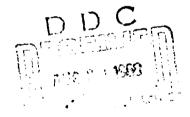
AN EVALUATION OF THE EFFECTIVENESS OF A STATIC DISSIPATOR FUEL ADDITIVE AFTER TRANSPORT IN A FULL SCALE FUEL DISTRIBUTION SYSTEM

HOWARD F. JONES Air Force Acro Propulsion Laboratory

EDDIE FRENCH Directorate of Air Force Aerospace Fuels

TECHNICAL REPORT AFAPL-TR-69-23

MAY 1969



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FOREWORD

This report was prepared as a joint effort by the Fuels, Lubrication, and Hazards Branch, Support Technology Division of the Air Force Aero Propulsion Laboratory, Project 3048, Task 304805, and the Product Engineering Branch, Quality Division, Directorate of Air Force Aerospace Fuels, Kelly AFB, Texas, Project POL 67-16. Mr. Howard F. Jones (APFL), Mr. Eddie French (SAOQ), and Lt. William H. Stark (SAOQ) directed the study.

The work described in this report was conducted from January 1968 to August 1968.

The authors wish to express their appreciation to Mr. F. Carter, Canadian Armed Services Headquarters, and Mr. L. Gardner, National Research Council of Canada, for their invaluable assistance on this program.

This report was submitted by the authors on 7 February 1969.

This technical report has been reviewed and is approved.

T. TRAY!

Quality Division // Directorate of Aerospace Fuels

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ARTHUR V. CHURCHILL Fuels Branch Fuels, Lubrication & Hazards Division Air Force Aero Propulsion Laboratory

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ABSTRACT

 $^{>}$ A test program was performed to determine the feasibility of blending a proven static dissipator additive, Shell ASA-3, into a fuel at a refinery, and transferring the product through a long distribution system to the using activity. The U. S. government owned pipeline complex connecting Loring AFB, Maine, with Searsport Storage terminal, which was receiving fuel from the Gulf coast area, was used for this test program. Test data obtained during the 8 months of the test program show that the conductivity of the fuel decreases to an unacceptable level from refinery to using activity, specific models of fuel quantity probes are adversely affected, and some types of corrosion inhibitors influence the fuel conductivity when used in combination with static dissipator additive ASA-3.

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SECTION I

INTRODUCTION

The flow of fuel through a pipeline or through filter media generates a electrical charge in the same manner as any dissimilar moving bodies in contact. Due to the relatively poor conductivity of the turbine fuels, rapid charge dissipation is impossible in the normal fuel handling systems. The electrical charge thus generated can build up to critical proportions which under the proper conditions can discharge in vapor spaces of the storage system, servicing trucks, or aircraft. These discharges may be of sufficient intensity to cause an explosion or fire. One method of minimizing this hazard is by the addition of metallo-organic compounds which will increase the conductivity of the fuel thus enabling a more rapid dissipation of any static charge which might be generated in the system.

While much data has been accumulated on the use of fuel containing a static dissipator additive in aircraft, no information has been obtained on the depletion rates of the additives which could be expected in a full-scale fuel distribution system which included ocean-going tankers and pipelines. The objective of the study discussed in this report was to gain this data on a proven static dissipator additive (Shell ASA-3) and provide information necessary to determine the optimum additive injection point which would provide the desired conductivity level throughout the base handling system. This program was also designed to gain a limited amount of data on (1) the effects of this additive on specification properties of large production batches of MIL-T-5624 grade JP-4 fuel; (2) determine if any gross changes in fuel filter/separator performance could be expected from use of the additive; and (3) determine if any problems would be encountered by the use of this additive on a relatively large number of operational USAF aircraft.

SECTION II

DISCUSSION

1. TEST PROGRAM

The test program involved the shipment of 470,597 barrels of ASA-3 treated JP-4 through five (5) separate handling systems which could be encountered in the normal transfer of fuel from the refinery to the point of servicing of the aircraft. Fuel was shipped from two gulf coast refineries by ocean-going tankers 3,000 miles into storage at the USAF Fuel Terminal at Searsport, Maine. Transportation time from refinery to storage terminal was approximately 7 days. It was then moved through a 200 mile pipeline into storage at the USAF Fuel Terminal, Limestone, Maine. Fuel from this terminal was transferred through a six (6) mile pipeline to the Loring AFB, M.ine, fuel handling system and subsequently serviced to the Aircraft. Figure 1 shows an outline of the system used in this study. Testing was conducted throughout the system in accordance with the schedules outlined in Table I.

