AN INVESTIGATION OF THE THERMAL STABILITY OF POTENTIAL SUPERSONIC JET FUELS

J. J. BIALY
R. A. FROST
K. L. DILLE

TEXACO INC.
TEXACO RESEARCH CENTER
BEACON, N. Y.

PROGRESS REPORT NO. 3
FOR

DIRECTORATE OF MATERIALS AND PROCESSES
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

CONTRACT NO. AF 33(616)-8045 PROJECT NO. 1(10-3048)
TASK NO. 30178 APRIL 1, 1962

NOTICES

AN INVESTIGATION OF THE THERMAL STABILITY OF POTENTIAL SUPERSONIC JET FUELS

J. J. BIALY

R. A. FROST

K. L. DILLE

TEXACO INC.

TEXACO RESEARCH CENTER

BEACON, NEW YORK

Progress Report No. 3

For

Directorate of Materials and Processes

Aeronautical Systems Division

Air Force Systems Command

United States Air Force

Wright-Patterson Air Force Base, Ohio

Contract No. AF 33(616)-8045
Task No. 30178

Project No. 1(10-3048)
April 1, 1962

Submitted by K. L. Dille
K. L. DILLE
PROJECT LEADER

FOREWORD

This is the third progress report on work done under Contract No. AF 33(616)-8045, Project No. 1 (10-3048), Task No. 30178 and covers work completed during December 1, 1961 to April 1, 1962. This work was performed at the Texaco Research Center, Beacon, New York and was sponsored by Directorate of Materials and Processes, Aeronautical Systems Division with Mr. C. J. Johnson as the Project Engineer.

Texaco personnel contributing to this contract included Messrs: Jerzy J. Bialy, Kenneth L. Dille, Frank P. Frascati, Richard A. Frost and Thomas A. Norris.

ABSTRACT

During the third four months of this program, project activity has been concerned with (1) maintaining and refining the Texaco Research Coker, (2) continuing the pretreatment and analytical testing of the project fuels, (3) evaluating and comparing the thermal stability of the project fuels, and (4) investigating the effects of high temperature storage on the properties of a kerosine fuel. It is estimated that 80 per cent of the program is complete.

TABLE OF CONTENTS

Figures

Tables

I. INTRODUCTION

With the advent of aircraft capable of sustained Mach 3-4 speeds, the high temperature to which the aircraft is subjected during such a flight becomes of major concern. Some of the heat generated during high-speed flight is transferred to the fuel and consequently the bulk fuel temperature increases. The bulk fuel temperature for Mach 3-4 flight may range from 200 to 500°F depending on fuel tank location, insulation, duration of flight, the amount of fuel and the heat capacity of the fuel.

Previous work has shown that heating fuels to 300°F for two hours adversely affects their thermal stabilities. Only limited work has been conducted on the effect of high thermal stress on other fuel properties. It is the purpose of this program to conduct applied research on the techniques for predicting the effect of high temperature storage on jet fuel properties. The high temperature storage conditions being investigated are 200 to 500°F for periods up to ten hours.

This program includes the following phases:

(1) Design and fabrication of a reservoir capable of simulating the thermal stresses anticipated in the fuel tanks of aircraft traveling at Mach 3-4.

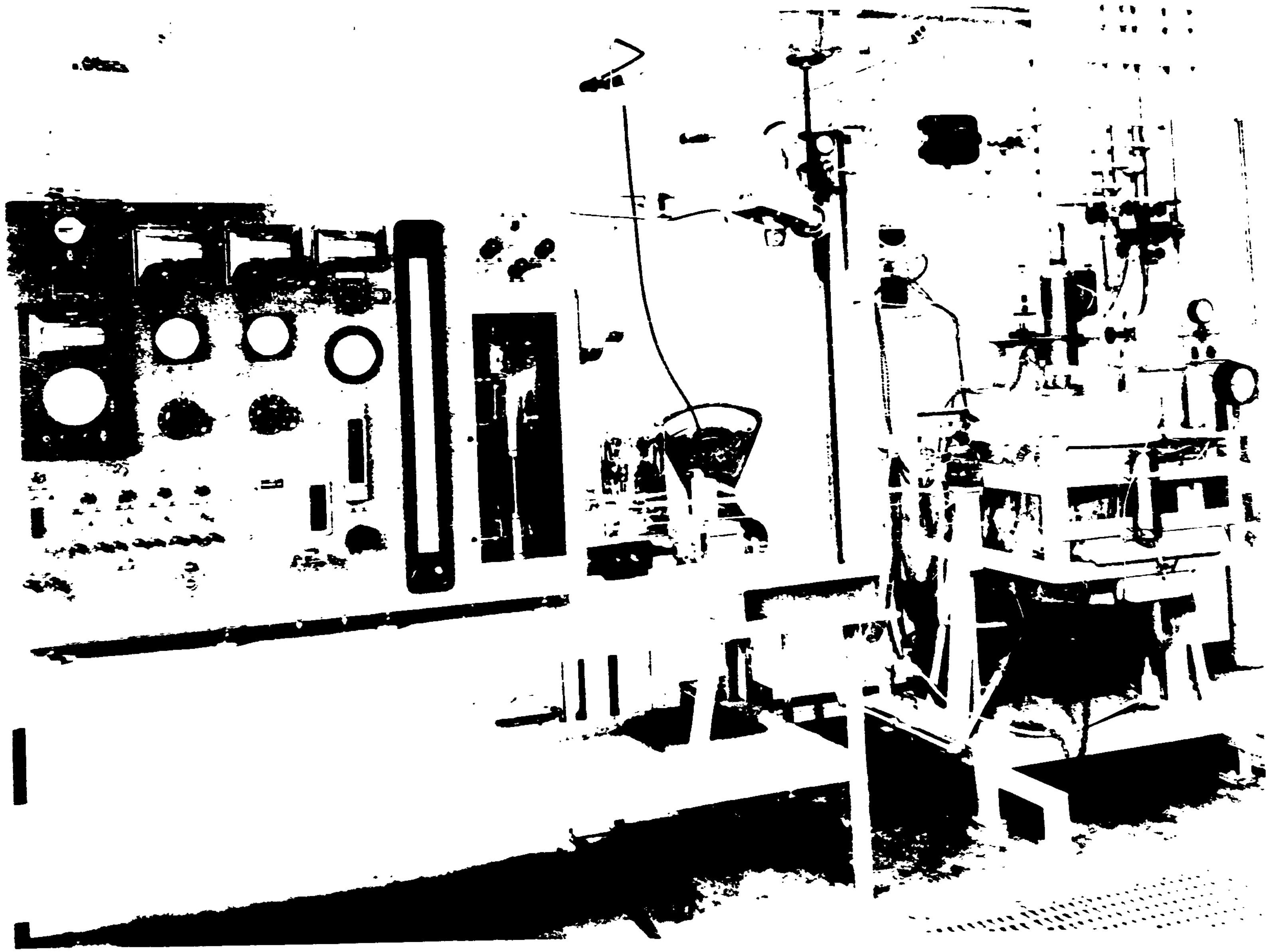
(2) Investigation of the thermal stability, vapor phase decomposition and other fuel properties for nine fuels before and after high temperature storage in the reservoir.

