

UNCLASSIFIED

AD NUMBER	
ADA801545	
CLASSIFICATION CHANGES	
TO:	UNCLASSIFIED
FROM:	CONFIDENTIAL
LIMITATION CHANGES	
TO: Approved for public release; distribution is unlimited.	
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 01 JAN 1945. Other requests shall be referred to Office of Scientific Research and Development, Washington, DC 20301.	
AUTHORITY	
OSRD list no. 3 dtd 2-11 Jan 1946; OTS index dtd Jun 1947	

THIS PAGE IS UNCLASSIFIED

Reproduced by
AIR DOCUMENTS DIVISION



HEADQUARTERS AIR MATERIEL COMMAND
WRIGHT FIELD, DAYTON, OHIO

The
U.S. GOVERNMENT

IS ABSOLVED

**FROM ANY LITIGATION WHICH MAY
ENSUE FROM THE CONTRACTORS IN -
FRINGING ON THE FOREIGN PATENT
RIGHTS WHICH MAY BE INVOLVED.**

REEL - C

1344

A.T.I.

3 1 5 1 5

703,11
CONFIDENTIAL

8.2-35

Division //

NATIONAL DEFENSE RESEARCH COMMITTEE

of the

OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

OSRD No. 4522

Copy No. 44

CONFIDENTIAL

CONFIDENTIAL

Division 11
NATIONAL DEFENSE RESEARCH COMMITTEE
of the
OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

EFFECT OF THICKENER AND GASOLINE QUALITY ON THE
PROPERTIES OF NAPALM FUELS

by
R. L. Betts, Chemist
Standard Oil Development Company

Report OSD No. 4522
Copy No. *44*
Date: January 1, 1945

Copy Nos.

- 1-28 Dr. Irvin Stewart
- 29 Commandant, U. S. Marine Corps, Headquarters
Attention: ~~Lt. Col. L. E. Marie~~ *Major J. W. Neuhing, Jr.*
- 30 Office of the Chief, Chemical Warfare Service
Technical Division, Washington 25, D. C.
- 31-34 Commanding General, Chemical Warfare Service
Technical Command, Edgewood Arsenal, Maryland
- 35 Chief, Bureau of Ordnance
Attention: ~~Captain J. H. Sides~~ *Comdr. J. A. C. Roundman*
- 36-37 Air Corps Liaison Officer with NDRC
- 38 Division 11 Files
- 39 Chemical Warfare Service Development Laboratory
Massachusetts Institute of Technology
Attention: Lt. Col. Willard Slagle
- 40 Dr. C. S. Keevil
- 41 Mr. E. P. Stevenson

Total Number of Copies - 44

This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, U.S.C. 50; 31 and 32. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

CONFIDENTIAL

CONFIDENTIAL

OSRD No. 4522

Division 11
NATIONAL DEFENSE RESEARCH COMMITTEE
of the
OFFICE OF SCIENTIFIC RESEARCH AND DEVELOPMENT

EFFECT OF THICKENER AND GASOLINE QUALITY ON THE
PROPERTIES OF NAPALM FUELS

Service Directive: CWS-10 and 21

Endorsement (1) From E. P. Stevenson, Chief, Division 11 to
Dr. Irvin Stewart, Executive Secretary of the National Defense
Research Committee.

Forwarding report and noting:

"This report describes the effect of gasoline variation on the properties of Napalm fuels. This study was part of a broad investigation embracing all possible causes of variation in the consistency of Napalm fuels. Variation in fuel consistency was wider, the greater the variety of gasoline types used. Fuels high in cyclic hydrocarbons gave higher consistencies than fuels high in paraffins. The effect was much greater in fuels of low concentrations of thickener: the ratio of maximum to minimum consistencies found was only 1.7:1 for 12% Napalm fuels, but was 10:1 for 4% Napalm fuels."

This is a progress report under Contracts OEMsr-354 and 390 with the Standard Oil Development Company.

CONFIDENTIAL

C O N F I D E N T I A L

STANDARD OIL DEVELOPMENT COMPANY

EFFECT OF THICKENER AND GASOLINE QUALITY ON THE
PROPERTIES OF NAPALM FUELS

ELIZABETH, NEW JERSEY, JULY 6, 1944

"This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, U.S.C. 50:31 and 32. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law."

