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PROCESSING - SURFACE PREPARATION - DOW #17 ANODIZE PROCESS - BONDING HK-31 MAGNESIUM-THORIUM ALLOY - PROCESS VARIABLES - INVESTIGATION OF

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PROCESSING-SURFACE PREPARATION - DOW #17 ANODIZE PROCESS - BONDING HK-31 MAGNESIUM-THORIUM ALLOY - PROCESS VARIABLES - INVESTIGATION OF

PURPOSE

A proposed elevon wedge design requires the use of bonded magnesium-thorium alloy. Previous experience has shown this alloy to be difficult to bond and to be subject to severe corrosion.

The Dow #17 treatment applied to HK-31 magnesium-thorium alloy* protects the surface of the alloy against corrosion and at the same time offers a potentially good surface for adhesive bonding. Therefore, the purpose of this test request was to obtain information applicable to the adhesive bonding of Dow #17 treated HK-31 magnesium-thorium alloy.

SUMMARY

Lap shear failure in the Dow #17 treated specimens with end point voltage above 70 volts was the result of failure in the Dow #17 coating itself at room temperature and below (see Tables II through VIII). The coating seemed to peel apart in layers. At test temperatures above room temperature, the lap shear failure was the result of either failure in the adhesive or failure between the adhesive and the Dow #17 coating (see Tables V through VIII).

Aging specimens at room temperature prior to priming and bonding slightly improved the bond strengths of specimens given the "standard" (70-75 volts end-point) Dow #17 treatment (see Table V and Figure 1), while aging at elevated temperatures produced a definite improvement (see Table VI).

Specimens which were given standard Dow #17 treatment, primed and then aged prior to bonding, showed no significant change in bond strengths (see Table VII and Figure 2).

Spot cleaning with M.E.K. (methyl ethyl ketone) prior to priming and bonding had no effect on the bond strengths of "standard" treated Dow #17 specimens (see Table VIII), nor did spot cleaning with M.E.K. followed by vapor degrease (see Table VIII).

* Nominal composition limits of HK31:

2.5 to 4.0%	Thorium
0.45 to 1.0 %	Zirconium
0.15% Max.	Manganese
Remainder	Magnesium

Specimens given the "standard" Dow #17 treatment and bonded without the application of primer produced lower bond strengths in all instances than was the case when the primer was applied (see Tables II through VII).

When magnesium-thorium specimens were given the "light" Dow #17 treatment (50-55, 60-65 volts end-point) subsequent bond strengths were superior at all test temperatures to those produced by either the "standard" or the "heavy" treatment (see Table IX). When this treatment was employed lap shear failure was the result of either failure in the adhesive or failure between the adhesive and Dow #17 coating. No failure in the coating itself was experienced. (see Table IX).

Bond strengths of specimens given the "light" Dow #17 treatment were not affected by fluid exposure test per Para. 4.2.4, MIL-A-8431 (see Table XII). The surface of the alloy itself was only slightly corroded after 30-day exposure to salt spray (see Table XII). *

Analysis by X-ray Diffraction showed the composition of the "heavy" Dow #17 coating to be entirely chromium sesquioxide (Cr_2O_3) while the composition of the "light" and "standard" coat is a mixture of hydrated and anhydrous oxides of chromium, none of these being chromium sesquioxide (see Table XVI). Thus it was shown that the composition of the Dow #17 changes as increased voltage is applied.

From the data obtained, it is concluded that a satisfactory surface for bonding with AF-31 is produced when HK-31 magnesium-thorium alloy is given the "light" (60-65 volts end-point) Dow #17 treatment and primed with EC-1459 prior to bonding. Higher end point voltages do not produce a satisfactory bonding surface whether or not the primer is applied.

PROCESSING - SURFACE PREPARATION - DOW #17 ANODIZE PROCESS - BONDING HK-31 MAGNESIUM-THORIUM ALLOY - PROCESS VARIABLES - INVESTIGATION OF

OBJECT

To evaluate the Dow #17 Anodize process as a bonding surface preparation for HK-31 magnesium-thorium alloy using the AF-31 adhesive system.

MATERIALS	SOURCE
AF-31 dry film adhesive	Minnesota Mining & Mfg. Co. St. Paul, Minn.
EC-1459 primer	" "
0.063 HK-31 magnesium-thorium alloy	Dow Chemical Co., Midland, Mich.

PROCEDURE

I. Preparation of Specimens - General

A. Remove all dyes and other foreign materials by wiping with methyl ethyl ketone.

B. Vapor degrease in stabilized trichlorethylene for 10 minutes.

C. Apply Dow #17 treatment - The Dow #17 Anodize Process consists of electrolytic treatment in an aqueous-acidic-electrolyte containing a combination of phosphate, fluoride and chromate ions. The "standard" Dow #17 treatment is applied as follows:*

1. Immerse in 17% chromic acid for 5 minutes at 190°F.
2. Rinse in cold running water.
3. Immerse in the following solution at 160° - 180°F:

   40 oz. ammonium acid fluoride
   133 oz. sodium dichromate
   11.5 oz. phosphoric acid (85%).
   water to make 1 gallon -

4. Apply a direct current of 10 amps/sq.ft. to an end point voltage of 70-75 volts. In this process the part being treated acts as the anode while the treatment tank is the cathode.

5. Spray rinse and dry.

*Application performed by The Anadite Co., Hurst, Texas.

II. Priming and Bonding

A. Priming

1. Apply one brush coat of EC-1459 primer to the surfaces to be bonded.

2. Allow the primer to air dry two hours at room temperature.

B. Bonding

1. Apply one thickness of dry film adhesive (AF-31) to the primed surface of one skin.

2. Assemble with a second primed skin to form a 0.5 inch overlap.

3. Assemble on a suitable bonding pad.

4. Place a 1/16" thickness of curable rubber over the area to be bonded.

5. Place the assembly in a bonding press at room temperature and apply a uniformly distributed pressure of 150 psi over the contact area. Raise the temperature to 350 ± 10°F in 35 ± 5 minutes and maintain at 350°F for one hour.

III. Testing - Lap Shear

A. Cut the bonded panel into 1" wide individual lap shear specimens forming a 0.5" x 1.0" bond area.

B. Test in tensile shear per MIL-A-8431 under one or more of the following test temperature conditions.

1. -67°F after 10 minutes at -67°F.
2. Room temperature.
3. 260°F after 10 minutes at 260°F.
4. 450°F after 30 minutes at 450°F.

IV. Determination of the effects of variations in processing and alterations in prebonding environmental conditions on the lap shear strengths of "standard" Dow #17 treated magnesium-thorium panels.

A. Determination of the effect of the omission of primer on the lap shear strengths of "standard" Dow #17 treated magnesium-thorium panels.

IV. Continued

1. Treat as outlined in
2. Bond as outlined in II except that "A" is omitted.
3. Test according to III at 450°F after 30 minutes at 450°F.

B. Determination of the effect of room temperature aging prior to bonding of "standard" Dow #17 treatment on the lap shear strengths of specimens which have not been primed.

1. Dow #17 treat as outlined in I.
2. Age Dow #17 treated panels at room temperature for 6, 48 and 96 hours.
3. Bond according to II except that "A" is omitted.
4. Test according to III at -67°F, room temperature and 260°F.

C. Determination of the effect of room temperature aging prior to priming and bonding on the lap shear strengths of "standard" Dow #17 treated specimens.

1. Dow #17 treat according to I.
2. Age Dow #17 treated panels at room temperature for 6, 48 and 96 hours.
3. Prime and bond according to II.
4. Test according to III at -67°F, room temperature, and 260°F.

D. Determination of the effect of elevated temperature aging (500°F for 10 hours) prior to bonding of "standard" Dow #17 treatment on lap shear strengths of specimens which have not been primed.

1. Treat as outlined in I.
2. Age Dow #17 treated panels at 500°F for 10 hours.
3. Bond according to II except that "A" is omitted.
4. Test according to III at room temperature and at 260°F after 30 minutes at 260°F.

E. Determination of the effect of elevated temperature aging (500°F for 10 hours) prior to priming and bonding on the lap shear strength of "standard" Dow #17 treated panels.