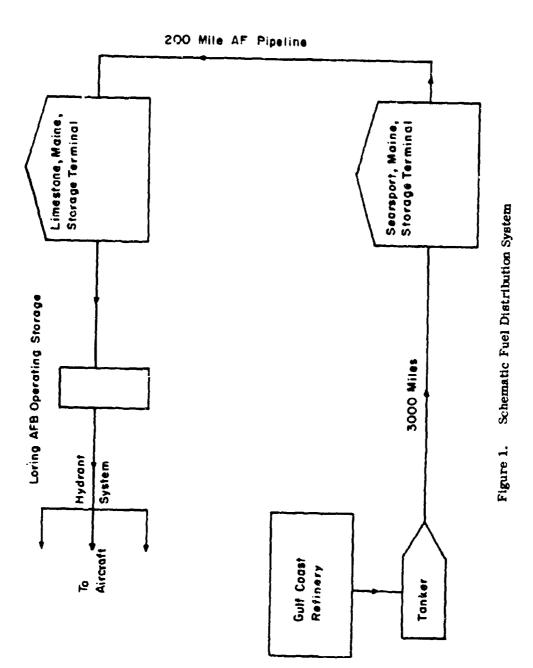
2. ADDITIVE BLENDING PROCEDURES

Fuel used in this test program consisted of four tanker shipments and was furnished from two refinery sources. Blending procedures used at each refinery source are outlined below.

Refinery A Blending was accomplished by diluting the required amount of concentrated ASA-3 in 25 gallons of ASTM aviation Jet A-1 and pouring this mixture through the top hatch of the JP-4 blend tank. The fuel tank was then circulated for a minimum of 8 hours and the conductivity determined. All operations have been done under the scrutiny of the Government Quality Control Representative. When the tank capacity did not permit blending of sufficient product to fill a tanker lifting requirement, ASA-3 was blended directly in ship tanks. This procedure was used on one 20,000 barrel quantity by loading approximately 3 feet of product into the ships tanks, adding the necessary amount of additive to the tank, and filling the remaining volume with product, thereby, utilizing the filling circulation to disperse the additive

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		FUEL TESTING SCHEDULE	HEDULE		
Tests Required	Tanker Refinery	Sample Source and Frequency of Test Tanker Searsport Lim Searsport Terminal Ter	nd Frequency o Searsport Terminal	f Test Linestone Terriinal	Loring AFD Op. Storage
Full Specification	After loading				
Routine 3C	After Loading	Prior to Discharge	Nonthly	Honthly	
Conductivity	After Loading	Prior to Discharge	ueekly	Week] v	Daily
MISM	Before and After ASA-3		Heekly	Neekly	Weekly

4

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TABLE I

Refinery B Procedures utilized by this refinery differed from that of Refinery A in that the ASA-3 was injected directly into the tanker loading line using two proportioning pumps. Both methods appear to give satisfactory results. e sisten i met tet men equalimentation (mild)

2

3. ADDITIVE CONCENTRATION

Since the prime objective of this program was to determine the changes in conductivity levels of the fuel throughout the transportation system and not additive effectiveness, the static dissipator was blended in all batches at a concentration level of 1.0 ± 0.1 ppm rather than to a specific conductivity level. Electrical conductivity measurements were accomplished in situ in vessel tankage prior to departure from the refinery. These data were used as the base line to estimate changes in additive concentration throughout the fuel distribution system.

4. FUEL CONDUCTIVITY

Fuel conductivities were measured from the refinery to the using activity in accordance with the schedule outlined in Table I, using ASTM Method D2624. These measurements recorded in Table II, were corrected to 60° F so that any changes in conductivity throughout the system would be readily apparent. Conductivity readings reported for Loring AFB in this table have been consolidated to show the daily average reading on all tanks. The high and low conductivities on any given day did not exceed ±8 picomhos per meter for this activity. All other data are actual readings as reported.

A total of four (4) shipments of fuel were transported from the Gulf Coast to Searsport, Maine, during this program. Shipments 1 and 3 were supplied by refinery "A" and were loaded on 19 January 1968 and 17 March 1968. These shipments arrived at Searsport, Maine on 29 January 1968 and 24 March 1968, respectively. Shipments 2 and 4 were supplied by refinery "B" and were loaded on 15 February 1968 and 26 April 1968. Shipment number 2 arrived at Searsport, Maine, on 24 February 1968 while shipment number 4 arrived on 7 May 1968. All shipments except number one (1) lost its identity upon receipt into the Searsport storage through mixing with previous ASA-3 batches in the storage tanks and the pipeline system between Searsport and Limestone, Maine.