(3) Evaluation of the effects on fuel properties produced by varying (a) temperature of the reservoir, (b) time in the reservoir, (c) oxygen availability, (d) trace compounds in the fuel, (e) specific heat of the fuels and (f) solid contamination.

Progress Report No. 1 submitted on August 1, 1961 covers the work completed during April 1 to August 1, 1961 on phase 1. Progress Report No. 2 briefly summarizes the work on phase 1 and covers the work completed during August 1 to December 1, 1961.

II. DISCUSSION

During the third four months of this program, project activity has been concerned with (1) maintaining and refining the Texaco Research Coker, (2) continuing the pretreatment and analytical testing of the project fuels, (3) evaluating and comparing the thermal stability of the project fuels, and (4) investigating the effects of high temperature storage on the properties of a kerosine fuel. These items are discussed below.



TEXACO RESEARCH COKER

FIGURE 1

A. Test Equipment

Figure 1 illustrates the equipment used to evaluate thermal stability of the fuels at high temperature. Details of this equipment, operating procedure and repeatability data are given in Progress Report No. 2 (December 1, 1961).

During the past four months problems have been encountered with the pumps. As a result two pumps in series are now being used to transfer the fuel from the reservoir to the coker preheater section. Difficulties have also occurred with the magnetic stirrer on the reservoir and with the electrical heaters, however, these problems have been solved and no further difficulties of this type are expected in the near future.

B. Fuels

The fuels investigated in this program are listed in Table I. These fuels were selected to cover a wide gamut of diverse hydrocarbon compositions. With the exception of JP-6 fuel these fuels were processed to meet volatility specification of 50 psia maximum at 500°F, and were clay percolated and inhibited to enhance their thermal stability characteristics. Detailed description of the fuel treatment is given on pages 13-14 , of the Appendix. Results of analytical tests on the program fuels are also given in the Appendix, pages 18 through 25 .

C. Test Program

1. Comparison of Supersonic Jet Fuels

Eight project fuels were compared with respect to their relative thermal stability using their threshold temperatures as criteria. The fuels were heated in the reservoir for one hour at 350°F and their threshold temperatures determined. The results from this phase of the program are summarized in Figure 2, page 5. These results show that the lowest thermal stability was exhibited by the JP-6 fuel. It should be pointed out that this was the only fuel which was not treated or inhibited prior to heating. There seems to be no significant difference in thermal stability of conventional JP-5 fuel and SO_2 extracted paraffinic kerosine and moreover between the above fuels and hydrogenated lauryl alcohol. On the other hand, there seems to be a consistent 50 degrees spread in threshold temperature between the SO_2 extracted paraffinic and naphthenic kerosine and although this spread falls within the repeatability limits of the test it favors the naphthenic stock very consistently. These data are confirmed further by the fact that two of the three most thermally stable fuels found were naphthenic in nature. The third stable fuel was somewhat of a surprise due to the fact that usually aromatic fuels exhibit poor thermal stability. From the present results it appears that from the thermal stability point of view alone it is not necessary to remove aromatic components from jet fuels.

TABLE I

PROGRAM FUELS

	Fuel	Type	Source
1.	SO_2 Extracted Kerosine	Paraffinic	Texaco
2.	SO_2 Extracted Kerosine	Naphthenic	Texaco
3.	Furfural Extract of LCGO	Aromatic	Texaco
4.	JP-5 Fuel	Mixture	Texaco
5.	JP-6 Fuel	Mixture	ASD
6.	Hydrogenated Lauryl Alcohol	normal-C_{12} paraffin	ASD
7.	Isopropyl Bicyclohexyl (HTF-27)	Naphthenic	ASD
8.	Alkyl Decalins (HTF-35)	Naphthenic	ASD
9.	Soltrol 170	Isoparaffins	ASD

Fuel 1 is the base fuel for this work.