NDRC Contracts OEMsr-390 and 354
S.O.D. Projects 30134 and 20907
Report PDN 2575
July 6, 1944

C O N F I D E N T I A L

C O N F I D E N T I A L

TABLE OF CONTENTS

	<u>Page No.</u>
SUMMARY	1
A - INTRODUCTION	3
B - CONCLUSIONS	4
C - RECOMMENDATIONS	6
D - MATERIALS	7
E - EXPERIMENTAL	8
F - DISCUSSION	
(a) Thickener Quality	10
(b) Effect of Gasoline Quality on the Properties of Napalm Fuels	10
(c) Significance of Variations in Fuel Consistency on Performance	14
(d) Effect of Oxidized Gasolines on Napalm Consistency	15
(e) Effect of Temperature on Setting Time	17

C O N F I D E N T I A L

C O N F I D E N T I A L

EFFECT OF THICKENER AND GASOLINE QUALITY ON THE
PROPERTIES OF NAPALM FUELS

ELIZABETH, NEW JERSEY, JULY 5, 1944

SUMMARY

A cooperative investigation was carried out by Eastman Kodak* and the Standard Oil Development Company to determine the quality of Napalm thickener currently produced by ten manufacturers under contract with the Chemical Warfare Service and the effect of gasoline quality, moisture content of the soap and thickener concentration on the properties of Napalm thickened fuels. The investigation carried out at the Standard Oil Development Company, which dealt mainly with the effect of gasoline quality, is the subject of this report.

The majority of the thickeners received were of uniform quality, 70% of the samples received from ten manufacturers giving 8% gels having consistencies between 600 and 750 grams Gardner, but 30% of the samples did not conform to specification requirements (500 to 800 grams Gardner).

The properties of Napalm fuels were found to be affected by the type of hydrocarbon employed. Cyclic hydrocarbons tended to give high consistencies while the paraffin, n-heptane, gave the lowest consistency values. Eleven gasolines meeting the requirements for 80 octane general purpose motor fuels all gave thickened fuels having consistencies within relatively narrow limits. Based on a wide variety of automotive fuels exclusive of those meeting the requirements of 80 octane gasoline, highly naphthenic or aromatic gasolines may be encountered which would markedly increase fuel consistency.

The majority of Napalm thickener samples when employed at lower concentrations, e.g., 4% by weight, yielded fuels which tended to decrease in consistency on aging; the decrease amounted to 50 to 70%. This aging phenomenon was the greatest single variable encountered in the investigation.

Considering the variation in thickener and gasoline qualities and the curing effect, the ratio of the maximum to minimum consistency values was found to be about 1.7:1 for fuels containing 12% of the thickener and 10:1 for low (4%) concentration fuels. The variation in consistency at high concentrations (8% of thickener or more) is about equally caused by differences in soap and gasoline quality while at low concentrations at least half of the variation was due to the change which occurred on curing.

* N.D.R.C. Report "An Examination of the Consistency of Napalm Gels," March 13, 1944.

C O N F I D E N T I A L

C O N F I D E N T I A L

-2-

Oxidized gasolines may greatly decrease the consistency of Napalm fuels. However, oxidation-susceptible gasoline can be inhibited at the source with suitable commercial inhibitors as specified for U.S. Army 80 octane general purpose gasoline and should then be suitable for use, unless stored for unusually long periods with excessive exposure.

In view of these results it is recommended that investigations should be undertaken to determine means of diminishing the variation in consistency of Napalm fuels of low concentration.

C O N F I D E N T I A L

C O N F I D E N T I A L

-3-

EFFECT OF THICKENER AND GASOLINE QUALITY ON THE
PROPERTIES OF NAPALM FUELS

A. INTRODUCTION

The review* of Napalm manufacture by the committee appointed by Section 11.3 of N.D.R.C., Division 11, indicated that there were variations in production methods and some differences in the properties of the raw materials employed, but all Napalm manufacturers appeared to be producing reasonably comparable products. Since each production method seemed to be under reasonable control, the time appeared opportune to carry out an investigation of thickeners from the various producers with respect to:

1. Soap quality as indicated by the properties of 8% gels tested in accordance with CWS specification 196-131-107.
2. The effect of aging time, temperature, and soap concentration on the consistency of Napalm fuels.
3. Moisture content.
4. The effect of moisture content on the properties of thickened fuels.
5. The relative hygroscopic properties of the various soaps under varying psychrometric conditions.
6. Oxidation susceptibility of the soap and methods of measurement.
7. The effect of gasoline quality on fuel properties.