1. Dow #17 treat according to I.
2. Age Dow #17 treated panels at 500°F for 10 hours.
3. Prime and bond according to II.
4. Test according to III at room temperature and 260°F.

F. Determination of the effect of room temperature aging prior to bonding on the lap shear strength of primed "standard" Dow#17 treated magnesium-thorium specimens.

1. Dow #17 treat according to I.
2. Prime Dow #17 treated panels according to IIA.
3. Age at room temperature for 6, 72 and 144 hours.
4. Bond according to IIB.
5. Test according to III at -67°F and 260°F.

G. Determination of the effect of spot cleaning with methyl ethyl ketone on the lap shear strength of "standard" Dow #17 treated magnesium-thorium panels.

1. Dow #17 treat according to I.
2. Wipe surfaces of Dow #17 treated panels with methyl ethyl ketone and allow to air dry.
3. Prime and bond according to II.
4. Test according to III at -67°F and 260°F.

H. Determination of the effect of spot cleaning with methyl ethyl ketone followed by vapor degrease on the lap shear strengths of "standard" Dow #17 treated magnesium-thorium panels.

1. Dow #17 treat according to I.
2. Wipe surfaces of Dow #17 treated panels with methyl ethyl ketone.
3. Vapor degrease with stabilized trichloroethylene for 10 minutes.
4. Prime and bond according to II.
5. Test according to III at -67°F and 260°F.

I. Determination of the effect of variations in end-point voltage in the Dow #17 treatment on the lap shear strengths of magnesium-thorium panels.

1. Treat according to I except that in C-3 end-point voltages of 50-55, 60-65, and 80-85 volts were used instead of the standard 70-75 volts.
2. Prime and bond according to II.
3. Test according to III at -67°F, room temperature and 260°F.

V. Special Testing On Light Dow #17 (60-65 volts) Treated Magnesium-Thorium Panels

A. Determination of the effect of elevated temperature aging on the lap shear strength of "light" Dow #17 (60-65 volts end-point) treated AF-31 bonded magnesium-thorium panels (primer omitted).

1. Treat according to I except that 60-65 volts is used as the end point voltage in C-3.
2. Bond according to II except that A is omitted.
3. Test according to III except that the specimens were aged at the test temperature for 100 hours. Test at 260°F and 350°F.

B. Determination of the effect of elevated temperature aging on the lap shear strength of "light" Dow #17 (60-65 volts end-point) treated, AF-31 bonded magnesium-thorium panels (specimens primed prior to bonding).

1. Dow #17 treat according to I except that 60-65 volts is used as the end-point voltage in C-3.
2. Prime and bond according to II.
3. Test according to III except age at test temperature is for 100 hours. Test at 260°F and 350°F.

C. Determination of the effect of exposure to various fluids on the lap shear strengths of "light" Dow #17 treated (60-65 volts end-point) magnesium-thorium panels which were primed prior to bonding.

1. Dow #17 treat according to I except that 60-65 volts is used as the end-point voltage in C-3.
2. Prime and bond according to II.
3. Test per Para. 4.2.4 MIL-A-8431.

D. Determination of the effect of exposure to tap water on the lap shear strength of "light" Dow #17 treated (60-65 volts end-point) magnesium-thorium panels which were not primed prior to bonding.

1. Dow #17 treat according to I except that the end-point voltage in C-3 is 60-65 volts.
2. Bond according to II except that A is omitted.
3. Test per Para. 4.2.4 MIL-A-8431 in tap water only.

E. Determination of the normal temperature fatigue strength of bonded "light" Dow #17 treated (60-65 volts end-point) magnesium-thorium lap shear specimens.

1. Dow #17 treat according to I except that the end-point voltage is 60-65 volts in C-3.
2. Prime according to II-A.
3. Bond according to IIB except that a 3/8" overlap is formed in B-5.
4. Test per para. 4.3.4.4 MIL-A-8431.

F. Determination of the effect of elevated temperature aging prior to priming and bonding on the lap shear strength of "light" Dow #17 treated (60-65 volts end-point) magnesium-thorium specimens.

1. Dow #17 treat according to I except that the end-point voltage is 60-65 volts in C-3.
2. Age at 500°F for 10 hours.
3. Prime and bond according to II.
4. Test according to III at -67°F, R.T. and 260°F.

VI. Special Testing on "Heavy" Dow #17 Treated (90-95 Volt End-Point) Magnesium-Thorium Panels

A. Determination of the effect of elevated temperature aging prior to priming and bonding on the lap shear strength of "heavy" Dow #17 treated (90-95 volt end-point) magnesium-thorium specimens.

1. Dow #17 treat according to I except that the end-point voltage is 90-95 volts in C-3.
2. Age at 500°F for 10 hours.
3. Prime and bond according to II.
4. Test according to III at room temperature.

VII. X-Ray Diffraction Studies on Dow #17 Coatings

A. Apply Dow #17 treatment according to I, using end-point voltage of 60-65 volts, 70-75 volts and 90-95 volts in C-3.

B. Scrape coating from treated panels.

C. Place scrapings in X-ray diffraction powder camera (Norelco X-Ray Diffraction Powder Camera Model No. 12045).

D. Make diffraction pattern using a three-hour exposure to copper radiation.

E. Interpret pattern by comparison with A.S.T.M. Standard Patterns of Chemical Compounds.

RESULTS

A summary of the test results is given in Table I and is illustrated in Figures 1 through 3. The results are given in detail in Tables II through XVI. (See Table Index on Page 1).

DISCUSSION

The Dow #17 treatment applied to magnesium-thorium gives protection against corrosion and at the same time offers a potentially good surface for adhesive bonding. Before the Dow #17 treated magnesium-thorium could be utilized to maximum benefit in production it was necessary to make a study of its basic properties as a bonding-surface preparation. This study was designed to provide information as to the relationship between the method of application of the Dow #17 coating, its effectiveness as a bonding surface and processing variables which may be encountered during production bonding of Dow #17 coated HK-31 alloy.

Dow #17 treating HK-31 magnesium-thorium alloy results in the formation of a surface coating on the alloy which acts as an electrical insulator. In order to sustain the coating formation, a current density of approximately ten amperes per square foot of surface area must be maintained. As the thickness of the coating increases the electrical resistance also increases and, therefore, progressively higher voltage must be applied to maintain the required current density. The voltage at which the treatment is stopped is known as the "end-point" voltage.

A study of the nature of the Dow #17 coating was made which provided information as to the relationship between the chemical and physical properties of the coating and its effectiveness as a bonding surface for magnesium-thorium. Specimens given the "standard" Dow #17 treatment (70-75 volts end-point) were tested in lap shear strength at various temperatures after being primed with EC-1459 and bonded with AF-31. Additional specimens given the "standard" treatment were subjected to certain conditions before bonding and testing such as room temperature aging both before and after application of EC-1459 primer and elevated temperature aging prior to application of primer. Thus the effect of these factors on the lap shear strength was determined. Also the treated specimens were cleaned with certain solvents prior to priming, bonding and testing in order to determine the effect of such cleaning on the lap shear strength.

Among the variations in processing investigated in this test was the end-point voltage during the application of the Dow #17 treatment. The end-point voltage which showed the most promise was 60-65 volts. Specimens given this treatment primed with EC-1459 and bonded with AF-31 were tested in lap shear strength at various temperatures. When the test originator was informed of the highly satisfactory results obtained using this end-point

voltage, it was requested that the remainder of the test be used for further study of this process ("light" Dow #17 Coating). Therefore, additional specimens treated in this manner were given more extensive testing such as normal temperature fatigue and fluid exposure. Thus a rather comprehensive evaluation was made of this "light" Dow #17 treatment as a bonding surface preparation for HK-31 magnesium-thorium alloy.

As part of the study of the Dow #17 treatment an analysis by x-ray diffraction was made of "light" "standard", and "heavy" Dow #17 coatings.

It was found in the course of this test that lap shear failure in bonded "standard" and "heavy" Dow #17 treated HK-31 is caused by failure in the coating itself, failure in the adhesive, or failure between the adhesive and the coating, while lap shear failure in bonded "light" Dow #17 treated specimens was due to failure either in the adhesive or between the adhesive and the coating. There was no failure in the coating itself.