FIGURE 2

COMPARISON OF SUPERSONIC JET FUELS

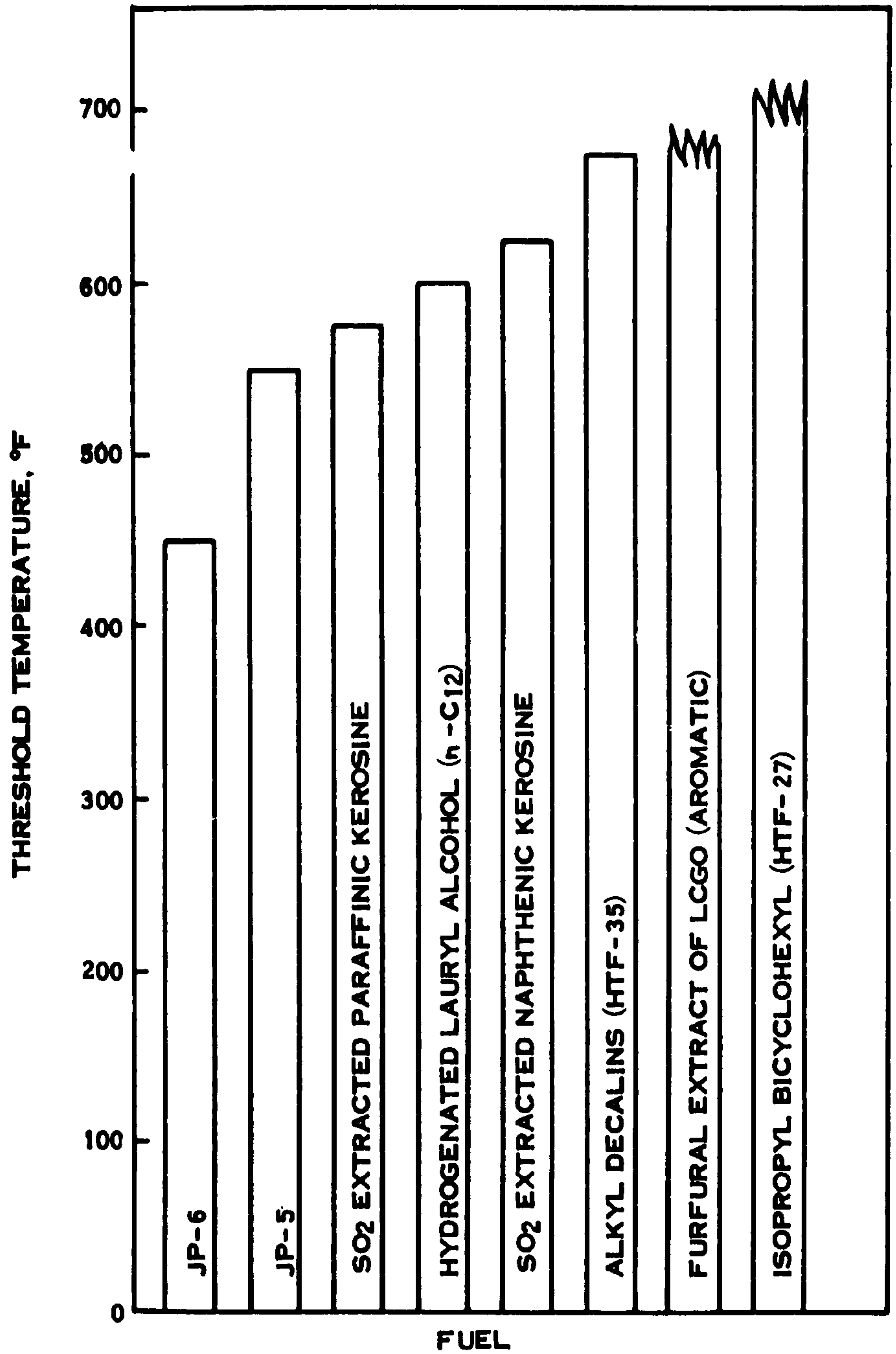
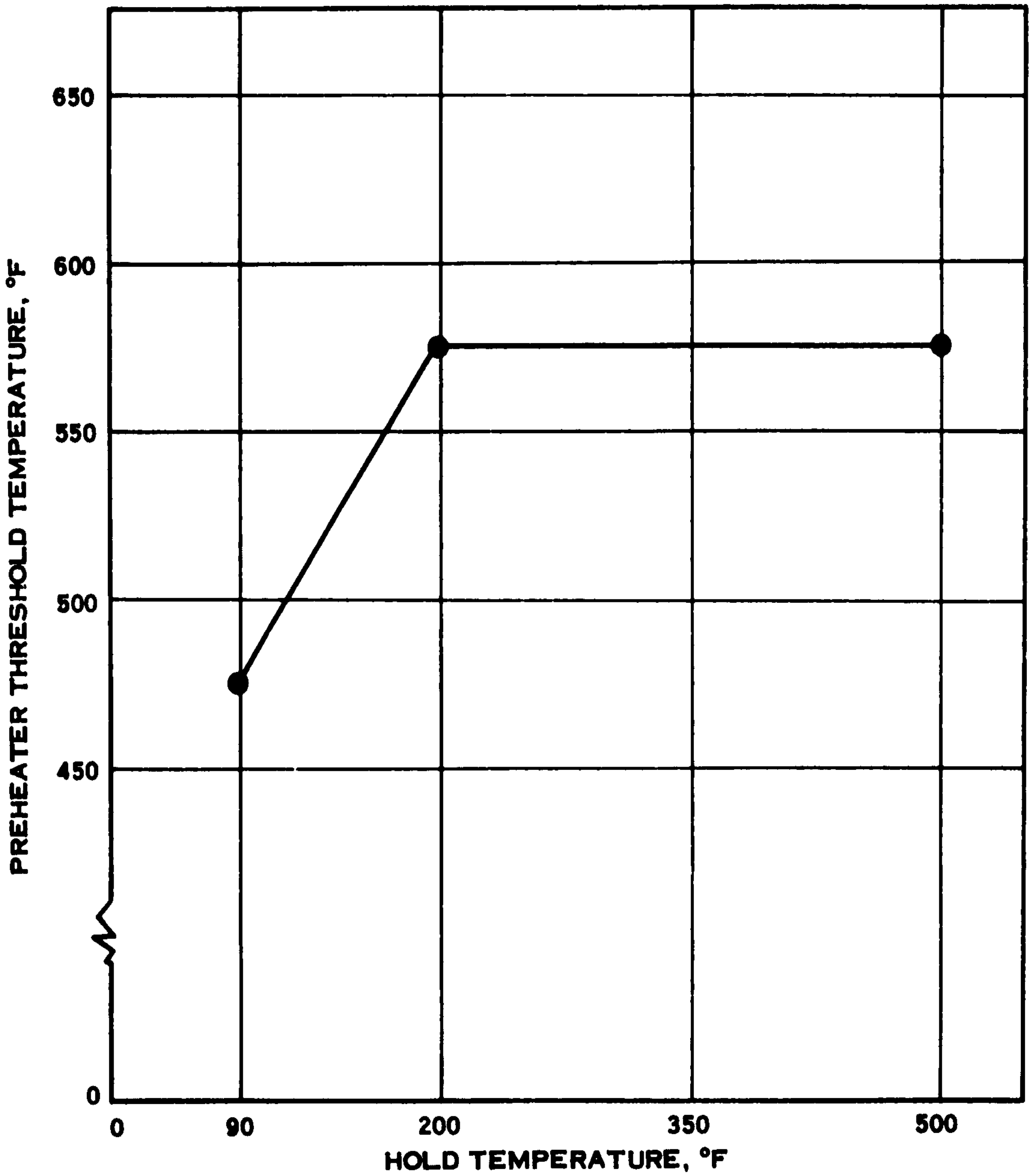