TABLE II

CONDUCTIVITY READLINCS AT 60°F

		Sears Termi	Searsport Storage Terminal	torage	Lineston	Linestone Storage Terminal	
	Gulf Coast Refinery	Conde	ct ivit;	Conductivity 060°F	Conduct1	Conductivity @60°F	Loring AF2 Maine
Date	G60°F	5	Tanka 7	8	1 1	11K5 2	Conductivity 660°F
19 Jan	610						
29 Jan		445		l			
6 Feb		228					
13 Feb		255				-	
15 Fcb	595	244					
24 Feb		280	209	255			
7 Mar		201	191	214			
17 Mar	375						
21 Nar		230					
24 Mar		215		230			
25 Mar		265		240			
3 Apr		200		250	140	150	
8 Apr				210	130	071	
11 Apr					130	135	68
12 Apr							78
13 Apr							112
15 Apr							72
16 APT		250			130	135	85
17 Apr							80
18 A pr							76
19 Apr					127	130	78
22 Apr		210		255	117	125	83
23 Apr							78
24 Apr					115	122	82
25 Apr							93
26 Apr	255			1			89
29 Apr							89
30 Apr		210		265	172	127	96
1 1							96
2 Nov							96
:							

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		Searsport Storage Terminal	ort Stoi	286	Terminel	Terminal Conductivity 860°F	Loring AFB Maine
-	Gulf Coast Refinery	Conduct	tivity i Tanka	660°F	F	Tanke	Distribution System
liate.	Conductivity	S		89	-	7	
							98
6 May				-			100
7 May		470		520		116	101
R MAY							101
Van P							100
10 Mar					201	115	101
13 14.4		410					101
14 Hav							100
N a a					501	116	100
In May							95
		460		310			
U NAV		470		310			
- Fer		050		310			
Jun 1		100		300			
10 Jun				300			00
13 Jun					60	67	00
4 J.B				Ţ			8
7 Jun				000	19	65	
18 Jun		5					57
19 C 6							57
D Jun				0.00	19	65	59
Il Jun		430					
07 Tun					5		59
25 1111							57
					:	193	57
		420	1	350			59
							57
		-					59
		420		1 360			83
2 Jul							88
10 141							88
11 Jul					61	19	00
12 Jul							22
•							- CA

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TABLE II (CONTD)

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TABLE II (CONTD)

		Searspo	ort Stor	ıgc	Limestone Terminal	Limestone Storage [crminal	
	Gulf Coast Refinery Conductivity	Conduc	Conductivity @60°F Tanks	60°F	Conduct 7	Conductivity @60°F Tanks	Loring AFB Maine Distribution System
	@60*F	°	5 7	8	1	2	Conductivity (460°F
		 ! !				60	16
				 -	96	99	91
				 			87
							91
23 Jul			!		100	72	
7		! 					
					103	95	95
-							97
							100
1					102	107	95
							96
		-			102	107	97
			1 1 1				98
				 			97
							96
				-			16

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The data shown in Table II with one exception, shipment number 4, shows a steady decrease in conductivity throughout the transportation system. This ont increase in conductivity of 215 picomhos noted from the refinery to consport, Maine for shipment number 4 may be the result of measuring the conductivity before the ASA-3 had completely ionized in the blended fuel. This explanation appears probable since Batch 1 showed an increase in conductivity of 235 picomhos per meter over a four day period from the time of blending in the refinery tanks to completion of the tanker loading operation. . 2

All other data appears to be self explanatory except for the 24 picohmo increase in conductivity at Loring AFB between readings taken on 2 July and 10 July. This increase was thought to be the result of the change in the meter used at Loring AFB, as shown in Table III. This explanation however, was not considered valid after analysis of the meter calibration data supplied by the National Research Council of Canada (Table IV) and the readings taken at the Limestone Terminal after that date. No increase in the fuel conductivity was noticed in the Limestone storage tanks until receipt of new fuel into tank number 1 on 18 July when an increase of 34 picomhos occurred.

The overall analysis of this data, as stated previously, shows a steady decrease in conductivity throughout the system. At no time in the program did the conductivity at the using activity meet the recommended concentration levels of 150 picomhos/meter to 450 picomhos/meter at 60°F. Data does indicate that the conductivity appeared to be stabilizing at individual points in the system from Searsport to Loring AFB toward the end of the program. However, because of the large losses between these points in the pipeline system, it is not believed that the conductivity levels recommended for servicing to the aircraft could be reached or maintained in this system without supplying additional additive at some intermediate point, such as the beginning of the pipeline at Searsport or just prior to entering the storage tonks at Limestone, Maine.

5. EFFECT OF STATIC DISSIPATOR ADDITIVE ASA-3 ON FUEL CHARACTERISTICS

Test data on all specification MIL-T-5624, Grade JP-4 requirements are summarized in Table V. The only fuel characteristic affected by the static

TABLE TIL

				LIMESTONE
	REFINERY "A"	REFINERY "B"	SEARSPUKI	LUKING AF
	Shipment 1 & 3	Shipment 2	,	5 June to 3 July 19

INDICATOR NO.	REFINERY "A"	REFINERY "B"	SEARSPORT	LIMESTONE/ LORING AFB
64022	Shipment 1 & 3	Shipment 2		5 June to 3 July 1968
64034				9 April to 21 May 1968
64043		Shipment 4		
64076			29 Jan to 3 July 1968	5 Julý to August 1968

.....

