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on

The Evaluation of Several Aromatic Fuel
Resistant Slushing Compounds

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AUTHORIZATION FOR TEST

1. This problem was submitted to this Laboratory by Bureau of Aeronautics' letter Aer.E-257-E.R.M. JJ/G1 F-38-2(12)(058471) of 12 May 1942 for review and comment. Subsequently, the Laboratory was directed to evaluate nine specific products that were submitted to the Bureau.

OBJECT OF TEST

2. The object of this test is to establish the relative value of nine coatings that have been submitted for the protection of inner surfaces of aeroplane fuel tanks. The samples were submitted by several competitors in the field of protective coatings.

ABSTRACT OF TEST

3. Two particular qualities of these materials considered to be of paramount importance in their performance were studied. First, their solubility in aviation grade gasoline was determined. Experiments were designed which possessed a tendency to exaggerate actual conditions likely to be encountered in service but which served well to establish the relative value of each product. Second, the protective quality of each material was evaluated when applied to aluminum alloy from which integral gasoline tanks are constructed.

CONCLUSIONS

(a) In all tests, P-27-b has been shown to be the most satisfactory material for use as an interior coating for airplane fuel tanks.

(b) Of the other materials tested, only two seem of any value at all. These were 2A-82, and 2A-82A, but even these fell short of P-27-b.

RECOMMENDATIONS

(a) On the basis of tests described herein it is recommended that zinc chromate primer, P-27-b, be used for coating the interior of integral gasoline tanks constructed of aluminum alloy. Care should be exercised to insure the use of a primer prepared on the standard formula of P-27-b, as some alternates supplied under AN-TT-P-656, would not possess the same solubility characteristics as the primer tested herein.

(b) It is further recommended that a full scale tank of at least 100 gallon capacity be furnished this Laboratory for conducting full scale tests on problems involving aviation gasoline and tank liners.

MATERIALS UNDER TEST

4. The materials under test were prepared by several manufacturers and a complete list of these products and their source follows:

<u>Manufacturer</u>	<u>Name</u>	<u>Code Number</u>
Presstite Engineering Co., St. Louis, Missouri	Fuel Tank Sealer - Type P-100	2A-82
Presstite Engineering Co., St. Louis, Missouri	Brush on Fuel Tank Sealer	2A-82-A
Presstite Engineering Co., St. Louis, Missouri	Slushing Compound	2A-113D
Pittsburgh Plate Glass Co., Pittsburgh, Pennsylvania	Fuel Tank Slushing Compound	IR-18780
Pittsburgh Plate Glass Co., Pittsburgh, Pennsylvania	Zinc Chromate Slushing Compound	LF-17646
Andrew Brown Co., Los Angeles, California	Rubbercote	SN-94
W. P. Fuller Co., Los Angeles, California	Slushing Compound	TL-284
Reliance Varnish Co. Inc. Louisville, Kentucky	Fuel Tank Slushing Compound	8094
E. I. duPont deNemours & Co.Inc Wilmington, Delaware	Zinc Chromate Primer	P-27-b

The various materials are hereafter designated by their code numbers.

5. Two sets of aluminum panels (2-1/4" x 4") were coated with these materials. One set of panels was anodized and the other was plain.

6. The panels were cut from 24ST aluminum alclad sheet .025" in thickness and those which were anodized were prepared by the standard chromic acid process as specified for Naval aircraft.

METHOD OF TEST

(a) Solubility of Materials in 40% Aromatic Gasoline

7. A tin dish was cut so that it could be flattened out and was coated with the material for test, allowed to dry for four days and was weighed. It was then bent to fit into the extraction tubes, which were pierced at several points, and placed in the tube along with 50 cc of 40% aromatic gasoline. The gasoline was then boiled under reflux for five hours to insure extraction. At the end of the heating period, the coated tin was removed, dried and weighed. The gasoline was poured out into a weighed dish, rinsed with 10 cc of the pure gasoline and evaporated, heated to constant weight at 100° C. and the residual weight calculated.

8. In order to accurately determine the extent of pollution of the gasoline; panels (2-1/4" x 4") were finished on one side with the sealers. One panel was plain 24ST alclad metal and another was anodized. These were allowed to dry for 24 hours and then each was placed in a pint can with 435 cc of 40% aromatic gasoline. The cans were placed on the rollers and tumbled for 24 hours. At the end of this period the gasoline was removed and a determination of gum made.

(b) Protective Quality of the Films in 40% Aromatic Gasoline

9. A second set of panels identical with the previous set was, in pairs consisting of plain and anodized panels with the same coating, placed in pint cans back to back with 150 cc of water and 275 cc of 40% aromatic gasoline. A small hole was punched through the top of each can. This group of cans was allowed to stand and examinations of the panels were made at intervals over a period of three weeks. This test was designed to determine the stability of the proposed interliners when exposed to the water-gasoline interface which is recognized as being among the most corrosive conditions encountered in gasoline tank construction. Protection afforded the metal by the liner was noted.