FIGURE 3

PREHEATER THRESHOLD TEMPERATURE VS HOLD TEMPERATURE AT 0 HOLD TIME



2. Effect of Storage on Thermal Stability

The time-temperature interchangeability with respect to the influence of heat on fuel thermal stability has been studied on the base fuel. This phase of the program has been completed with the exception of one run. The results obtained are shown in Figure 3 and 4, pages 6 and 8. Detailed run data are shown in Table II, in the Appendix.

The results summarized in Figure 3 indicate that significant improvement in thermal stability occurs after the fuel has been soaked for a short time at elevated temperature. There is no additional improvement with further increase in soaking temperature.

Figure 4 shows results of the various time and temperature conditions to which the base fuel was subjected. The results indicate that there is no significant change in fuel thermal stability with increase of the soaking time. Visual inspection of the inside surfaces of the reservoir did not show any discernible deposits. On the other hand careful inspection of the test coupon on the reservoir lid showed a slight increase in deposit level with increase in hold temperature, but not with the increase of hold time. The results showing various deposit levels on the test coupons are shown in Figure 5, page 9.

III. PROJECT STATUS

It is estimated that the project is 80 per cent complete. Specific items accomplished are:

1. Procurement and construction of test apparatus - 100 per complete.

2. Shakedown runs on Texaco Research Coker - 100 per cent complete.

3. Development of operating procedure for Texaco Research Coker - 100 per cent complete.

4. Procurement of project fuels - 90 per cent complete.

5. Pretreating project fuels - 90 per cent complete.

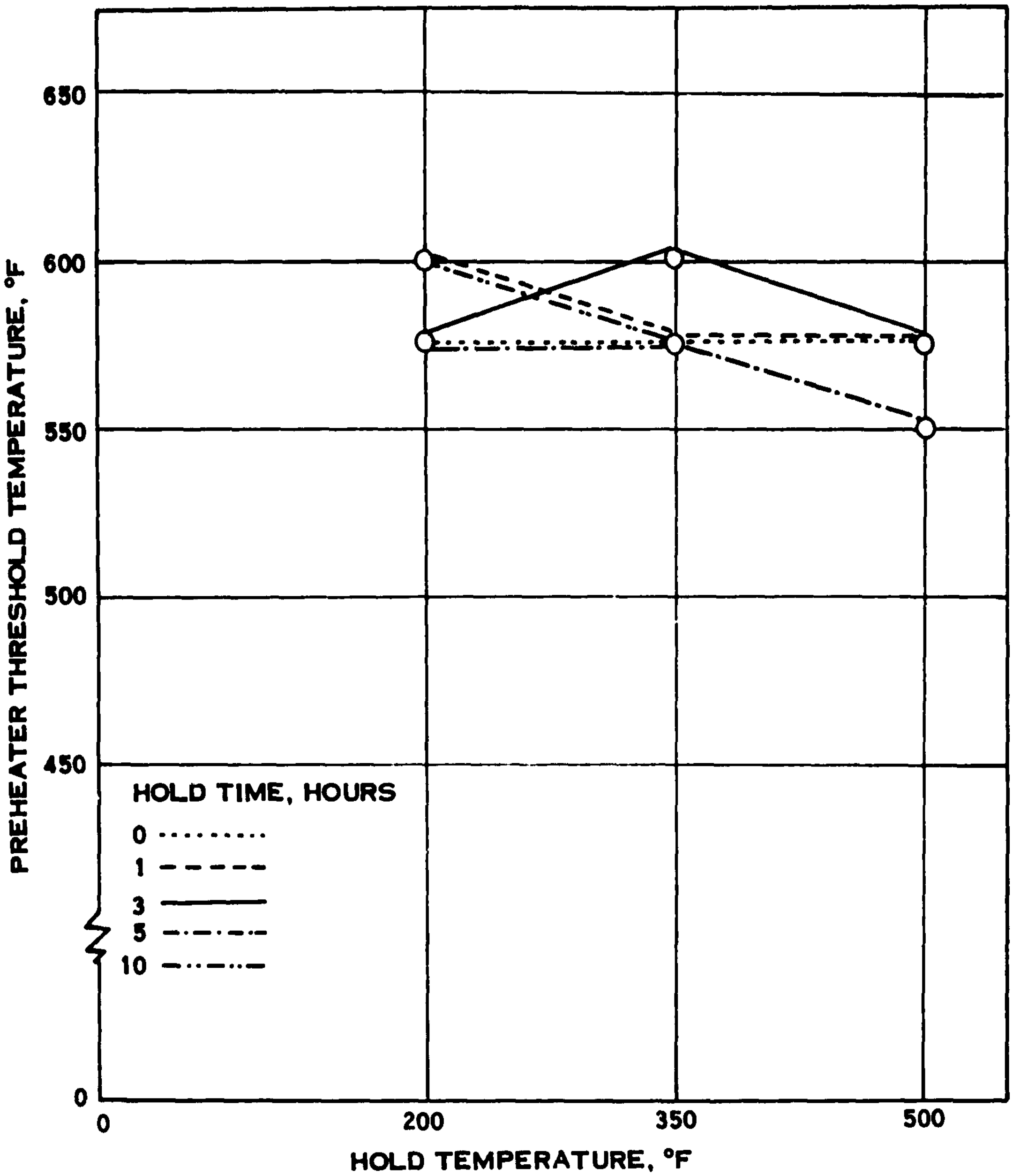
6. Inspection tests on project fuels - 60 per cent complete.