TABLE IV

MAIHAK CONDUCTIVITY INDICATORS CORRELATION DATA

Neter		Electr	ical Conductiv	ity, Picomho/m	76ªF	
Number	Fuel A	Fuel 3	13 Fuel C Fuel D	Fuel D	Fuel E	Fuel F
64034	20	210	460	60	170	415
64043	45	202	475	50	165	400
64076	60	235	535	60	190	470
64022	50	200	480	50	170	430

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Text Specification Batch				1221	TPST RPSINTS	
Teat Teat Benuitments 1 2 3		Constitution	Batch	Retch	Batch	Retub
Etv Shipped. Gale. 84. 986 131.679 96. 731 Vapor Fressure FST @ 100°F 2.0 31 56.3 56.7 54.2 Vapor Fressure FST @ 100°F 2.0 31 56.3 56.7 54.2 Versen FST @ 100°F 2.0 31 56.3 56.7 54.2 Versen FST @ 100°F 2.0 31 56.3 56.7 54.2 Versen FST @ 100°F 31 0.001 0.001 0.001 0.013 Versen FST @ 100°H 1 1.4 30 0.01 0.6 0.4 Attal Found, P 7 0.001 0.01 0.01 0.01 0.01 Attal Found, P 7 2.0 0.5 0.01 0.0 0.0 Attal Found, P 7 2.0 0.7 1.0 1.1 Attal Found, P 7 2.0 0.7 1.0 1.1 Attal Found, P 7 2.0 0.7 1.0 1.1 Attal Found, P 7 2.0 0.7 1.0 1.0 Attal Found 7 2.0 0.7 1.0 1.0 Attal Found 7 1.0 1.0 1.0 1.0 <td< th=""><th>Test</th><th>Regulrements</th><th>1</th><th>2</th><th>5</th><th>4</th></td<>	Test	Regulrements	1	2	5	4
CV, SUPPEG, Out Sint			700 70	151 670	06 701	171 761
Wear Freature FSI 100° 2.0 3.0 0.01 0.013 <th0.013< th=""> <th0.013< th=""> <th0.013< t<="" th=""><th>Vuuntity Shipped, Gals.</th><th></th><th></th><th></th><th>1 2 2 4 2 7 A</th><th>4 22</th></th0.013<></th0.013<></th0.013<>	Vuuntity Shipped, Gals.				1 2 2 4 2 7 A	4 22
Verter Persure FSI @ 100°F 2.0 3.0 3.0 0.013 <th0.013< th=""> 0.013 <th0.013< th="" th<=""><th>API (0 00 P</th><th>45-57</th><th>1. 10</th><th>0.00</th><th>7. 10 7.00</th><th>0.00</th></th0.013<></th0.013<>	API (0 00 P	45-57	1. 10	0.00	7. 10 7.00	0.00
Rr. M. S. M.	por Pressure PSI	2.0 - 3.0	2.7	12.5		4
pfein Sulfur, Wt. X 0.001 0.001 0.001 0.002 0.012 0.012 0.012 <th>¥t. X</th> <th>0.4 max.</th> <th>0.0023</th> <th>10.0</th> <th></th> <th>L-</th>	¥t. X	0.4 max.	0.0023	10.0		L-
ttal Gam, Hga./100 HL. 14.0 max. 1.4 3.0 0.8 0.4 0.4 1.0 0.6 0.4 0.4 1.0 0.6 0.4 0.4 1.0 0.5 1.0 0.5 1.0 0.5 1.0 0.5 1.0 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5 1.5	Sul	0.001 max.	0.001	0.001	.0002 .0002	
Rest Com 7.0 max. 0.6 1.0 0.6 0.6 0.6 Title Folat, F 2.7 max.	IJ	14.0 max.	1.4	3.0	1-	11N
ting Point, F fice, Vol. Z Resction, Interface Nating Resction, Interface Nating Resction, Interface Nating Resction, Interface Nating Responded F Saax, 19.0 Responded F Saax, 19.0 Responded F Saax, 19.0 Responded F Supported 8 4/0 F Supported 8	I 3	7.0 mex.	0.6	1.0	t	
titles, Vol. X 25 max. 19.0 10.5 14.0 12.5 ns, Vol. X 5 max. 2.0 0.5 0.5 1.0 1 seion. Goper Strip, ASTM 1 max. 1 1.0 1 1 1 seion. Jopper Strip, ASTM 1 max. 1 1.0 1 1 1 1 seion. Gopper Strip, ASTM 1 max. 1 1.0 1.0 1.0 2.5 2.28 vaporated F Report 216 196 5.7 5.0 1.1 1 1 x alporated F Report 216 91.0 94. 92.0 33.0 X Evaporated AOF Report 91.0 94. 92.0 33.0 X Evaporated AOF Report 1.0 1.2 1.0 1.0 1.0 X Evaporated AOF Report 91.0 94. 95.0 33.0 34.6 60.9 35.0 35.0 Vol. X Lupout X 1.0 1.2 1.0 1.2 1.0 1.0 <td>Freezing Point, F</td> <td>-72 max.</td> <td>0.26 -></td> <td><-80</td> <td>ŧ</td> <td> </td>	Freezing Point, F	-72 max.	0.26 ->	<-80	ŧ	
Image Nol. X 0.5 1.0 1	Vol.	25 max.	19.0	10.5	! -	-
Reaction, Interface Rating 18 max. 1 <	01. 2	5 max	2.0	0.5		0.5
