ketone solvent

Paper cups

Pig 371, filler

Abrasive cloth - 120 grit

Sharp knife

Spatula

Scissors

Paper towels or clean rags

Small-diameter narrow-wheel roller

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13. ABSTRACT

This report presents the results of the environmental and ballistics study of Vithane sealing materials subjected to various environmental and ballistic conditions. Work was also conducted in testing two adhesive systems. This evaluation resulted in recommendations to limit the use of these materials to certain environmental conditions.

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