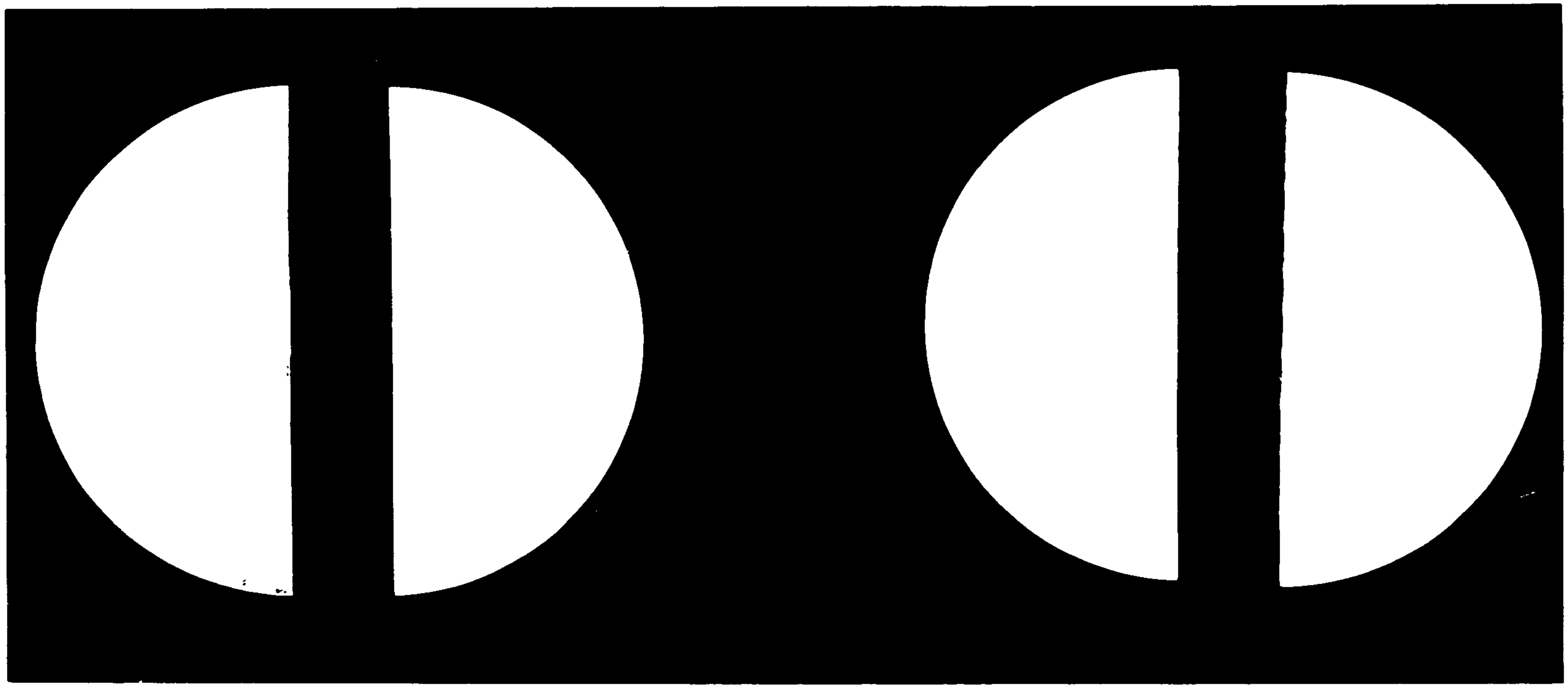
7. Determination of repeatability of CRC Research Coker - 100 per cent complete.

8. Comparison of the thermal stability of project fuels - 85 per cent complete.

FIGURE 4

PREHEATER THRESHOLD TEMPERATURE VS HOLD TEMPERATURE





500°F 350°F 200°F BLANK

DEPOSIT LEVELS AT VARIOUS HOLD TEMPERATURES

HOLD TIME - 10 HOURS

FIGURE 5

9. Effect of high temperature storage on project fuels - 95 per cent complete.

10. Effect of impurities on the thermal stability of project fuels - 0 per cent complete.

IV. FUTURE WORK

Project activity during the final four month period will be to complete the unfinished items listed under section III and to initiate and complete the work outlined for PR 164349 RCN.

V. APPENDIX

TABLE OF CONTENTS-APPENDIX

TABLES

APPENDIX

FINISHING TREATMENT OF TEST FUELS
Contract No. AF 33(616)-8045

1. Clay Percolation

a. Apparatus

The percolating column used in fuel treating consisted of a ten foot Pyrex glass pipe (6" I.D.) joined at the bottom to a twelve inch Pyrex glass pipe (3" I.D.) through a Pyrex glass reducer. All flanges and fittings on the effluent side of the column were stainless steel. The top of the column was equipped with an automatic fuel level controller with a provision for fuel overflow to return to the feed drum. A conventional brass fuel pump was used for transferring the fuel from the feed drum to the top of the column.

b. Materials

The adsorbent material used in fuel treating was commercially available 60-90 mesh, LVM grade Attapulgus clay. This clay was used as delivered, without any pretreatment prior to use.

Pyrex glass wool was used at the bottom of the column to prevent clay particles from entering the flow regulating valve.

c. Procedure

Fuel was pumped directly from a drum into the top of the column which was filled with an appropriate amount of clay (8 lbs/bbl). The fuel was allowed to percolate by gravity into a clean receiving drum without changing the flow rate. Every effort was made to maintain an undisturbed equilibrium within the column. The flow rate was predominantly limited by viscosity of the fuel and usually varied between 1 to 2 gal/hr. When more than one drum was treated, the fuel was combined from all the receiving drums to get a homogeneous effluent fuel.