seion, Coper Strip, ASTM 1 max. 1 1 1 1 ai Boiling Point F Report 1.48 154 160 202 Supported 8 support 20 min 49.5 51 45.0 42.0 X supported 8 30°F 50 min 83.0 91.0 94.0 92.0 81.0 74.5 X supported 8 400°F Report 1.5 91.0 94.0 92.0 33.0 X supported 8 400°F Report 1.5 91.0 1.2 1.0 1.0 X supported 8 40°F 9.0 min. 99.0 0.8 1.0 1.0 1.0 X tuported 8 40°F 9.0 min. 99.0 0.8 1.0 1.0 1.0 X tuported 8 40°F 1.5 max. 1.0 1.0 1.0 1.0 X tuported 8 40°F 1.0 0.1 0.1 0.1 0.1 1.0 X tuported 8 0.14 1.5 max. 1.0 1.2 1.0 1.0 1.0 X tu	2	1B max.		1.0	1	1
al Boiling Point, F Report 128 154 166 202 Evaporated F Evaporated F Report 216 186 226 228 Evaporated F Evaporated (3)0°F 50 min 84,0° 42.0° 42.0° Z Evaporated (3)0°F 50 min 84,0° 84,0° 42.0° 42.0° Z Evaporated (3)0°F 50 min 84,0° 84,0° 42.0° 42.0° Z Evaporated (3)0°F 90 min 94,0° 92.0° 31.0° 42.0° Z Evaporated (3)0°F 90 min 99.0° 94.0° 23.6° 43.6° 43.6° Volit, F 1.0° 1.3° 1.0° 1.0° 1.0° 1.0° 1.0° Volit, F 1.0° 1.0° 0.1° 1.0° 0.1° 1.0° 1.0° Volit, F 1.0° 0.1° 0.1° 0.1° 1.0° 1.0° 1.0° Volit, F 1.0° 0.1° 0.1° 0.1° 0.1° 1.0° 1.0° Volit, F 1.0° 0.1° 0.1° 0.1° 0.1° 1.0° <td>ä</td> <td>1 max.</td> <td></td> <td>1</td> <td>1 1</td> <td>Pass</td>	ä	1 max.		1	1 1	Pass
Svaporated F Report 216 186 216 228 45.0 42.0 43.0 42.0 43.0 42.0 43.0 42.0 43.0 42.0 43.0 42.0 43.0 42.0 43.0 <t< td=""><td>g Point,</td><td>Report</td><td>148</td><td>154</td><td></td><td>136</td></t<>	g Point,	Report	148	154		136
X Evaporated (0.200°F) 200°f 200°f 200°f 49.5 63 45.0 42.0 45.0 42.0 45.0 42.0 45.0 42.0 45.0 42.0 45.0 42.0 45.0 42.0 45.0 42.0 45.0 43.0 74.5 50 61.0 10.	54. P	Report	216	186	•	176
z Sveporated \emptyset 370°F 50 min 91.0 $94.$ 92.0 31.0 z Evaporated δ 400°FReport 91.0 $94.$ 92.0 31.0 z Evaporated δ 400°FReport 91.0 $94.$ 92.0 33.0 z Evaporated δ 400°FReport 91.0 $94.$ 92.0 33.0 z Evaporated δ 400°FReport 10.0 1.2 1.0 1.0 2.2 z old T 1.5 Max 1.0 1.2 1.0 1.0 1.0 z volitility $Trdex$ 5250 min 6687 7185 6566 7360 z volitility $0.0.1$ z 1.0 1.0 1.0 1.0 z volitility $0.0.7$ 0.7 0.7 0.7 0.7 0.7 z volitility 0.00^{2} $300/400^{7}$ 3^{2} min 6687 7185 65.66 7360 z volitility 0.00^{2} 0.13 0.11 0.14 1.0^{2} 1.0^{2} z volitility 0.010^{2} 0.00^{2} 3^{2} min 0.11 0.14 1^{2} z volitility 0.00^{2} $300/400^{7}$ 3^{2} min 3^{2} 3^{2} 3^{2} 3^{2} z volitility 0.01^{2} 0.01^{2} 0.01^{2} 0.01^{2} 0.01^{2} 0.11^{2} 0.14^{2} z volitility 0.00^{2} 0.00^{2} 0.01^{2} 0.01^{2} 0.01^{2} 0.0^{2} 0.0^{2} <td>Z Evaporated</td> <td>20 min</td> <td>49.5</td> <td>63</td> <td>t</td> <td>58</td>	Z Evaporated	20 min	49.5	63	t	58
X Evaporated (0.40) F 90.00 F Report 91.0 94.00 S 92.0 83.0 X Evaporated (0.4) F 90.0 min. 99.0 - </td <td>Z Zveporated</td> <td>50 min</td> <td>83.0</td> <td>89</td> <td></td> <td>A6</td>	Z Zveporated	50 min	83.0	89		A6
X Evaporated @ 470*F 90 min. 99.0 - <t< td=""><td>X Evaporated</td><td>Report</td><td>0.16</td><td>76</td><td></td><td>92</td></t<>	X Evaporated	Report	0.16	76		92
Point, F Report 456 436 442 436 due Vol. Z 1.5 max. 1.5 max. 1.0 1.0 1.0 1.0 due Vol. Z 1.5 max. 1.5 max. 1.0 1.2 1.0 1.0 1.0 due Vol. Z 1.5 max. 1.5 max. 1.0 1.2 1.0 1.0 1.0 due Vol. Z 215 max. 1.0 1.2 1.0 1.0 1.0 1.0 e Volitility Index 22 min. Hg 27 min. d. 5.7 67.6 60.9 0.3 <td< td=""><td>X Evaporated @</td><td>90 min.</td><td>0.66</td><td></td><td></td><td></td></td<>	X Evaporated @	90 min.	0.66			
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Picomhos/Meter 3 60°F Report 370 595 375	ASA-3, ppm	1.0 +0.1	1.0	1.0	-	1.0
		Report	370	595	375	255