The "light" Dow #17 treatment produced bond strengths superior to those produced by either the "standard" or "heavy" treatment, although aging at room temperature produced a slight improvement of lap shear strengths of specimens given the "standard" treatment and aging at elevated temperatures results in a significant improvement in lap shear strength.

Also, the bond strengths produced by the "light" treatment are resistant to weakening by exposure to fluids per Para. 4.2.4 MIL-A-8431. Significantly, thirty-day exposure to salt spray caused only slight corrosion on the surface of the "light" Dow #17 treated magnesium-thorium alloy. Fluid exposure tests were not performed on bonded magnesium-thorium specimens given the "standard" nor the "heavy" Dow #17 treatment.

Results of the x-ray diffraction determination showed the composition of the "heavy" Dow #17 coatings to be entirely chromium sesquioxide (Cr_2O_3) while the "light" and "standard" coats are composed of mixtures of hydrated and anhydrous lower oxides of chromium with no chromium sesquioxide present. Thus the lower oxides of chromium found in the "light" Dow #17 coating produce a good bonding surface for magnesium-thorium alloy while the chromium sesquioxide (Cr_2O_3) found in the "heavy" coating produces a poor bonding surface. It has also been shown that it is possible to change the composition of the Dow #17 coating by varying the end-point voltage during its application.

CONCLUSION

1. The "light" (60-65 volts end-point) Dow #17 anodize process produces a satisfactory surface for adhesive bonding with AF-31 adhesive when the treated surface is coated with EC-1459 primer prior to bonding.

2. The "standard" (70-75 volts end-point) and heavy (80-85 volts end-point) Dow #17 anodize process do not produce a satisfactory surface for adhesive bonding with AF-31 adhesive whether the treated surface is or is not coated with EC-1459 primer.

ANALYSIS
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TABLE I
EFFECT OF CERTAIN PROCESS VARIABLES ON DOW #17 TREATED HK-31 MAGNESIUM-THORIUM BONDED WITH AF-31 ADHESIVE

DOW #17 Treatment End-Point Voltage	Additional Treatment Prior to Bonding	Prime	Additional Treatment Prior to Bonding	Treatment After Bonding	Average Lap Shear Strength (PSI)	Percent Cohesive Failure	Test Temp.	Nature of Failure	Reference Table No.
70-75	None	Yes	None	None	781	0	-67°F	In Dow #17 Coating	II
					1218	0	R.T.	" " "	
					1321	10	260°F	In Adhesive	
					519	5	450°F	" "	
70-75	None	No	None	None	510	5	450°F	In Adhesive	III
70-75	None	No	6 hr. age at R.T.	None	675	0	-67°F	In Dow #17 Coating	IV
	"	"			1016	0	R.T.	" " "	
	"	"			1250	0	260°F	Between Adhesive and	
								Dow #17 Coating	
70-75	None	No	48 hr. age at R.T.	None	718	0	-67°F	In Dow #17 Coating	IV
	"	"			1045	0	R.T.	" " " "	
	"	"			1195	5	260°F	In Adhesive	
70-75	None	No	96 hr. age at R.T.	None	640	0	-67°F	In Dow #17 Coating	IV
	"	"			1052	0	R.T.	" " "	
	"	"			1451	5	260°F	In Adhesive	
70-75	6 hr. age at R.T.	Yes	None	None	865	0	-67°F	In Dow #17 Coating	V
	"	"			1453	0	R.T.	" " "	
	"	"			1418	0	260°F	Between Adhesive and	
								Dow #17 Coating	
70-75	48 hr. age at R.T.	Yes	None	None	871	0	-67°F	In Dow #17 Coating	V
	"	"	"		1470	0	R.T.	" " "	
	"	"			1428	0	260°F	Between Dow #17 Coating	
								and Adhesive	
70-75	96 hr. age at R.T.	Yes	None	None	815	0	-67°F	Dow #17 Coating	V
	"	"			1555	0	R.T.	In Dow #17 Coating	
	"	"			1634	5	260°F	In Adhesive	
70-75	None	No	10 hr. Age at 500°F	None	1438	0	R.T.	In Dow #17 Coating	VI
	"	"			1358	30	260°F	In Adhesive	

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TABLE I - Continued

Dow #17 Treatment End-Point Voltage	Additional Treatment Prior to Bonding	Prime	Additional Treatment Prior to Bonding	Treatment after Bonding	Average Lap Shear Strength (PSI)	Percent Cohesive Failure	Test Temp.	Nature of Failure	Reference Table
70-75	10 hr. at 500°F	Yes	None	None	1997	0	R.T.	In Dow #17 Coating	VI
	"	"			1899	30	260°F	In Adhesive	
70-75	None	Yes	6 hr. age at R.T.	None	953	0	-67°F	In Dow #17 Coating	VII
	"	"			1242	0	260°F	Between Dow #17 Coating and Adhesive.	
70-75	None	Yes	72 hr. age at R.T.	None	768	0	-67°F	In Dow #17 Coating	VII
	"	"			1178	30	260°F	In Adhesive	VII
70-75	None	Yes	144 hr. age at R.T.	None	1073	0	-67°F	In Dow #17 Coating	VII
					1266	20	260°F	In Adhesive	
70-75	MEK Solvent Wipe	Yes	None	None	728	0	-67°F	In Dow #17 Coating	VIII
					1479	0	260°F	Between Dow #17 Coating and Adhesive	
70-75	MEK Solvent Wipe & Vapor Degrease	Yes	None	None	894	0	-67°F	Dow #17 Coating	VIII
					1547	0	260°F	Between Dow #17 Coating and Adhesive	
50-55	None	Yes	None	None	1321	0	-67°F	Between Dow #17 Coating and Adhesive	IX
					2676	0	R.T.		
					1676	90	260°F	In Adhesive	
60-65	None	Yes	None	None	1328	0	-67°F	Between Dow #17 Coating and Adhesive	IX
					2622	0	R.T.		
					1773	40	260°F	In Adhesive	
80-85	None	Yes	None	None	684	0	-67°F	Between Dow #17 Coating and Adhesive	IX
					976	0	R.T.		
					1026	5	260°F	In Dow #17 Coating	
60-65	None	No	None	100 hr. age at Test Temp.	1896	0	260°F	Between Adhesive & Dow #17	X
					1762	0	350°F	In Adhesive	

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(FORT WORTH)

TABLE I - Continued

DOW #17 Treatment End-Point Voltage	Additional Treatment Prior to Bonding	Prime	Additional Treatment Prior to Bonding	Treatment After Bonding	Average Lap Shear Strength (PSI)	Percent Cohesive Failure	Test Temp.	Nature of Failure	Reference No.	Table
60-65	None	Yes	None	100 hr. age at test temp.	2125	0	260°F	In Adhesive	XI	
					1741	10	350°F	"		
60-65	None	Yes	None	7 day exposure to Type III Fuel at R.T.	2447	0	R.T.	Between Dow #17 Coating and Adhesive	XII	
60-65	None	Yes	None	7 day exposure to MIL-O-5606 Hydraulic Fluid at R.T.	2188	0	R.T.	" "	XII	
60-65	None	Yes	None	7 day exposure to JP-4 fuel at R.T.	2249	0	R.T.	" " "	XII	
60-65	None	Yes	None	7 day exposure to MIL-F-5566 Anti-Icing Fluid at R.T.	2268	0	R.T.	" " "	XII	
60-65	None	Yes	None	30 day exposure to salt spray	2883	0	R.T.	" " "	XII	
60-65	None	Yes	None	30 day exposure to tap water at R.T.	2740	0	R.T.	" " "	XII	
60-65	None	No	None	30 day exposure to tap water at R. T.	2652	0	R.T.	" " "	XII	
60-65	100 hr. age at 500°F.	Yes	None	None	1682	0	-67°F	" " "	XIV	
					2658	0	R.T.			
					1661	0	260°F			
90-95	100 hr. age at 500°F	Yes	None	None	833	0	R.T.	In Dow #17 Coating	XV	