The investigation was carried out in cooperation with Eastman Kodak, substantially as outlined in the letter from Dr. E. K. Carver to Mr. N. F. Myers dated October 3, 1943, and from Mr. N. F. Myers to Dr. E. K. Carver dated October 14, 1943. Items 1, 2 and 3 were studied at both laboratories in order to determine the reliability and reproducibility of the test methods employed. Item 7 was carried out by the Standard Oil Development Company and the remainder of the program by Eastman Kodak. In view of this arrangement, the results obtained at the Standard Oil Development Company and presented herein should be considered in conjunction with the Eastman N.D.R.C. report, "An Examination of the Consistency of Napalm Gels," March 13, 1944.

* The Manufacture, Properties and Testing of Napalm Soap, O.S.R.D. No. 2036, November 17, 1943.

C O N F I D E N T I A L

C O N F I D E N T I A L

-4-

B. CONCLUSIONS

1. All Napalm samples were within the 0.8% maximum moisture content permitted by specification.

2. Three (30%) of the soaps received from ten manufacturers were outside specification limits for thickening power (500 to 800 grams Gardner), two giving low and one giving high consistency fuels. Seven (70%) of the soaps gave 8% fuels having consistencies between 600 and 750 grams Gardner after aging 24 hours at 150°F.

3. Six of seven soaps received from one manufacturer were also within these limits (600 to 750 grams Gardner).

4. The consistencies obtained after aging the gels for 24 hours at 150°F. were comparable to the values obtained in the surveillance tests. They thus appear to be representative of the ultimate stable condition of the gel and are generally lower and more reproducible than those obtained after aging the gel 48 hours at 77°F. There is some doubt whether the latter test serves any useful purpose as currently prescribed in the CWS specifications. Consequently, it may be advisable both from the point of view of reliability and time saving, to delete the 48 hour test at 77°F. and use only the 150°F. test.

5. Napalm is now being produced with sufficient uniformity to permit consideration of selecting soaps that fall within a rather narrow consistency range for use in the field compounding of flame thrower fuels.

6. The three soaps employed in studying the effect of gasoline quality gave 8% fuels of similar consistency, but at other concentrations one soap differed markedly from the other two, giving a very much narrower consistency range at 4% and a higher range at 12% concentrations in all gasolines.

7. Fuels prepared in naphthenic and aromatic type hydrocarbons were of high consistency.

8. Cyclohexane (naphthenic) yielded fuels containing 4 to 12% of thickener which exhibited no significant change in consistency on curing at 70°F. or 125°F. In other pure hydrocarbons and gasolines tested, including highly naphthenic gasoline, there was a decrease in consistency during the aging of fuels containing less than 8% thickener.

9. The decrease in consistency of 4% fuels on curing which occurs in all gasolines may be as much as 70% and is the greatest variable disclosed in this investigation. One of the soaps, however, did not exhibit a curing effect in any of the gasolines.

C O N F I D E N T I A L

C O N F I D E N T I A L

-5-

10. Variation in the composition of the gasoline may affect the consistency of 4% Napalm fuels by a factor of approximately 2. This spread is due mainly to one highly naphthenic gasoline. In other gasolines, particularly the 80 octane general purpose products, the effect of gasoline quality on consistency is relatively small.

11. Considering all soaps, all gasolines, and the curing effect, the ratio of the maximum to minimum consistency values is about 1.7:1 for fuels containing 12% of soap and 10:1 for low concentration fuels (4%). The variation at high concentrations is about equally divided between differences in soap and gasoline quality, while at low concentrations at least half of the variation is due to the change which occurs on curing.

12. The presence of peroxides in gasolines greatly decreases fuel consistency. It is essential, therefore, that all gasolines used in the preparation of Napalm fuels be properly inhibited to prevent oxidation.

13. The results of this investigation agree with previous experience that the solvation rates of Napalm soaps are very sensitive to changes in temperature. This temperature-solvation rate relationship changes so greatly from lot to lot of soap that no general quantitative correlation can be obtained from existing data.

14. With Napalm of current quality, the variations in the consistency of field compounded thickened fuels, particularly at low concentrations, may be so great as to have a relatively large effect on the performance of flame throwers. For this particular application, therefore, it is advisable to select Napalm of greater uniformity.

15. If compounding is carried out in properly equipped plants, 8% fuels having a relatively narrow variation in consistency (150 grams Gardner) can be produced with available Napalm and gasoline provided that adequate methods of control are employed.