PROCUREMENT SPECIFICATION TEST RESULTS

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TABLE V

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dissipator additive Shell ASA-5 was the Water Separometer Index Modified (WSIM). Reductions ranging from 19 to 36 numbers were noted after the addition of the ASA-3.

WSIM ratings were monitored at all points in the distribution system in accordance with the schedule shown in Table I. ASTM test method D-2550 was used for obtaining this data on fuel from the Refinery, Searsport Storage Terminal and the pipeline. Since a standard WSIM apparatus was not available at the Linestone terminal, a new experimental apparatus, the Esso Mini Separometer, was used to obtain the WSIM ratings reported on fuel samples obtained from the Linestone Terminal and the Loring AFB operational storage system. The USAF Aero Propulsion Laboratory has completed a small scale test program on this equipment. WSIM ratings, correlated favorably with those obtained by the standard WSIM test apparatus.

WSIM test results for the ASA-3 program are shown in Table VI. Ali data with the exception of that reported for Batches 1, 2, 3, and 4 are average results for each location. Data from these batches represent the fuel from the refinery to receipt at Searsport Terminal. At this point, with the exception of Batch 1, identity of the product was lost due to mixing with previous batches of ASA-3 treated fuel. This dats shows a significant decrease in WSIM ratings after the addition of ASA-3. In addition, a significant decrease is also noted after addition of corrosion tabibitor during movement of the fuel in the pipeline system. This decrease in WSIM appears to be recovered by the time the fuel reaches Limestone, Maine, indicating that the majority of the corrosion inhibitor added at Searsport is being plated out in the pipeline system. No major changes in WSIM can be noted in fuel during storage and handling in the Searsport, Limestone, or Loring AFB systems.

6. EFFECUS OF ASA-3 ON AIRCRAFT SYSTEMS

The aircraft stationed at Loring AFB Maine, which used the fuel containing the static dissipator additive on a continuous basis during the test program are as follows: B-52, KC-135, F-106. No problems were encountered in these aircraft systems. Dow Air Force Base, although not specifically included in the test program, received fuel at an intermediate point on the Searsport to Limestone pipeline. Fuel with static dissipator additive was used to service

	Before ASA-3	After ASA-3	Searsport Storage	Pipeline -	Limestone Storage	Loring AFB Storage
Batch 1	81	22	46			
Batch 2	95	76	60			
Batch 3	85	49	70			
Batch 4	86	83	84			
February 1968			60	21		
March 1968			60	1		
April 1968			69	62	83	64
May 1968			79	57	72	72
June 1968			69	44	64	57
July 1968					75	
7 August 1968					• •••••••••••••••••••••••••••••••••••••	
15 August 1968						
Non-ASA-3 Fuel					g;	83
			TEST COMPLETE	31		