TABLE NO. II

LAP SHEAR STRENGTH OF STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY - PRIMED WITH EC-1459 AND BONDED WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
1	-67	.503	495	984	0*	No data
2	-67	.498	355	713	0*	
3	-67	.502	310	618	0*	
4	-67	.495	400	808	0*	
Average				781		
5	R.T.	.510	570	1193	0*	
6	R.T.	.491	605	1230	0*	
7	R.T.	.512	630	1230	0*	
Average				1218		
8	260	.487	725	1489	10**	
9	260	.487	790	1622	10**	
10	260	.510	680	1333	10**	
Average				1321		
11	450	.540	395	732	5**	
12	450	.538	312	580	5**	
13	450	.534	260	487	5**	
14	450	.538	297	552	5**	
15	450	.539	303	562	5**	
16	450	.528	180	341	5**	
17	450	.533	250	469	5**	
18	450	.530	157	293	5**	
19	450	.538	300	558	5**	
20	450	.527	323	613	5**	
Average				519		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive

TABLE NO. III

LAP SHEAR STRENGTH OF STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY BONDED WITH AF-31 ADHESIVE (PRIMER OMITTED)

Specimen No.	Test Temp. °F	Bond Area In^2	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
1	450	.513	270	526	0*	No data
2	450	.535	308	576	0*	
3	450	.513	284	554	0*	
4	450	.524	270	515	0*	
5	450	.522	196	375	0*	
6	450	.510	252	494	0*	
7	450	.537	320	596	0*	
8	450	.516	261	506	0*	
9	450	.495	266	537	0*	
10	450	.539	224	416	0*	
Average				510		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Adhesive

TABLE NO. IV
EFFECT ON LAP SHEAR STRENGTH OF AGING STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY AT ROOM TEMPERATURE PRIOR TO BONDING WITH AF-31 ADHESIVE (NO PRIME)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
1	Aged 6 hrs at R.T. prior to bonding					
1	-67	.513	370	720	0*	No data
2	-67	.506	375	740	0*	
3	-67	.499	335	670	0*	
4	-67	.493	385	780	0*	
5	-67	.489	250	510	0*	
6	-67	.497	305	615	0*	
7	-67	.484	345	715	0*	
8	-67	.523	365	700	0*	
9	-67	.497	375	755	0*	
10	-67	.501	270	540	0*	
Average				675		
11	R.T.	.469	528	1126	0*	
12	R.T.	.472	456	966	0*	
13	R.T.	.473	458	968	0*	
14	R.T.	.474	540	1139	0*	
15	R.T.	.462	422	913	0*	
16	R.T.	.481	530	1102	0*	
17	R.T.	.475	462	973	0*	
18	R.T.	.476	438	920	0*	
19	R.T.	.477	416	872	0*	
20	R.T.	.463	548	1104	0*	
Average				1016		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating

TABLE NO. IV - Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
21	260	.509	640	1257	0**	No data
22	260	.501	620	1238	0**	
23	260	.489	635	1273	0**	
24	260	.484	605	1250	0**	
25	260	.520	675	1298	0**	
26	260	.505	545	1079	0**	
27	260	.506	630	1245	0**	
28	260	.505	685	1356	0**	
29	260	.496	580	1169	0**	
30	260	.508	680	1339	0**	
Average				1250		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

** Failure between Adhesive and Dow #17 Coating

TABLE NO. IV - Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
	Aged 48 hrs. at R.T. prior to bonding					
1	-67	.495	355	718	0*	No data
2	-67	.501	355	710	0*	
3	-67	.498	325	650	0*	
4	-67	.511	360	705	0*	
5	-67	.510	425	835	0*	
6	-67	.512	370	720	0*	
7	-67	.514	395	770	0*	
8	-67	.517	330	640	0*	
Average				718		
9	R.T.	.479	516	1077	0*	
10	R.T.	.488	540	1107	0*	
11	R.T.	.474	450	949	0*	
12	R.T.	.484	557	1151	0*	
13	R.T.	.472	452	958	0*	
14	R.T.	.500	492	984	0*	
15	R.T.	.474	494	1042	0*	
16	R.T.	.482	464	963	0*	
17	R.T.	.489	608	1243	0*	
Average				1045		
18	260	.494	625	1265	10**	
19	260	.487	750	1540	10**	
20	260	.502	680	1355	10**	
21	260	.489	550	1125	10**	
22	260	.489	625	1278	0***	
23	260	.510	285	559	10**	
24	260	.513	700	1365	5**	
25	260	.518	610	1178	5**	
26	260	.509	485	953	5**	
27	260	.486	645	1327	5**	
Average				1195		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi)

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive
*** Failure between Adhesive and Dow #17 Coating

TABLE NO. IV - Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
	Aged 96 hrs. at R.T. prior to bonding					
1	-67	.504	325	645	0*	No data
2	-67	.522	325	623	0*	
3	-67	.565	345	611	0*	
4	-67	.518	310	598	0*	
5	-67	.529	400	756	0*	
6	-67	.511	265	519	0*	
7	-67	.519	315	607	0*	
8	-67	.513	430	838	0*	
9	-67	.518	325	627	0*	
10	-67	.524	300	573	0*	
Average				640		
11	R.T.	.515	526	1021	0*	
12	R.T.	.511	484	888	0*	
13	R.T.	.514	566	1101	0*	
14	R.T.	.589	544	924	0*	
15	R.T.	.514	480	934	0*	
16	R.T.	.513	550	1072	0*	
17	R.T.	.516	599	1160	0*	
18	R.T.	.515	642	1247	0*	
19	R.T.	.510	552	1082	0*	
20	R.T.	.506	554	1088	0*	
Average				1052		
21	260	.525	765	1455	5**	
22	260	.570	745	1310	5**	
23	260	.512	775	1515	5**	
24	260	.510	740	1450	5**	
25	260	.516	745	1445	5**	
26	260	.506	690	1365	5**	
27	260	.511	755	1480	5**	
28	260	.514	740	1440	5**	

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive

TABLE NO. IV-Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
29	260	.502	745	1585	5**	
30	260	.542	795	1465	5**	
Average				1451		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

*Failure in Dow #17 Coating
**Failure in Adhesive

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. V

EFFECT ON LAP SHEAR STRENGTH OF AGING STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY AT ROOM TEMPERATURE PRIOR TO PRIMING WITH EC-1459 AND BONDING WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
	Aged 6 hrs. at R.T. prior to bonding					
1	-67	.504	490	970	0*	No data
2	-67	.516	505	980	0*	
3	-67	.500	380	760	0*	
4	-67	.519	430	830	0*	
5	-67	.498	430	865	0*	
6	-67	.502	400	795	0*	
7	-67	.493	455	925	0*	
8	-67	.485	410	845	0*	
9	-67	.508	415	815	0*	
Average				865		
10	R.T.	.487	775	1591	0*	
11	R.T.	.485	680	1402	0*	
12	R.T.	.475	640	1347	0*	
13	R.T.	.476	650	1366	0*	
14	R.T.	.470	700	1489	0*	
15	R.T.	.476	685	1439	0*	
16	R.T.	.484	675	1395	0*	
17	R.T.	.471	725	1539	0*	
18	R.T.	.470	640	1362	0*	
19	R.T.	.473	755	1596	0*	
Average				1453		
20	260	.492	750	1524	0***	
21	260	.499	695	1393	0***	
22	260	.501	750	1497	0***	
23	260	.500	710	1420	0***	
24	260	.509	770	1513	0***	
25	260	.519	765	1474	0***	
26	260	.506	620	1225	0***	
27	260	.524	740	1412	0***	

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
***Failure between Adhesive and Dow#17 Coating

TABLE NO. V-Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
28	260	.493	710	1440	0***	
29	260	.497	635	1298	0***	
Average				1418		
	Aged 48 hrs. R.T. prior to bonding					
1	-67	.497	415	835	0*	No data
2	-67	.484	515	1065	0*	
3	-67	.496	400	805	0*	
4	-67	.477	460	965	0*	
5	-67	.503	450	895	0*	
6	-67	.505	435	860	0*	
7	-67	.496	365	735	0*	
8	-67	.498	360	725	0*	
9	-67	.516	460	890	0*	
10	-67	.498	465	935	0*	
Average				871		
11	R.T.	.464	696	1500	0*	
12	R.T.	.476	717	1506	0*	
13	R.T.	.469	672	1433	0*	
14	R.T.	.464	720	1552	0*	
15	R.T.	.481	692	1439	0*	
16	R.T.	.464	680	1466	0*	
17	R.T.	.477	700	1468	0*	
18	R.T.	.473	650	1374	0*	
19	R.T.	.472	732	1551	0*	
20	R.T.	.468	660	1410	0*	
Average				1470		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive
***Failure between Dow #17 Coating and Adhesive