DATA RECORDED DURING TESTS

(a) Solubility of Material in 40% Aromatic Gasoline

10. A method, closely simulating actual service conditions, consisted of painting small tin panels with the test materials, rolling them so as to fit the extraction thimble, and extracting this dried film for several hours. The data obtained from this experiment is contained in columns 1 and 2 of Table I.

TABLE I

Extraction Data on Solid Constituents of Fuel Tank Liners

<u>Product</u>	<u>1</u> Wt. Loss of <u>Coated Tin</u>	<u>2</u> Gasoline <u>Residue</u>
8094	52 mg	56 mg
2A-82	58	54
2A-82A	57	56
2A-113D	100	117
LF-17646	71	78
LR-18780	60	64
SN-94	73	74
TL-284	68	80
P-27-b	36	34

11. Navy Aeronautical Specification M-475B requires that the contamination suffered by fuel in contact with the surfaces of tanks, other than metal surfaces, be determined by presenting to the action of a definite volume of fuel a definite area of surface. This surface-volume relationship is 7.5 cc of fuel to each cm² of effective surface. To simulate these conditions, small panels (2-1/4" x 4") having a total area on one side of 58 sq. cm. were coated as described in paragraph 8 and tumbled in 435 cc of fuel for 24 hours. The amounts of gum recovered from each 100 cc sample of gasoline in which the solids were tested are listed in Table II.

TABLE II

Gum Residues from Gasoline Samples

<u>Product</u>	<u>8094</u>	<u>2A-82</u>	<u>2A-82A</u>	<u>2A-113D</u>	<u>LF-17646</u>	<u>LR-18780</u>	<u>SN-94</u>	<u>TL-284</u>	<u>P-27-b</u>
Plain Panel	3.6	4.0	3.6	8.6	6.4	3.2	4.4	7.8	3.4
Anodized Panel	3.8	3.4	3.0	9.0	6.8	4.2	3.8	7.8	1.6

The gasoline used in these determinations contained 0.2 mg. of gum per 100 cc.

12. The standard aromatic fuel ordinarily used in tests of this kind is known by the designation AN-813. It is prepared by adding a known aromatic blend to 100 octane fighting grade fuel meeting the requirement of Army-Navy Specification AN-VV-F-781 which normally contains from 2 to 3% aromatics. The composition of the Aromatic additive is as follows:

Benzene - 12.5%
 Toluene - 50.0
 Xylene - 37.5

This mixture is added to the above gasoline so that the aromatic constituents occur in the final blend in the following proportions:

Benzene - 5%
 Toluene - 20
 Xylene - 15

Protective Quality of Films in 40% Aromatic Gasoline

13. Panels coated with the test material were placed in mixtures of water and gasoline and allowed to remain for approximately 3 weeks. The panels were observed periodically for signs of deterioration in the film and for corrosion on the panels. The result of these inspections are set forth in Table III. In this table the number of x's indicate the severity of the condition involved.

TABLE III

Protective Quality of Films in 40% Aromatic Gasoline

	<u>Time in days</u>	<u>1</u>			<u>10</u>			<u>19</u>			<u>1</u>			<u>10</u>			<u>19</u>			<u>1</u>			<u>10</u>			<u>19</u>		
		<u>Swelling</u>	<u>Leaching</u>	<u>Softening</u>	<u>Blistering</u>	<u>Corroding</u>	<u>Other</u>	<u>Change</u>																				
1	8094 Plain	x	x	x	x	xx	xx	x	x	x				x	x		x	x										
2	Anodized	x	x	x	x	xx	xx	x	x	x							x	x										
3	2A-82 Plain				x	x	x	x	xx	xxxxxx				x														
4	Anodized				x	x	x	x	xx	xx	xx																	
5	2A-82A Plain	x	x	x	x	x	x	x	x	x	x	x																
6	Anodized	x	x	x	x	x	x	x	x	x	x	x																

Lifted
Discolored

Discolored

TABLE III (Continued)

Time in days	<u>1 10 19</u>			<u>1 10 19</u>			<u>1 10 19</u>			<u>1 10 19</u>			<u>1 10 19</u>		
	<u>Swelling</u>	<u>Leaching</u>	<u>Softening</u>	<u>Blistering</u>	<u>Corroding</u>	<u>Other Changes</u>									
7 2A-113D Plain	x	xx	x	x	x		xx	xx		xx	xx	x			tacky tacky tacky tacky tacky
8 Anodized	x	xx	x	x	x		xx	xx		x	x				tacky tacky tacky tacky tacky
9 LF-17646 Plain	xx	xx	x	xx	xx	x	x	x		x	x	x			ruined
10 Anodized	xx	xx	x	x	x	x	x	x		x	x				ruined
11 IR-18780 Plain	x	xx	xx				x	x	x	x	x	x			ruined
12 Anodized	x	xx	xx				x	x	x	x	x				ruined
13 SN-94 Plain	x	x	x				x	x	x						ruined Poor adhesion discolored
14 Anodized	x	x	x				x	x	x				x		ruined discolored
15 TL-284 Plain	x	xx	xx							x	x				ruined Poor adhesion
16 Anodized	x	xx	xx							x	x				ruined Poor adhesion
17 P-27-b Plain				x	x										Scum Film off
18 Anodized				x	x										Scum

DISCUSSION OF RESULTS

14. The number of ways that the foregoing data can be used to obtain an empirical classification of these products according to decreasing merit is innumerable, but each has some value. Several of these orders are, therefore, shown and it will be noted that certain of the materials consistently fall in the upper ends of the tables while others are usually in the lower parts. Thus each order, while of little value alone, lends support to the final choice of the most satisfactory product. The first

order is by merely arranging the weights in tables I and II in their increasing order.