TABLE VI

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AVERAGE MONTHLY WSIM RATINGS

14

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F-89J aircraft stationed at Dow AFB. Erroneous fuel quantity readings were reported by pilots flying these aircraft. Investigation of the reported problem showed that the fuel quantity probes manufactured by Avien Corp., part numbers 165-047-454, 165-147-993, 165-077-713, 165-077-722, 165-077-12922, 165-090-633, PN165-047-455, 165-047-994, 165-077-716, 165-077-724, 165-077-1293, 165-047-461, P165-077-710, 165-077-718, 165-077-726, and 165-077-1506gave low resistance readings when operating on fuel containing the static dissipator additive. These probes are constructed of metal tubes making up the capacitor plates. Fuel quantity probes manufactured by Avien Corp., part number 165-0513-B2008 which were used in a small number of these aircraft, were not affected by the fuel containing the static dissipator additive. These fuel probes were constructed of Phenolic material with characterized printed plates. Test data is summarized in Table VII.

7. FILTER/SEPARATOR PERFORMANCE

The filter/separators, a vital component in the fuel handling system at all US Air Force Bases, were observed during this study to determine the effects of the static dissipator additive on performance. The filters in specific filter/ separators units were removed at the start of the test program for comparison with filter/separator elements at the completion of the test program. Also this procedure assured that new elements were placed in the system, thus eliminating the chance that deterioration of the filter/separator element had occurred prior to the start of the test program. All filter/separator elements met the performance requirements of MIL-F-8901. During the test program no filter separator element replacements were necessary due to high differential pressure or other evidence of degradation. Evaluation of the filter/separator elements at the completion of the test program showed that no excessive degradation of the filter elements performance had occurred due to 5 months use of the static dissipator additive.

8. TEMPERATURE EFFECTS

The fuel used in this test program originated in a relatively warm area the Gulf Coast of the United States. At the time of blending at the refinery, the fuel temperature was approximately 65°F. The loaded tankers traveled through

DUARITITY PROBES	Tank Units with Tubes and Print Plates
EFFECT OF STATIC DISSIPATUR ADDITIVE ON FUEL QUANTITY PROBES	Tank Units with Metal Tubular Plates
EFFECT OF STAT	

	Tank Units with Metal Tubular Plates	Tank Units with Phenolic Tubes and Printed Metallic Plates
Fuel with Static Dissipator Additive Conductivity 360 Picomhos @ Test Temp.	500 meg 0H/15	2,000 neg 0HMS
Fuel with Static Dissipator Additive Concuctivity 120 Picomhos @ Test Temp.	1,200 meg OH:15	10,000 meg 0H:15
Fuel without Static Dissipator Additive Conductivity 20 Picomhos @ Test Temp.	9,000 meg OHAS	10,000 meg OHMS

TABLE VII

the warm waters of the Gulf of Mexico to the colder areas of the Atlantic Ocean near Searsport, Maine, where the temperature of the fuel was reduced to approximately 30°F. This resulted in a decrease in temperature of approximately 35°F. While some loss of conductivity was observed from the refinery to Searsport, Maine, the effects of these temperature changes on the conductivity were not determined, but must be considered in the overall evaluation of the data.

9. CORROSION INHIBITORS

The two corrosion inhibitors used throughout this program have been Santolene "C" and AFA-1. Both products are qualified in accordance with Specification MIL-I-25017. At the time of the initial blending, all four batches of fuel contained Santolene "C" at a concentration of 4-5 pounds per 1000 barrels. Corrosion inhibitor was injected into all fuel transported in the 200 mile Searsport to Limestone pipeline at a concentration of 7 pounds per 1000 barrels of product. In the initial shipments of fuel from the storage tanks at Searsport, some changes in the conductivity of the fuel were noted on line samples after injection of the corrosion inhibitor. A laboratory test program was established to determine if the corrosion inhibitor was influencing the fuel conductivity. Nine samples (five gallons each) of non-additive fuel were blended as follows:

Α	JP-4 + FSII
В	JP-4 + FSII + ASA-3
С	JP-4 + FSII + Santolene ''C''
D	JP-4 + FSII + Santolene "C" + ASA-3
E	JP-4 + FSII + AFA-1
F	JР-4 + FSII + АFА-1 + АSА-3
B ₂	JР-4 + FSII + ASA-3
\mathbf{D}_2^-	JP-4 + FSII + Santolene ''C'' + ASA-3
F ₂	JP-4 + FSII + AFA-1 + ASA-3

The corrosion inhibitor concentration selected for this test was 10.0 #/1000 barrels for both inhibitors. FSII + ASA-3 concentration was set at 0.15% and 1.0 ppm nominal, respectively, at the time of blending. Conductivity of the

samples were measured over a one week period. Test results and testing frequency are shown in Table VIII.