TABLE NO. V- Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
21	260	.503	605	1203	5**	
22	260	.496	735	1482	5**	
23	260	.496	565	1139	5**	
24	260	.500	700	1400	5**	
25	260	.490	760	1551	5**	
26	260	.513	795	1550	5**	
27	260	.477	760	1593	0***	
28	260	.491	735	1497	5**	
29	260	.498	655	1315	0***	
30	260	.471	730	1550	0***	
Average				1428		
	Aged 96 hrs. at R.T. prior to bonding					
1	-67	.498	475	955	0*	No data
2	-67	.487	500	1025	0*	
3	-67	.509	400	785	0*	
4	-67	.504	340	675	0*	
5	-67	.500	360	720	0*	
6	-67	.500	450	900	0*	
7	-67	.502	340	675	0*	
8	-67	.496	365	735	0*	
9	-67	.490	405	825	0*	
10	-67	.509	435	855	0*	
Average				815		
11	R.T.	.508	706	1390	0*	
12	R.T.	.515	874	1697	0*	
13	R.T.	.522	840	1609	0*	
14	R.T.	.514	728	1416	0*	
15	R.T.	.516	666	1291	0*	
16	R.T.	.514	820	1595	0*	
17	R.T.	.514	962	1872	0*	
18	R.T.	.516	738	1430	0*	
19	R.T.	.505	854	1691	0*	
20	R.T.	.504	784	1556	0*	
Average				1555		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
Failure in Adhesive * Failure between Dow #17 Coating and Adhesive

TABLE NO. V- Continued

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
21	260	.501	880	1755	0***	
22	260	.500	760	1520	5**	
23	260	.501	875	1745	5**	
24	260	.502	830	1655	5**	
25	260	.500	895	1790	5**	
26	260	.508	855	1685	5**	
27	260	.511	840	1645	5**	
28	260	.509	745	1465	5**	
29	260	.506	825	1630	5**	
30	260	.509	735	1445	5**	
Average				1634		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. VI

EFFECT ON LAP SHEAR STRENGTH OF EC-1459 PRIMED - STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY WHICH HAS BEEN AGED AT 500°F FOR TEN HOURS PRIOR TO BONDING WITH AF-31 AHDESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
Specimen not primed.						
1	R.T.	.548	810	1478	0*	No data
2	R.T.	.538	770	1431	0*	
3	R.T.	.564	800	1418	0*	
4	R.T.	.563	735	1405	0*	
5	R.T.	.517	755	1460	0*	
Average				1438		
6	260	.498	630	1265	30**	
7	260	.497	690	1388	30**	
8	260	.505	690	1366	30**	
9	260	.492	690	1402	30**	
10	260	.497	680	1368	30**	
Average				1358		
Specimens primed						
1	R.T.	.506	990	1955	0*	No data
2	R.T.	.509	1050	2065	0*	
3	R.T.	.505	1000	1980	0*	
4	R.T.	.506	1025	2025	0*	
5	R.T.	.505	940	1960	0*	
Average				1997		
6	260	.501	1025	2046	30**	
7	260	.500	960	1920	30**	
8	260	.506	960	1897	30**	
9	260	.508	935	1841	30**	
10	260	.508	910	1791	30**	
Average				1899		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

*Failure in Dow #17 Coating
**Failure in Adhesive

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. VII

EFFECT ON LAP SHEAR STRENGTH OF AGING EC-1459 PRIMED - STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY AT ROOM TEMPERATURE PRIOR TO BONDING WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
Aged 6 hours at room temperature prior to bonding						
1	-67	..474	.390	823	0*	No data
2	-67	.473	.365	772	0*	
3	-67	.478	.450	941	0*	
4	-67	.477	.420	881	0*	
5	-67	.478	.340	711	0*	
6	-67	.482	.520	1079	0*	
7	-67	.507	.525	1078	0*	
8	-67	.487	.505	1037	0*	
9	-67	.490	.555	1133	0*	
10	-67	.483	.520	1077	0*	
Average				953		
11	260	.346	.435	1257	10**	
12	260	.348	.535	1537	5**	
13	260	.345	.545	1580	0***	
14	260	.346	.520	1503	0***	
15	260	.344	.540	1570	0***	
16	260	.510	.440	863	0***	
17	260	.507	.410	809	0***	
18	260	.498	.575	1155	5**	
19	260	.493	.495	1004	0***	
20	260	.481	.550	1143	10**	
Average				1242		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive
***Failure between Dow #17 Coating and Adhesive

TABLE NO. VII (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
Aged 72 hours at room temperature prior to bonding						
1	-67	.643	440	684	0*	
2	-67	.649	460	709	0*	
3	-67	.631	445	705	0*	
4	-67	.629	465	737	0*	
5	-67	.620	460	742	0*	
6	-67	.543	390	718	0*	
7	-67	.530	385	726	0*	
8	-67	.520	410	788	0*	
9	-67	.509	475	933	0*	
10	-67	.493	460	933	0*	
Average				768		
11	260	.656	540	823	0***	
12	260	.653	560	858	0***	
13	260	.650	645	992	5**	
14	260	.650	585	900	10**	
15	260	.641	655	1022	15**	
16	260	.547	700	1280	10**	
17	260	.543	815	1501	40**	
18	260	.537	820	1527	30**	
19	260	.531	765	1441	30**	
20	260	.519	745	1435	50**	
Average				1178		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive
***Failure between Dow #17 Coating and Adhesive

TABLE NO. VII (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
Aged 144 hours at room temperature prior to bonding						
1	-67	.488	475	973	0*	No data
2	-67	.488	505	966	0*	
3	-67	.488	475	973	0*	
4	-67	.491	490	998	0*	
5	-67	.485	445	918	0*	
6	-67	.486	420	864	0*	
7	-67	.491	615	1253	0*	
8	-67	.493	605	1227	0*	
9	-67	.491	655	1334	0*	
10	-67	.500	610	1220	0*	
Average				1073		
11	260	.477	450	945	20**	
12	260	.498	520	1045	10**	
13	260	.507	515	1015	20**	
14	260	.512	500	975	20**	
15	260	.514	665	1295	10**	
16	260	.523	800	1530	20**	
17	260	.518	845	1630	15**	
18	260	.511	735	1440	30**	
19	260	.496	650	1310	30**	
20	260	.495	730	1475	30**	
Average				1266		

Bonding Conditions:
.Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure in Adhesive

TABLE NO. VIII

EFFECT ON LAP SHEAR STRENGTH OF SPOT CLEANING STANDARD DOW #17 TREATED MAGNESIUM-THORIUM ALLOY PRIOR TO PRIMING WITH EC-1459 AND BONDING WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
MEK Solvent wipe						
1	-67	.472	315	667	0*	No data
2	-67	.474	300	633	0*	
3	-67	.476	340	714	0*	
4	-67	.476	360	756	0*	
5	-67	.471	410	870	0*	
Average				728		
6	260	.479	745	1555	0**	
7	260	.473	660	1395	0**	
8	260	.479	715	1493	0**	
9	260	.477	750	1572	0**	
10	260	.475	655	1378	0**	
Average				1479		
MEK Solvent wipe and vapor degrease						
1	-67	.494	460	930	0*	No data
2	-67	.494	470	950	0*	
3	-67	.489	365	745	0*	
4	-67	.494	420	850	0*	
5	-67	.488	485	995	0*	
Average				894		
6	260	.494	730	1478	0**	
7	260	.499	815	1633	0**	
8	260	.493	735	1491	0**	
9	260	.492	785	1596	0**	
10	260	.492	735	1535	0**	
Average				1547		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*Failure in Dow #17 Coating
**Failure between Dow #17 Coating and Adhesive