TABLE IV

Order of Values of Tested Products from Table I

<u>Order Number</u>	<u>Column 1</u>		<u>Column 2</u>	
1	P-27-b	36	P-27-b	34
2	8094	52	2A-82	54
3	2A-82A	57	8094	56
4	2A-82	58	2A-82A	56
5	IR-18780	60	IR-18780	64
6	TL-284	68	SN-94	74
7	LF-17646	71	LF-17646	78
8	SN-94	73	TL-284	80
9	2A-1130	100	2A-1130	117

TABLE V

Order of Value of Products Tested from Table II

<u>Order No.</u>	<u>Column 1</u>	<u>Table II</u>	<u>Column 2</u>	
1	IR-18780	3.2	P-27-b	1.6
2	P-27-b	3.4	2A-82A	3.0
3	2A-82A	3.6	2A-82	3.4
4	8094	3.6	8094	3.8
5	2A-82	4.0	SN-94	3.8
6	SN-94	4.4	IR-18780	4.2
7	LF-17646	6.4	LF-17646	6.8
8	TL-284	7.8	TL-284	7.8
9	2A-1130	8.6	2A-1130	9.0

A slightly different order is obtained by arranging the sums of the weights recorded in Table I.

TABLE VI

<u>Order No.</u>	$\frac{1}{1}$ A		$\frac{2}{2}$ B	
1	P-27-b	70	P-27-b	5.0
2	8094	108	2A-82A	6.6
3	2A-82	112	8094	7.4
4	2A-82A	113	2A-82	7.4
5	LR-18780	124	LR-17646	7.4
6	SN-94	147	SN-94	8.2
7	TL-284	148	LF-17646	13.2
8	LF-17646	149	TL-284	15.6
9	2A-113D	227	2A-1130	17.6

- 1 - Column A is the sum of the weights from Columns 1 and 2 in Table I.
 2 - Column B is the sum of the weights in Table II.

15. By adding the order numbers from the various methods a composite of the different methods is obtained.

TABLE VII

<u>Table & Column No.</u>	<u>IV-1</u>	<u>IV-2</u>	<u>V-2</u>	<u>VI-1</u>	<u>VI-2</u>	<u>Total</u>
P-27-b	1	1	1	1	1	5
8094	2	3	4	2	3	14
2A-82A	3	4	2	4	2	15
2A-82	4	2	3	3	4	16
LR-18780	5	5	6	5	5	26
SN-94	8	6	5	6	6	31
LF-17646	7	7	7	8	7	36
TL-284	6	8	8	7	8	37
2A-113D	9	9	9	9	9	45

16. This table shows the consistency between the coated tin method and the coated aluminum panels. The conditions of these two methods were widely different since the former was run at the boiling temperature and the latter at room temperature. In all cases P-27-b was the best and the following three products were far superior to the rest: 8094, 2A-82A, and 2A-82.

17. As can readily be seen there was only a little corrosion observed in two cases. With 8094 the corrosion was visible at the lower edge of both panels even with the film on, but in the case of SN-94, the corroded spot did not show until the film was removed. The entire set of panels showed no sign of the interface between the water and gasoline after the film had been removed.

18. Several materials can be eliminated immediately by virtue of their complete breakdown in water. These are LF-17646, IR-18780, SN-94, and TL-284. In addition to these 8094 was shown to be useless due to the corrosion which occurred on both panels. This leaves only four products left. These are 2A-82, 2A-82A, 2A-1130, and P-27-b. Of these, the P-27-b was alone in showing no swelling, softening, or blistering. All four, however, were leached considerably, but the data obtained in the other methods showed P-27-b to be the lowest on this score in gasoline. However, in water no quantitative data was sought. The other three products seemed to arbitrarily fall in the decreasing order 2A-82, 2A-82A, and 2A-1130.

CONCLUSIONS

19. In all tests P-27-b has been shown to be the most satisfactory material for use as an interior coating for airplane fuel tanks.

20. Of the other materials tested, only two were of any value at all. These were: 2A-82, and 2A-82A, but even these fell far short of P-27-b.

RECOMMENDATIONS

21. On the basis of tests described herein it is recommended that zinc chromate primer, P-27-b, be used for coating the interior of integral gasoline tanks constructed of aluminum alloy. Care should be exercised to insure the use of a primer prepared on the standard formula of P-27-b, as some alternates supplied under AN-TT-P-656, would not possess the same solubility characteristics as the primer tested herein.

22. It is further recommended that a full scale tank of at least 100 gallon capacity be furnished this laboratory for conducting full scale tests on problems involving aviation gasoline and tank liners.