As can be noted from these test results, the AFA-1 and the Santolene "C" do not appear to have any effect on the conductivity of the base fuel; however, Santolene "C" used in conjunction with ASA-3 increases the conductivity over that of the fuel containing ASA-3 alone. Conversely AFA-1 decreases the conductivity level below that of the fuel containing ASA-3 alone. This apparently is due to some reaction of the constituents of the inhibitors with the metallic ions in the ASA-3. The differences in the effects caused by these two inhibitors may be related to the wide differences in the acidity levels of Santolene "C" and AFA-1.

TABLE VIII

INFLUENCE OF CORROSION INHIBITOR ON FUEL CONDUCTIVITY

	10 000	0	325	0	485	0	215	355	515	225	
CONDUCTIVITY PICOMHOS/METER	12 Dec 58	ъ	365	0	550	O	230	375	570	230	
CONDUCTIV	11 Dec 68	I	315	0	470	0	205	300	650	061	
	10 Dec 68		290	0	620	0	'	•	1	1	
	SAMPLE	A	a	J	۵	ш	Ŀ	B-2	D-2	F-2	

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SECTION III

CONCLUSIONS

1. The blending of a static dissipator additive at the petroleum refinery and subsequent transfer through a system such as that used in this test program will not permit desired fuel conductivity at the point of aircraft servicing.

2. While some stabilizing effect is noted in the latter portion of the test program in the amount of conductivity lost during transfer, it is concluded that the loss in fuel conductivity from refinery to user in the type of system used for the test is valid and continuous losses will occur.

3. The use of a fuel containing a static dissipator additive renders some types of fuel quantity probes used in USAF aircraft inoperable and causes erroneous fuel quantity readings resulting in mission aborts.

4. Fitter/separator performance did not appear to be significantly affected by fuel containing a static dissipator additive in the concentration encountered at Loring AFB, Maine.

5. Corrosion inhibitors show a definite effect on the fuel conductivity when used in combination with the static dissipator additive, ASA-3. Data on the two corrosion inhibitors used in this program does not show a definite effect of corrosion inhibitor on conductivity when used alone.

UNCLASSIFIED Security Classification			
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/ ir Force Aero Propulsion Laboratory, Wrigh	•		
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AN EVALUATION OF THE EFFECTIVENESS (AFTER TRANSPORT IN A FULL SCALE FUE)			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
B: AUTHOR(B) (First name, middle initial, last name)			
Howard F. Jones, Air Force Aero Propulsion I Eddie French, Directorate of Air Force Aeros			
. REPORT DATE	TA. TOTAL NO. D	P PAGES	75. NO. OF REFS
May 1969	26		<u> </u>
BA. CONTRACT OR GRANT NO.	S. ORIGINATOR	entered when the oregult report to classified 20. REPORT SECURITY CLASSIFICATION Unclassified 20. REPORT SECURITY CLASSIFICATION Unclassified 20. REPORT FUEL ADDITIVE TON SYSTEM 20. NO. OF REFS 20. REPORT NUMBER(3) CR-69-23 CR	
6. PROJECT NO. 3048	AFAPL-T	R-69-23	Interest the oright report is classified IN. REPORT SECURITY CLASSIFICATION Unclassified Unclassified ID. STATOR FUEL ADDITIVE ON SYSTEM PAGES The no. or REFS REPORT NUMBER(S) I-69-23 T NO(II) (Ary other numbers that may be assigned its distribution is unlimited. SQUEAR ACTIVITY Actor Propulsion Laboratory terson Air Force Base, Ohio Stibility of blending a el at a refinery, and o the using activity. Loring AFB, Maine, from the Guif coast during the 8 months decreases to an un- dols of fuel quantity inhibitors influence e dissipator additive UNCLASSIFIED
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13. ABSTRACT	<u></u>		
A test program was performed to deter proven static dissipator additive, Shell ASA transferring the product through a long distrib The U. S. government owned pipeline comple with Searsport Storage terminal, which was area, was used for this test program. Test of the test program show that the conductive acceptable level from refinery to using activit probes are adversely affected, and some types the fuel conductivity when used in combinat ASA-3.	A-3, into a fr aution system ax connecting receiving fue data obtained ity of the fue y, specific m s of corrosion	tel at a rei to the usin Loring Al I from the during the decreases od als of fu n inhibitor	finery, and ag activity. FB, Maine, Gulf coast e 8 months s to an un- el quantity s influence
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