TABLE NO. IX

EFFECT ON LAP SHEAR STRENGTH OF VARIATIONS IN END-POINT VOLTAGE OF DOW #17 TREATED MAGNESIUM-THORIUM ALLOY PRIMED WITH EC-1459 AND BONDED WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
50-55 Volt End-Point						
1	-67	.487	545	1119	0*	No data
2	-67	.483	755	1563	0	
3	-67	.464	595	1282	0	
4	-67	.509	550	1081	0	
5	-67	.472	535	1133	0	
6	-67	.474	580	1224	0	
7	-67	..483	650	1404	0	
8	-67	.463	695	1401	0	
9	-67	.471	680	1444	0	
10	-67	.466	680	1459	0	
Average				1321		
11	R.T.	.498	1555	3122	5	
12	R.T.	.506	1380	2727	5	
13	R.T.	.478	1290	2699	0	
14	R.T.	.476	1305	2742	0	
15	R.T.	.469	1140	2431	0	
16	R.T.	.473	1300	2748	0	
17	R.T.	.471	1095	2325	0	
18	R.T.	.473	1165	2463	0	
19	R.T.	.476	1355	2847	0	
20	R.T.	.472	1255	2659	0	
Average				2676		
21	260	.471	855	1815	90	
22	260	.471	790	1677	90	
23	260	.496	910	1835	90	
24	260	.472	965	2044	90	
25	260	.465	850	1828	90	
26	260	.519	695	1339	90	
27	260	.481	790	1642	90	
28	260	.468	625	1335	90	
29	260	.475	670	1411	90	
30	260	.464	850	1832	90	
Average				1676		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

*When lower voltages were applied, there was no failure in the Dow #17 Coating

TABLE NO. IX (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
60-65 Volt End-Point						
1	-67	.495	610	1232	0	No data
2	-67	.492	505	1026	0	
3	-67	.501	625	1248	0	
4	-67	.482	615	1442	0	
5	-67	.491	485	988	0	
6	-67	.494	615	1245	0	
7	-67	.476	695	1460	0	
8	-67	.494	515	1123	0	
9	-67	.472	820	1737	0	
10	-67	.473	840	1176	0	
Average				1328		
11	R.T.	.477	1280	2683	0	
12	R.T.	.474	1380	2911	0	
13	R.T.	.483	1200	2484	0	
14	R.T.	.491	1165	2373	0	
15	R.T.	.482	1180	2448	0	
16	R.T.	.488	1270	2602	0	
17	R.T.	.491	1350	2749	0	
18	R.T.	.408	1385	2897	0	
19	R.T.	.497	1290	2596	0	
20	R.T.	.491	1235	2515	0	
Average				2622		
21	260	.479	930	1940	40	
22	260	.480	900	1875	50	
23	260	.478	805	1685	50	
24	260	.515	830	1610	40	
25	260	.504	850	1685	50	
26	260	.494	885	1790	50	
27	260	.481	850	1765	60	
28	260	.496	810	1635	10	
29	260	.492	865	1760	15	
30	260	.492	975	1980	20	
Average				1773		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. IX (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
80-85 Volt End-Point						
1	-67	.490	365	745	0*	No data
2	-67	.491	270	550	0*	
3	-67	.496	335	675	0*	
4	-67	.495	375	758	0*	
5	-67	.494	340	688	0*	
6	-67	.516	345	669	0*	
7	-67	.531	375	706	0*	
Average				684		
8	R.T.	.514	650	1265	0*	
9	R.T.	.495	440	890	0*	
10	R.T.	.492	280	570	0*	
11	R.T.	.490	490	1000	0*	
12	R.T.	.512	685	1340	0*	
13	R.T.	.500	505	1010	0*	
14	R.T.	.496	430	865	0*	
15	R.T.	.495	455	920	0*	
16	R.T.	.512	470	920	0*	
Average				976	0*	
17	260	.512	450	880	10*	
18	260	.499	530	1060	5*	
19	260	.505	500	990	5*	
20	260	.508	495	975	0*	
21	260	.505	540	1070	0*	
22	260	.509	635	1245	0*	
23	260	.514	670	1305	0*	
24	260	.500	450	900	0*	
25	260	.495	400	810	0*	
Average				1026		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

*Failure in Dow #17 Coating

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. X

EFFECT ON LAP SHEAR STRENGTH OF AGING "LIGHT" (60-65 Volts End-Point) DOW #17 TREATED MAGNESIUM-THORIUM ALLOY - BONDED WITH AF-31 ADHESIVE (NO PRIME) AT TEST TEMPERATURE FOR 100 HOURS PRIOR TO TESTING

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
1	260	.518	925	1785	0	No data
2	260	.518	1080	2085	0	
3	260	.521	870	1670	0	
4	260	.518	885	1710	0	
5	260	.523	955	1825	0	
6	260	.508	990	1950	0	
7	260	.507	915	1805	0	
8	260	.513	975	1900	0	
9	260	.518	1105	2135	0	
10	260	.516	1085	2100	0	
Average				1896		
11	350	.525	1810	1543	0	
12	350	.574	1010	1760	0	
13	350	.524	825	1560	0	
14	350	.541	1005	1858	0	
15	350	.585	1050	1795	0	
16	350	.551	1060	1924	0	
17	350	.518	920	1776	0	
18	350	.522	960	1839	0	
19	350	.563	1105	1963	0	
20	350	.526	840	1597	0	
Average				1762		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. XI

EFFECT ON LAP SHEAR STRENGTH OF AGING "LIGHT" (60-65 Volts End-Point) DOW #17 TREATED MAGNESIUM-THORIUM ALLOY - PRIMED WITH EC-1459 AND BONDED WITH AF-31 ADHESIVE - AT TEST TEMPERATURE FOR 100 HOURS PRIOR TO TESTING

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
1	260	.505	1060	2099	0	No data
2	260	.484	1120	2314	0	
3	260	.489	1215	2485	0	
4	260	.520	1055	2029	0	
5	260	.513	975	1901	0	
6	260	.504	1115	2212	0	
7	260	.507	1075	2120	0	
8	260	.509	915	1798	0	
9	260	.495	1080	2182	0	
10	260	.501	1055	2106	0	
Average				2125		
11	350	.518	835	1612	10	
12	350	.513	840	1637	10	
13	350	.485	1035	2134	10	
14	350	.506	720	1423	10	
15	350	.498	740	1486	10	
16	350	.512	860	1680	10	
17	350	.498	945	1898	10	
18	350	.506	930	1838	10	
19	350	.492	940	1911	10	
20	350	.518	925	1786	10	
Average				1741		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. XII

EFFECT ON LAP SHEAR STRENGTH OF ENVIRONMENTAL AGING "LIGHT" DOW #17 (60-65 Volts End-Point) TREATED MAGNESIUM-THORIUM ALLOY - PRIMED WITH EC-1459 AND BONDED WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
Seven day exposure to Type III Fuel at room temperature						
1	R.T.	.544	1340	2465	0	No data
2	R.T.	.569	1375	2415	0	"
3	R.T.	.539	1430	2655	0	"
4	R.T.	.557	1360	2440	0	"
5	R.T.	.533	1390	2610	0	"
6	R.T.	.514	1205	2344	0	"
7	R.T.	.498	1275	2560	0	"
8	R.T.	.546	1205	2205	0	"
9	R.T.	.560	1330	2375	0	"
10	R.T.	.522	1255	2405	0	"
Average				2447		"
Control 1	R.T.	.449	1205	2685	0	"
Control 2	R.T.	.454	1210	2665	0	"
Control 3	R.T.	.485	1340	2760	0	"
Control 4	R.T.	.466	1250	2680	0	"
Control Average				2698		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll
Lot 23