2. Inhibition

The clay treated fuel was unhibited with 2 lbs/M bbl of DMD and 5 lbs/M bbls of Parabar 441 by adding the required amounts of additives directly into the drums and stirring the fuel vigorously with an air driven stirrer for one hour.

3. Filtration

Just prior to the thermal stability evaluation the fuel was filtered through a millipore 0.45μ filter.

4. Gas Saturation

The filtered fuel was either evaluated without gas saturation or saturated with air or nitrogen.

TABLE II

SUMMARY OF THERMAL STABILITY DATA ON THE SO_2 EXTRACTED PARAFFINIC KEROSINE

Test No.	Fuel No.	Air	N2	Reservoir Type	Reservoir Hold Hrs	Reservoir Temp °F	Temp. °F Preheat	Temp. °F Filter	Fuel Flow lbs/hr	Filter ΔP/time* In.-Hg/Min	Tube Rating	Bubbles in Rotometer	Remarks
18203-19	61-5416		X	TXCO	0	90	450	550	6.00	0.70	2	X	
-18					0	90	475	575	5.99	2.92	3		
-20					0	200	450	550	6.00	20.65	1		Overheated vapor phase, broken Te
-21					0	200	500	600	5.99	1.00	1		Water solenoid failure
-22					0	200	550	650	6.03	0.60	2		
-23					0	200	575	675	5.95	5.95	6		
-24					1	200	550	650	5.99	0.30	2		
-25					1	200	575	675	6.00	5.75	2		
-28					1	200	600	700	6.00	0.45	3		
-29					3	200	550	650	6.00	0.65	2		
-27					3	200	575	675	5.98	0.70	3		
-26					3	200	600	700	5.99	23.85/218	4		By-passed filter after 228 min
18203-30					5	200	550	650	6.01	0.30	2		
-31					5	200	575	675	5.98	0.45	3		
-32					10	200	550	650	6.02	21.50/72.8	2		By-passed filter
-33					10	200	575	675	5.99	24.0/6.1	2		By-passed filter
-37					10	200	600	700	5.99	0.2	4		
-34					0	350	550	650	5.99	24.65/107.0	2		By-passed filter
-35					0	350	575	675	6.00	1.65	4		
-36					1	350	550	650	6.00	1.00	2		
-38					1	350	575	675	5.99	1.25	5		
-39					3	350	550	650	5.98	0.7	2		
-40					3	350	575	675	6.01	1.25	2		
-41					3	350	600	700	6.01	0.40	5		Vapor Phase heater burned out
-43					5	350	550	650	6.00	0.70	2		
-42					5	350	575	675	5.99	0.85	3		
-45					10	350	550	650	6.00	3.15	2		
-44					10	350	575	675	6.02	1.05	3		
-46					0	500	550	650	5.99	9.25	2		2 shutdowns - Pump trouble and By-pass leaking
-47					0	500	575	675	6.00	22.30	3		
19047-6					1	500	550	650	5.99	0.00	2		High and low pressure valves inoperative
18203-49					1	500	575	675	5.97	25.00/57.4	3		Pump trouble - 1 shutdown 12 min
19047-3					3	500	550	650	6.00	0.75	Void		Filter furnace and transfer pump failure
-10					3	500	550	650	5.98	1.75	1		
-2					3	500	575	675	6.16	25.00/273.9	3		By-passed filter
-9					5	500	525	625	5.99	6.90	1		
-12					5	500	550	650	5.98	5.05	1		
-1					5	500	575	675	5.98	3.00[a]	3		
-4					10	500	575	675	6.00	25.00/212.0	2[b]		
-11		X			3	350	575	675	6.01	25.0/215.8	5		
-24		X		MC	0	200	500	600	6.00	0.65	3		
18203-48			X	TXCO	0	Rm (80)	400	500	5.99	9.60	3		
19047-5			X	TXCO	0	300	500	600	6.01	24.9	3		

[a] 282.0 min reading Pump trouble, shutdown 20 min.
[b] Section dark 1 or light 7.
* 300 min unless noted.

TABLE III

SUMMARY OF THERMAL STABILITY DATA ON THE SO_2 EXTRACTED NAPHTHENIC KEROSINE

Test No.	Fuel No.	Air	N_2	Type	Hold Hrs	Temp °F	Temp. °F Preheat	Temp. °F Filter	Fuel Flow lbs/hr	Filter ΔP/time[1] In.-Hg/Min	Tube Rating	Bubbles in Rotometer	Remarks
19047-14*	61-5103		X	TXCO	3	350	575	675	6.00	25.0/143.3	2a	-	By-passed filter
-15*	↓		↓	↓	1	350	600	700	5.98	14.65/56.8	2	X	By-passed filter 10 in. initial pressure
-16*	↓		↓	↓	1	350	650	750		-	Void	-	Shut down after 32.0 min Bearing on reservoir stirrer gone
-17*	↓		↓	↓	1	350	650	750	5.99	25.0/226.4	6	X	By-passed filter
-18*	↓		↓	↓	1	350	625	725	-	25.0/205.9	- 8 void	-	Shut down at 211.1 min Filter leaked
-19*	↓		↓	↓	1	350	625	725	6.05	24.85/100.0	2b	X	By-passed filter
-25*	↓	X		NC	0	300	500	600	6.00	3.05	3	-	
-31	62-510		X	TXCO	1	350	575	675	5.99	By-passed	2	X	
-29	↓		↓	↓	1	350	600	700	Void	-	-	-	
-30	↓		↓	↓	1	350	600	700	6.01	25/109	7	X	
-33	↓		↓	↓	1	350	600	700	6.0	25/176.5	2	X	
-28	↓		↓	↓	1	350	625	725	5.98	25/159.8	4	X	
-27	↓	X	↓	NC	0	300	500	600	6.01	0.90	2	-	

[1] 300 min unless noted.
[a] Rainbow effect on sections of the tube.
[b] Sections of tube dark 2 or light 7.