C O N F I D E N T I A L

C O N F I D E N T I A L

-6-

C. RECOMMENDATIONS

1. All gasolines used in the preparation of Napalm fuels should be properly inhibited to prevent oxidation of the gasolines as prescribed by the U.S. Army specification No. 2-103B.

2. A review of the inspection data on Napalm manufactured since June 1, 1943, by the various producers appears advisable in order to determine whether sufficient thickener which could yield 8% gels in test gasoline having consistencies between 600 and 750 grams Gardner has been produced to justify selection of lots for use in field compounding.

3. Since preliminary results indicate that dehydrating agents may be effective in reducing the change in consistency which occurs on aging, further investigation should be vigorously prosecuted to determine their practicability.

4. Because of the wide variations in the solvation rates of various Napalms, it appears advisable to undertake a study of the factors affecting the dispersion of Napalm thickener in gasolines.

C O N F I D E N T I A L

C O N F I D E N T I A L

-7-

D. MATERIALS

(a) Napalm Thickener. Samples of Napalm (aluminum soap) thickener obtained from each of ten manufacturers were employed in this investigation.

(b) Pure Hydrocarbons. The pure hydrocarbons which were used to determine the effect of hydrocarbon type on fuel properties consisted of toluene, cyclohexane, di-isobutylene, iso-octane, and n-heptane. The latter material was studied with 8% fuels only.

(c) Gasolines. Twenty-three samples of gasolines whose inspections are shown in Tables 1 and 2 were used. Nine of these materials were chosen to include:

- (1) A variety of hydrocarbon types.
- (2) Several methods of processing.
- (3) N.D.R.C. "test" gasoline meeting CWS specification No. 196-131-144 which has been extensively used in determining the quality of Napalm thickeners.
- (4) Samples of gasolines used at various plants under contract to CWS for filling incendiary bombs.

One sample of "test" gasoline was also distilled to yield several cuts which were studied to determine the effect of the various fractions on fuel consistency.

Twelve samples represented 80 octane general purpose (pool) gasolines and were obtained from six refineries located in the east, south, midwest, and the Pacific coast. These gasolines, which are similar to those that may be encountered in the field, exhibited similar inspections except for the type and quantity of inhibitors present, and were prepared from eight different crudes or mixtures thereof by the various methods employed in refining automotive fuels. Analysis of one of the samples (No. 25) indicated the presence of a rust preventive oil which affects the consistency of Napalm fuels, hence the data obtained with this sample were excluded.

C O N F I D E N T I A L

E. EXPERIMENTAL

The investigation was concerned with a study of the following:

- (1) Quality of various thickeners with respect to the consistency and moisture content limitations specified in CWS specification 196-131-107A,
- (2) The effect that various gasolines may have on the consistency of fuels prepared with Napalm thickener,
- (3) The change in properties of the fuels on aging at 70° and 125°F.,
- (4) The effect of temperature on the time required to mix the soap and gasoline.

Fuel consistency and the changes in consistency which occurred on aging were determined by means of Gardner mobilometers which were calibrated and operated in accordance with CWS directive 201B. This directive requires that a cap covering the top of the tube be used when the fuel contains more than 9% of thickener, in order to prevent the gel from being spilled from the tube when the plunger is raised. During the course of the investigation, it was found that different types of caps were used by Eastman Kodak and Standard Oil Development Company. In the latter case, the cap sits loosely on the top of the mobilometer tube while Eastman Kodak used a plug that is inserted into the tube and comes to rest on the gel. As a result of the difference in techniques, the consistencies of gels containing 10% or more of thickener determined by the Eastman procedure were appreciably higher than those obtained at Standard Oil Development Company. With fuels containing 8% or less of thickener comparable results were obtained in the two laboratories. The moisture contents of the soap samples were determined by a modified Dean and Stark procedure as described in CWS specification 196-131-107A while the gasoline inspections were obtained by methods commonly employed in the petroleum industry.

In the evaluation of the quality of the thickeners, the fuels (8% thickener) were prepared with N.D.R.C. test gasoline aged at 150°F. and 70°F. and tested in accordance with the above mentioned CWS specification. Since the time required to disperse Napalm is dependent upon the hydrocarbon composition of the gasoline, all fuels used in the surveillance study were compounded at such temperatures that 8% gels could be prepared within 5 minutes. In most cases the temperatures were between 75 and 90°F., but with di-isobutylene and iso-octane the temperature was increased to 100 and 125°F., respectively. Fuels

C O N F I D E N T I A L

-9-

() employed in the surveillance study contained 4, 8 and 12% by weight of thickener. With each gasoline, all three batches were prepared at the same temperature using soaps from McGean Chemical Company, Harmon Color Works, and Imperial Paper and Color Company, which represent three methods of manufacture. In the case of "test" gasoline No. 14, the fuels contained 4, 6, 8, 10, 12 and 14% by weight of thickener.