TABLE NO. XII (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
Seven day exposure to MIL-O-5606 Hydraulic Fluid at room temp.						
1	R.T.	.541	960	1775	0	No data
2	R.T.	.551	950	1725	0	"
3	R.T.	.570	1040	1825	0	"
4	R.T.	.530	1120	2115	0	"
5	R.T.	.515	1130	2195	0	"
6	R.T.	.559	1415	2530	0	"
7	R.T.	.559	1475	2640	0	"
8	R.T.	.597	1390	2330	0	"
9	R.T.	.581	1330	2290	0	"
10	R.T.	.550	1350	2455	0	"
Average				2188		"
Control 1	R.T.	.497	1290	2595	0	"
Control 2	R.T.	.492	1235	2510	0	"
Control 3	R.T.	.476	915	1920	0	"
Control 4	R.T.	.489	1195	2440	0	"
Control Average				2366		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll
Lot 23

TABLE NO. XII (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
Seven day exposure to JP-4 Fuel at room temp.						No data
1	R.T.	.594	1300	2325	0	"
2	R.T.	.557	1340	2405	0	"
3	R.T.	.569	1285	2260	0	"
4	R.T.	.531	1260	2370	0	"
5	R.T.	.562	1100	1955	0	"
6	R.T.	.559	1310	2345	0	"
7	R.T.	.562	1180	2100	0	"
8	R.T.	.534	1200	2245	0	"
9	R.T.	.540	1260	2335	0	"
10	R.T.	.572	1230	2150	0	"
Average				2249		
Control 1	R.T.	.490	1200	2650	0	
Control 2	R.T.	.463	1240	2680	0	
Control 3	R.T.	.499	1000	2005	0	
Control 4	R.T.	.482	1350	2800	0	
Control Average				2534		
Seven day exposure to MIL-F-5566 Anti-icing Fluid at room temperature						
1	R.T.	.534	1235	2310	0	"
2	R.T.	.522	1215	2325	0	"
3	R.T.	.540	1145	2120	0	"
4	R.T.	.597	1260	2110	0	"
5	R.T.	.551	1365	2475	0	"
Average				2268		
Control 1	R.T.	.482	1230	2550	0	
Control 2	R.T.	.496	1335	2690	0	
Control Average				2620		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll
Lot 23

TABLE NO. XII (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
Thirty day exposure to salt spray *						No data
1	R.T.	.501	1380	2754	0	"
2	R.T.	.501	1425	2844	0	"
3	R.T.	..498	1500	3012	0	"
4	R.T.	.500	1495	2990	0	"
5	R.T.	.494	1540	3117	0	"
6	R.T.	.497	1410	2837	0	"
7	R.T.	.502	1420	2829	0	"
8	R.T.	.506	1410	2787	0	"
9	R.T.	.504	1430	2837	0	"
10	R.T.	.504	1425	2827	0	"
Average				2883		
Control 1	R.T.	.497	1360	2736		"
Control 2	R.T.	.492	1530	3110		"
Control 3	R.T.	.491	1415	2882		"
Control 4	R.T.	.496	1420	2863		"
Control Average				2898		"

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll
Lot 23

*Surface of alloy itself only slightly corroded

TABLE NO. XII (Cont'd)

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
Thirty day exposure to tap water at room temp.						
1	R.T.	.504	1510	2996	0	
2	R.T.	.500	1460	2920	0	
3	R.T.	.499	1430	2866	0	
4	R.T.	.498	1480	2972	0	
5	R.T.	.498	1415	2841	0	
6	R.T.	.487	1250	2567	0	
7	R.T.	.498	1230	2495	0	
8	R.T.	.492	1195	2429	0	
9	R.T.	.494	1270	2571	0	
Average				2740		
Control 1	R.T.	.491	1340	2729	0	
Control 2	R.T.	.483	1180	2443	0	
Control 3	R.T.	.495	1440	2909	0	
Control 4	R.T.	.487	1405	2885	0	
Control Average				2742		
Thirty day exposure to tap water at room temp. (no prime)						
1	R.T.	.487	1270	2608	0	
2	R.T.	.491	1275	2597	0	
3	R.T.	.487	1300	2669	0	
4	R.T.	.490	1280	2612	0	
5	R.T.	.500	1330	2660	0	
6	R.T.	.488	1220	2500	0	
7	R.T.	.485	1380	2845	0	
8	R.T.	.494	1360	2753	0	
9	R.T.	.493	1320	2677	0	
10	R.T.	.492	1280	2602	0	
Average				2652		
Control 1	R.T.	.489	1215	2485		
Control 2	R.T.	.484	1130	2335		
Control 3	R.T.	.470	1365	2904		
Control 4	R.T.	.486	1225	2521		
Control Average				2561		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll
Lot 23

TABLE XIII

NORMAL TEMPERATURE FATIGUE STRENGTH OF BONDED* "LIGHT" (60-65 VOLTS END POINT) TREATED MAGNESIUM-THORIUM LAP SHEAR SPECIMENS

Specimen No.	Cycles Per Minute	Total Cycles	Remarks
1	1930	10,167,240	No failure
2	2020	10,097,310	No failure
3	1800	11,793,600	No failure
4	2030	10,409,840	No failure
5	2120	799,240	Metal failure
7	1990	171,140	"
8	1960	4,589,800	"
9	1780	6,653,640	"
10	1840	2,327,600	"

* AF-31 Adhesive

TABLE NO. XIV

EFFECT ON LAP SHEAR STRENGTH OF AGING "LIGHT" (60-65 Volts End-Point) DOW #17 TREATED AT 500°F FOR 100 HOURS PRIOR TO PRIMING WITH EC-1459 AND BONDING WITH AF-31 ADHESIVE

Specimen No.	Test Temp. °F	Bond Area In^2	Load to Failure		% Cohesive Failure	Glueline Thickness Mils
			Pounds	PSI		
1	-67	.517	820	1586	0	No data
2	-67	.514	945	1839	0	
3	-67	.515	835	1621	0	
Average				1682		
4	R.T.	.508	1365	2690	0	
5	R.T.	.505	1330	2635	0	
6	R.T.	.515	1320	2565	0	
7	R.T.	.511	1400	2740	0	
Average				2658		
8	260	.506	880	1739	5	
9	260	.513	855	1667	0	
10	260	.514	810	1576	0	
Average				1661		

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE NO. XV

EFFECT ON LAP SHEAR STRENGTH OF AGING "HEAVY"(90-95 Volts End-Point) DOW #17 TREATED MAGNESIUM-THORIUM ALLOY - BONDED WITH AF-31 ADHESIVE (NO PRIME) AT TEST TEMPERATURE FOR 100 HOURS PRIOR TO TESTING

Specimen No.	Test Temp. °F	Bond Area In²	Load to Failure Pounds	Load to Failure PSI	% Cohesive Failure	Glueline Thickness Mils
1	R.T.	.516	470	910	0*	No data
2	R.T.	.515	425	825	0*	
3	R.T.	.516	420	815	0*	
4	R.T.	.513	440	860	0*	
5	R.T.	.517	390	755	0*	
Average				833		

*Failure in Dow #17 Coating

Bonding Conditions:
Temp. (°F) 350
Time (Hrs) 1
Pressure (psi) 150

Material Bonded:
Type Material
Adhesive AF-31
Roll 37
Lot 19

TABLE XVI

RESULTS OF X-RAY DIFFRACTION ANALYSIS OF DOW #17 TREATMENT COATINGS

Composition of "Light" (60-65 Volts End Point) Dow #17 Coating	Composition of "Standard" (70-75 Volts End Point) Dow #17 Coating	Composition of "Heavy" (90-95 Volts End Point) Dow #17 Coating
Mixture of Anhydrous and Hydrated Oxides of Chromium (No chromium sesquioxide present).	Mixture of Anhydrous and Hydrated Oxides of Chromium (no chromium sesquioxide present).	Composed entirely of chromium sesquioxide