TABLE IV

SUMMARY OF THERMAL STABILITY DATA ON OTHER FUELS

Fuel	Test No.	Fuel No.	Air	N_2	Type	Hold Hrs.	Temp °F	Temp. °F Preheat	Temp. °F Filter	Fuel Flow lbs/hr	Filter Δ P/time* In.-Hg/Min	Tube Rating	Bubbles in Rotometer	Remarks
Hydrogenated Lauryl alcohol	19047-20	61-8792		X	TXCO	1	350	550	650	6.03	0.15	3a	X	
	-21	↓		X	TXCO	1	350	575	675	6.03	0.35	2b	X	
	-22	↓		X	TXCO	1	350	600	700	-	-	Void	-	Shut down at 62.8 min. Stirrer not working properly.
	-36	↓		X	TXCO	1	350	600	700	6.0	6.15	3	X	
	-13	↓	X		NC	0	300	500	600	6.01	0.05	4	-	
Furfural Extract of LCGO (Aromatic)	-44	58-10686		X	TXCO	1	350	575	675	6.01	16.7	1	X	
	-45	↓		X	TXCO	1	350	625	725	6.01	4.55	2	X	
	-46	↓		X	TXCO	1	350	650	750	6.0	13.3	2	X	
	-47	↓		X	TXCO	1	350	675	775	-	-	Void	-	Preheater seal leakage
	-48	↓		X	TXCO	1	350	675	775	-	-	Void	Furnace	Preheater seal leakage
	-49	↓		X	TXCO	1	350	675	Amb	5.99	NA	2	X	Furnace not used for run
	-7	↓	X		NC	0	300	500	600	5.99	6.0	4	-	
HTF-35 Alkyl Decalin	-35	62-40A		X	TXCO	1	350	600	700	5.99	4.70	2	X	
	-36	↓		X	TXCO	1	350	625	725	5.99	2.05	2	X	
	-37	↓		X	TXCO	1	350	650	750	6.0	0.70	2	X	
	-38	↓		X	TXCO	1	350	675	775	-	-	Void	-	Filter Furnace leaked
	-39	↓		X	TXCO	1	350	675	775	6.01	25/152.4	3	X	
	-23	↓	X		NC	0	300	500	600	5.99	0.25	3	-	
HTF-27 Isopropyl bicyclohexyl	-40	62-40B		X	TXCO	1	350	650	750	-	-	Void	-	Preheater flange leaked
	-41	↓		X	TXCO	1	350	650	750	6.0	0.10	2c	-	
	-42	↓		X	TXCO	1	350	700	800	6.0	25/178	2c	-	
	-26	↓	X		NC	0	300	500	600	5.8	0.25	2		
JP-5	19048-2	61-4142		X	TXCO	1	350	500	600	6.0	25/281	2	X	
	-3	↓		X	TXCO	1	350	525	625	6.01	12.1	1	X	
	-1	↓		X	TXCO	1	350	550	650	6.0	25.85/205	5	X	
	-4	↓		X	TXCO	1	350	550	650	6.02	18.70	3	X	
	19047-43	↓		X	TXCO	1	350	575	675	6.00	25/284	3	X	
	-8	↓	X		NC	0	300	500	600	5.99	6.0	4	-	
JP-6	19048-6	61-5731		X	TXCO	1	350	450	550	6.02	2.15	3	X	
	-5	61-5731		X	TXCO	1	350	500	600	5.99	0.20	4	X	

a Parts of tube peacock color, other parts dark 2 or light 7
b Parts of tube dark 2 or light 7
c No bubbles. Rating nearer to 1. Run stopped at 210 min/w bad filter leak.
*300 min unless noted

Sample Number TRCB 62-40B
Description Isopropylbicyclohexyl

MIL-F-25656 and MIL-J-5624
Inspection Tests

Distillation

% Recovered	Temp, °F
IBP	510
5	520
10	524
20	527
30	529
40	592
50	530
60	530
70	531
80	532
90	534
95	537
EP	541

Recovery, %	98.5
Residue, %	Coke
Loss, %	1.5

% Evaporated	Temp. °F
10	523
40	528
50	529
90	533

Gravity, °API		28.2
Existent Gum, mg/100 ml		<1
Potential Gum, mg/100 ml		<1
Sulfur, Total, %		<0.002
Mercaptan Sulfur, %		0.000
RVP, lb.		0.0
Freezing Point, °F		-26
Thermal Value		
Heat of Combustion, Btu/lb.,	gross	19,656
	net	18,507
Aniline-Gravity Product		8,903
Viscosity, cs - 30°F		651.9
Aromatics, vol %		4.0
Olefins, vol %		0.3
Smoke Point, mm		20
Smoke Volatility Index		None
Explosiveness, %		10
Corrosion, Cu Strip		1A
Water Reaction		Clean and clear no increase in volume
Flash Point, °F		235
Aniline Point, °F		181.7

Exhibit A Tests (b through j)

Particulate Matter in Hydrocarbons

Total Contamination, mg/l	2.80
Noncombustible Contamination, mg/l	0.11

Particle Analysis

Size Range,	Number/Ml	% In Each Size Range
2 to 5	26.0	75.9
5 to 10	4.71	13.7
10 to 20	0.69	2.0
20 to 30	1.51	4.4
30 to 50	0.75	2.2
50 to 100	0.63	1.8
100 or larger		
Total Larger than 2	34.3	
Largest Particle Observed	250μ	

Saybolt Color	+30
Peroxide Number	0.0
Neutralization and Acid Number	TAN 0.01
Basic Nitrogen, ppm	1
Water Content, %	0.002
Total Oxygen, %	0.15
Naphthalenes, % wt	0.02
Gas Chromatographic Analysis (complete fuel)	

Additional Tests

Specific Heat	100°F-0.44, 200°F-0.50, 300°F-0.57 cal/g/°C
Luminometer Number	56.6
Potential Deposit Test	<#1 no discoloration
Thermal Stability	

Test Conditions

Preheater Temperature, °F	400
Filter Temperature, °F	500
Nominal Fuel Flow Rate	6
Fuel Container Weight	
Before	32.7
After	2.7
Exact Average Fuel Flow Rate	6