: Immediately after preparation the fuels were divided into pint Mason jars in which they were stored at 70 and 125°F. while one sample of each of the 8% fuels was cured in a steel tube for 24 hours at 150°F. At intervals varying from one to thirty-two days, samples were examined for consistency in the Gardner mobilometer. During the course of the investigation it was discovered that there was appreciable evaporation from the jars even when the caps were tightened by means of a wrench. As a result, some of the consistency values are erroneously high, especially after 32 days storage at 125°F.

The setting time of certain soaps was determined by adjusting 460 grams of gasoline to the desired temperature, then adding 40 grams of thickener. The mixture was stirred until there was no evidence of settling, then tested once per minute for setting time with the aid of a 60 degree conical funnel having an outlet of 5/8 in. I.D. and 3/4 in. length. The interval in minutes from addition of the soap until less than 90% of the mix would flow through the funnel in 15 seconds represented the setting time.

C O N F I D E N T I A L

CONFIDENTIAL

Table A

CONSISTENCY OF 8 PERCENT NAPALM FUELS CONTAINING
SOAPS FROM VARIOUS MANUFACTURERS

(Tested in accordance with C.W.S. Specification 196-131-107A)

Soap		Consistency-Grams Gardner				Moisture
		24 hours at 150°F.		48 hours at 77°F.		
Manufacturer	Lot No.	Individual	Ave.	Individual	Ave.	% (c)
Oronite (a)	J-33-C	680 710	695	800 740 840	793	0.4
Oronite (b)	J-33-C	805 800 775	793	975 925 915	938	-
Ferro	184	655 680 660	665	775 775 640	730	0.8
McGean	462	660 670 640	657	615 675	645	0.8
Harmon	R11285	670 675 665	670	675 665 695	678	0.6
Pfister	N-3-2432-94	665 665	665	660 710	685	0.5
Imperial	NR-232	640 610 645	632	665 735 730	708	0.6
Colgate	N-3-2854-56	585 625	605	685 740	713	0.3
Nuodex	19149	740	740	730 730	730	-
Nuodex	19162	730	730	720 720	720	-
Nuodex	19812	670 670	670	660 710	685	0.7
Nuodex	19889	655 690	673	705 690	698	0.7
Nuodex	19839	670 675	673	675 665	670	0.7
Nuodex	20532	630 600	615	625 645	635	-
Nuodex	21318	525 540	533	515 530	523	-
Cal. Ink.	98	480 475	478	585 610	598	0.6
Eakins	N-3-2981-431	415 450 430 475	443	560 610 560 625	589	0.6

- (a) As received.
(b) Sample thoroughly mixed at Eastman Kodak
(c) ASTM D95-90 as modified by CWS.

Standard Oil Development Company
RLB/gs - 6/30/44 - PDN 2575a

CONFIDENTIAL

C O N F I D E N T I A L

-10-

F. DISCUSSION

(a) Thickener Quality

The results of tests carried out with the various soaps in accordance with CWS specifications are shown in Table A, opposite. All soaps examined were within the maximum allowable moisture content of 0.8 percent and they exhibited, in general, similar consistencies after aging 24 hours at 150°F. Sixty percent of the soaps illustrative of products from ten manufacturers, gave 8% fuels having consistencies between 630 and 675 grams Gardner, while 70% were within the range of 600 to 750 grams. Of the seven lots received from one manufacturer (Nuodex), between June 1, 1943, and February 1, 1944, six (86%) were within the consistency range of 600 to 750. Three of the samples examined were off grade, two giving 8% fuels below the 500 grams specified and one yielding consistencies above 800 grams, particularly when aged 2 days at 77°F. With the latter sample (Oronite), reproducible results could not be obtained at either the Eastman Kodak or Standard Oil Development Company laboratories even when tests were carried out on a portion of the soap which was carefully blended. Both laboratories were in agreement that 8% gels containing the Oronite soap possessed consistencies above 800 grams in the 77°F. test.