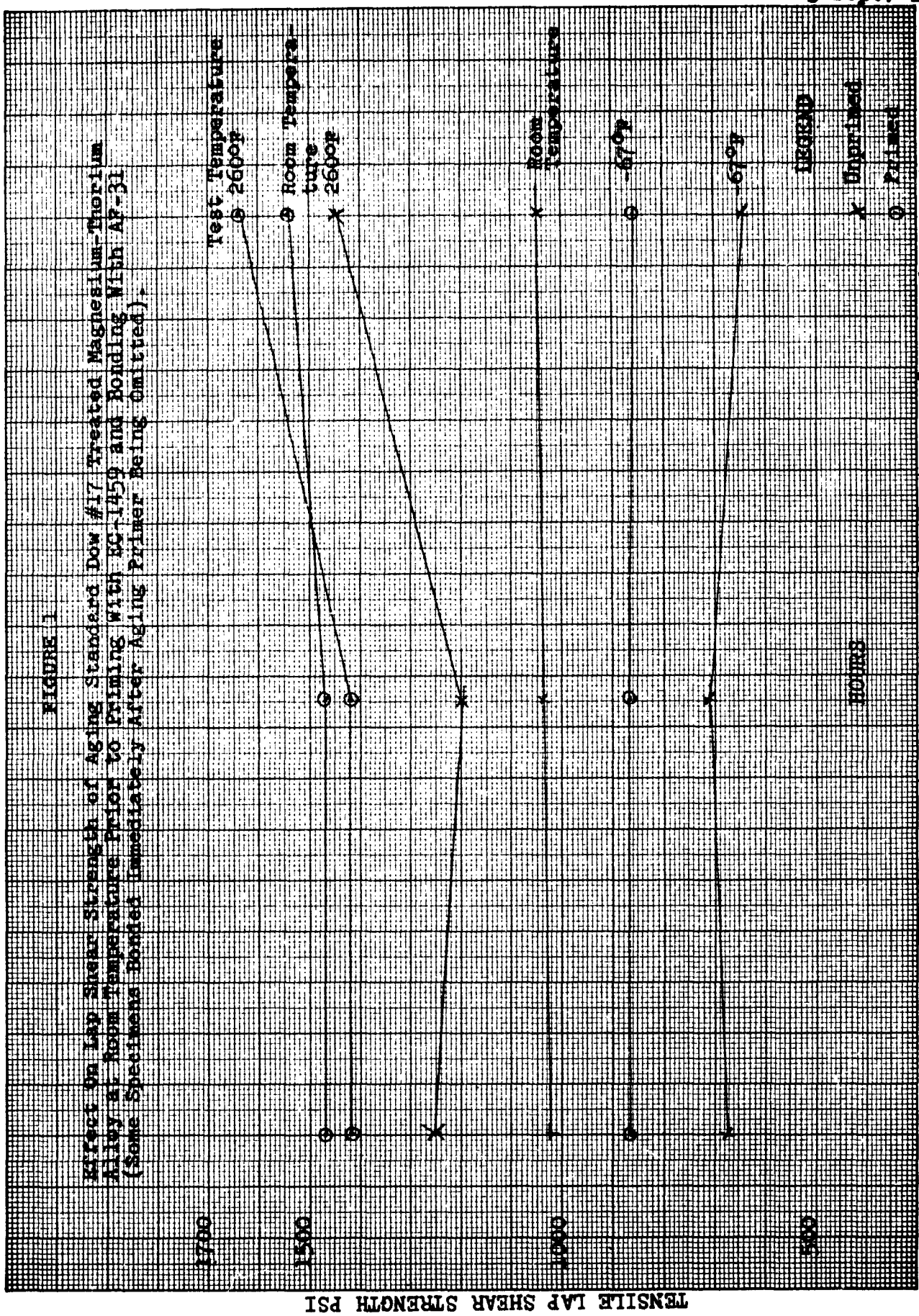

FIGURE 1

Effect On Lap Shear Strength of Aging Standard Dow #17 Treated Magnesium-Thorium Alloy at Room Temperature Prior to Priming With EC-1459 and Bonding With AF-31 (Same Specimens Bonded Immediately After Aging Primer Being Omitted).

Effect of Aging 20 Hrs. @ 450°F on Tensile Lap Shear Strength of Aluminum Adherends Bonded with AF-31 Adhesive
Adherends Pretreated by Phosphoric Acid Anodize Process
Bonded Specimens Post Cured 1 Hr. @ 350°F
Tested at Indicated Temperatures
-67°F
+250°F
TENSILE LAP SHEAR STRENGTH PSI
POUNDS

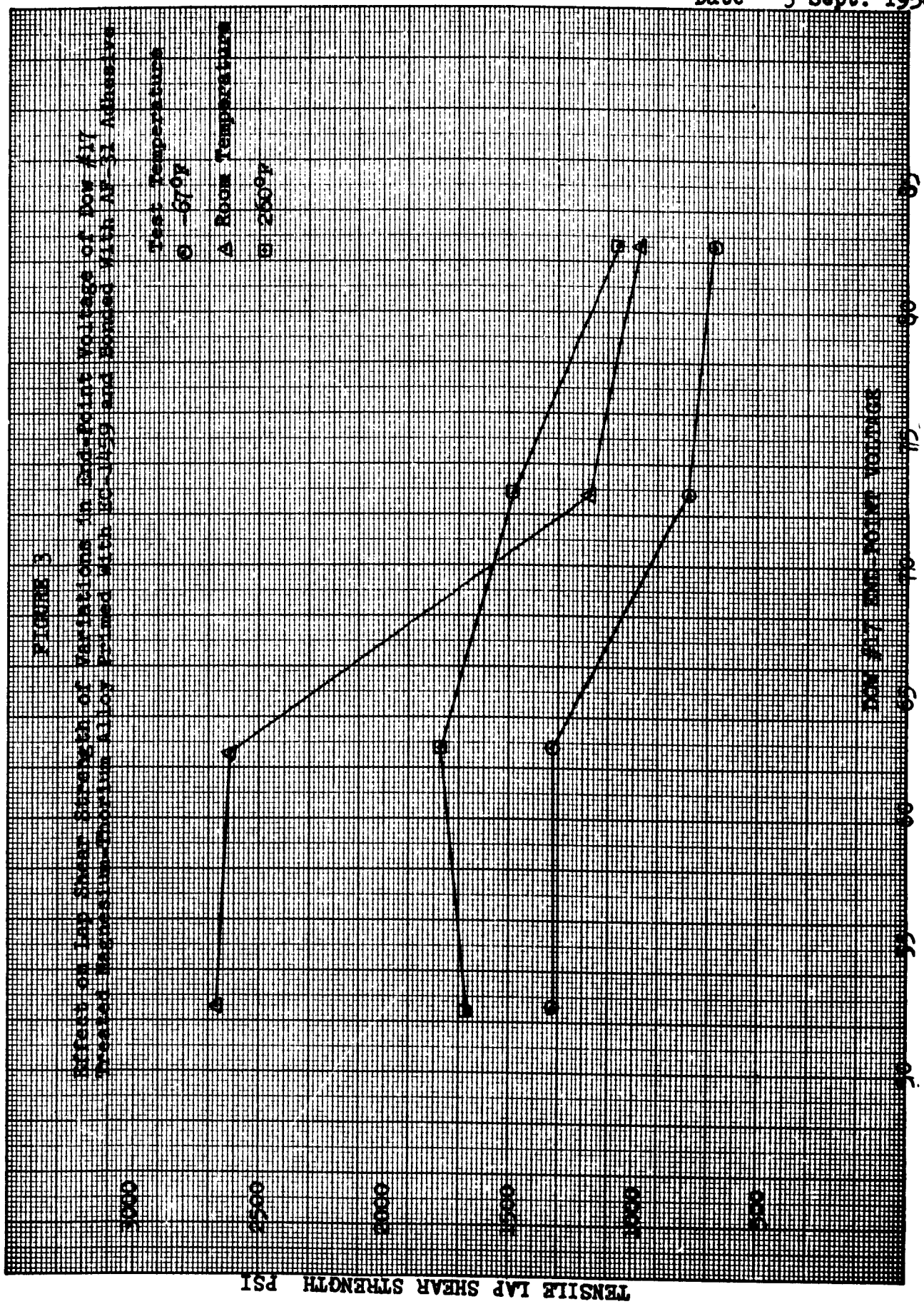
FIGURE 3
Effects on Lap Shear Strength of Variations in Cure Pulse Voltage of Dow 41F
Treated Magnesium Alloy Primed with AC-131 and Bonded with AF-32 Adhesive
Test Temperature
⊙ -67°F
Δ Room Temperature
□ 260°F
TENSILE LAP SHEAR STRENGTH PSI
PSI
3000
3500
4000
4500
5000
5500
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
400
410
420
430
440
450