Test Data

	Manometer Reading	Minutes
Conditions Set	0.0	0
0.3 in. Hg ΔP above conditions set		
1.0 in. Hg ΔP		
3.0 in. Hg ΔP		
10 in. Hg ΔP		
25 in. Hg ΔP		
End of Test	0.0	300
Preheater Tube Deposit Rating		
CRC Rate	3	
CRC Rate, inches	4/0 5/2 4/3	

Sample Number TRCB 61-8792
Description Hydrogenated Lauryl Alcohol

MIL-F-25656 and MIL-J-5624
Inspection Tests

Distillation

% Recovered	Temp, °F
IBP	406
5	408
10	410
20	411
30	412
40	414
50	414
60	415
70	416
80	418
90	421
95	430
E.P.	474

Recovery, %	98.0
Residue, %	1.2
Loss, %	0.8

% Evaporated	Temp, °F
10	409
40	413
50	413
90	420

Gravity, °API	56.2
Existent Gum, mg/100 ml	<1
Potential Gum, mg/100 ml	<1
Sulfur, Total	<0.002
Mercaptan Sulfur	0.000
RVP, lb	0.0
Freezing Point, % F	+10
Thermal Value	
Heat of Combustion, Btu/lb., gross	20,336
net	19,006
Aniline-Gravity Product	15,117
Viscosity, cs -30°F	Not suitable
Aromatics, vol. %	5.0
Olefins, vol %	5.0
Smoke Point, mm	45
Smoke Volatility Index	None
Explosiveness, %	15
Corrosion, Cu Strip	1A
Water Reaction	Clean and clear
Flash Point, °F	190
Aniline Point, °F	

Exhibit A Tests (b through j)

Particulate Matter in Hydrocarbons

Total Contamination, mg/l	0.26
Noncombustible Contamination, mg/l	0.26

Particle Analysis

Size Range,	Number/Ml	% In Each Size Range
2 to 5	14.7	39.8
5 to 10	9.8	26.7
10 to 20	4.6	12.5
20 to 30	3.45	9.4
30 to 50	3.48	9.2
50 to 100	0.98	2.6
100 or larger		
Total Larger than 2	36.9	
Largest Particle Observed	125μ	

Saybolt Color	+30
Peroxide Number	-0.05
Neutralization and Acid Number	TAN 0.03
Basic Nitrogen, ppm	<1
Water Content	0.002
Total Oxygen	
Naphthalenes, % (wt)	0.05
Gas Chromatographic Analysis (complete fuel)	

Additional Tests

Specific Heat	100°F-0,54, 200°F-59, 300°F-0.64
Luminometer Number	159.3
Potential Deposit Test	<1 no discoloration
Thermal Stability	

Test Conditions

Preheater Temperature, °F	400
Filter Temperature, °F	500
Nominal Fuel Flow Rate, lb/hr	6
Fuel Container Weight, lb.	
Before	32.7
After	2.7
Exact Average Fuel Flow Rate, lb/hr	30.0

Test Data

	Manometer Reading	Minutes
Conditions Set	0.0	0
0.3 in. Hg ΔP above conditions set		
1.0 in. Hg ΔP		
3.0 in. Hg ΔP		
10 in. Hg ΔP		
25 in. Hg ΔP		
End of Test	0.0	300
Preheater Tube Deposit Rating		
CRC Rate	2	
CRC Rate, inches	6/0 2/1 5/2	

Sample Number 62-40-A
Description Alkyldecalin

MIL-F-25656 and MIL-J-5624
Inspection Tests

Distillation

% Recovered	Temp, °F
IBP	408
5	418
10	420
20	420
30	420
40	420
50	420
60	420
70	424
80	424
90	426
95	430
EP	433

Recovery, %	98.0
Residue, %	1.5
Loss, %	0.5

% Evaporated	Temp, °F
10	419
40	419
50	419
90	425

Gravity, °API	33.1
Existent Gum, mg/100 ml	<1
Potential Gum, mg/100 ml	<1
Sulfur, Total, %	<0.002
Mercaptan Sulfur	0.000
RVP, lb.	0.0
Freezing Point, °F	-46
Thermal Value	
Heat of Combustion, Btu/lb., gross	19,517
net	18,331
Aniline-Gravity Product	4296.4
Viscosity, cs - 30°F	131.4
Aromatics, Vol, %	2.0
Olefins, vol, %	0.5
Smoke Point, mm	21
Smoke Volatility Index	21
Explosiveness, %	24.0
Corrosion, Cu Strip	1B
Water Reaction	Clean and clear
Flash Point, °F	165
Aniline Point, °F	129.8

Exhibit A Tests (b through j)

Particulate Matter in Hydrocarbons

Total Contamination, mg/l	0.26
Noncombustible Contamination, mg/l	
Particle Analysis	

Saybolt Color	+30
Peroxide Number	0.02
Neutralization and Acid Number	Ph 7.9, TAN 0.01
Basic Nitrogen, ppm	1
Water Content	0.003
Total Oxygen	
Naphthalenes, % wt	0.02
Gas Chromatographic Analysis (complete fuel)	

Additional Tests

Specific Heat	100°F-.432, 200°F-.496, 300°F-.560
Luminometer Number	47.7
Potential Deposit Test	< 1 no discoloration
Thermal Stability	

Test Conditions

Preheater Temperature, °F	400
Filter Temperature, °F	500
Nominal Fuel Flow Rate, lb/hr	6
Fuel Container Weight, lb	
Before	32.7
After	2.7
Exact Average Fuel Flow Rate, lb/hr	6

Test Data

	Manometer Reading	Minutes
Conditions Set	0.0	0
0.3 in. Hg ΔP above conditions set		
1.0 in. Hg ΔP		
3.0 in. Hg ΔP		
10 in. Hg ΔP		
25 in. Hg ΔP		
End of Test	0.0	300

Preheater Tube Deposit Rating

CRC Rate	3
CRC Rate, inches	1/10 4/1 6/2 2/3