There is considerable variation in the consistency values obtained after aging 48 hours at 77°F., sometimes amounting to 100-150 grams even with the same soap as illustrated by the results obtained with the Ferro thickener. It has been the experience with 8% gels in this laboratory that about one batch in four cured at 70-80°F. may be expected to deviate up to 150 gms. from the average of the other three. It is questionable, therefore, whether this method of test is sufficiently reliable in evaluating the quality of Napalm thickener.

These data indicate that the manufacture of Napalm has progressed to the stage where uniform, reproducible soaps are being manufactured and it may be expected that approximately 75% of the Napalm output from the majority of manufacturers will give 8% gels in gasoline which have consistencies within the restricted range of 600 and 750 grams Gardner. Consequently, it would appear feasible to select soaps of this quality for use in the preparation of flame thrower fuels provided that those lots of soap from a given manufacturer which are outside this range but within the specification limits can be directed to the preparation of fuels for incendiary bombs.

(b) Effect of Gasoline Quality on the Properties of Napalm Fuels

Samples of Napalm thickener from three producers (Harmon, McGean and Imperial) and representing three methods of manufacture were dispersed in a variety of hydrocarbons to

C O N F I D E N T I A L

CONFIDENTIAL

TABLE B

CONSISTENCY (GRAMS GARDNER) OF NAPALM FUELS IN "TEST" GASOLINE
#14 USING MC GEAN, HARMON AND IMPERIAL SOAPS

% Soap Storage Temp. °F. McGeen Soap Days Aging	4			6			8			10			12			14		
	70	125		70	125		70	125		70	125		70	125		70	125	
1	185	220		405	475		710	685		1105	1180		1360	1425		1720	1760	
2	180	125		390	390		675	760		1025	970		1330	1280		1590	1680	
4	250	130		405	350		705	710		1060	945		1300	1280		1740	1560	
8	230	100		455	430		745	755		1000	1140		1440	1650		1985	1850	
16	200	100		450	360		745	710		1040	1110		1410	1420		1930	1940	
32	210	110		570	415		800	800		1175	1110		1220	-		1740	1910	
<u>Harmon Soap</u>																		
1	170	150		470	375		850	755		1070	1180		1400	1425		1725	1760	
2	150	105		380	430		825	635		1060	1035		1590	1435		1840	1640	
4	110	95		490	400		750	610		1015	1085		1375	1360		1730	1815	
8	120	90		380	420		790	630		940	925		1330	1500		1740	1810	
16	95	90		375	330		780	635		820	1110		1330	1320		1685	1850	
32	110	90		340	370		650	600		950	1065		1420	1390		1790	1670	
<u>Imperial Soap</u>																		
1	74	80		350	425		705	750		1120	1000		1400	1120		1630	1510	
2	60	74		320	440		810	645		1025	1025		1340	1215		1600	1420	
4	61	62		345	345		760	625		1050	1070		1330	1410		1530	1950	
8	68	69		275	370		655	675		1050	890		1220	1460		1300	1640	
16	85	65		325	605		690	730		975	1100		1160	1570		1545	2120	
32	90	70		295	1030		700	770		920	980		1160	1370		1660	2070	

Standard Oil Development Company
RLB:BCS - 6/30/44 - PDN 2575a

CONFIDENTIAL

C O N F I D E N T I A L

-11-

determine the effect of hydrocarbon type and gasoline quality on the consistency and stability of Napalm fuels. Gels containing 4, 8 and 12% by weight of thickener were examined for consistency after curing 2, 16 and 32 days at 70°F. and after 6, 16 and 32 days at 125°F. and, in addition, 8% fuels were tested after 24 hours at 150°F. In the case of "test" gasoline a more extensive surveillance study was carried out in cooperation with Eastman Kodak using gels containing 4 to 14% of thickener in 2% increments and aged from 1 to 32 days in order to determine the degree of reproducibility that may be expected between laboratories. During a conference with the Eastman group it was found that the data were reasonably comparable, the deviations being attributable to evaporation which occurred from the imperfectly sealed containers.

The results of the study (Table B, opposite) indicated that:

- (1) All three soaps gave gels of similar consistency when aged under similar conditions.
- (2) With the Harmon and McGean soaps, the percentage change in consistency of the fuels on aging increased with decrease in concentration of the thickener, and amounted to less than 15% for fuels containing 14% by weight of thickener and about 50-70% for fuels containing 4% of thickener.
- (3) The Imperial soap exhibited similar behavior at higher concentrations, but the 4% fuels showed practically no aging effect and their consistencies were slightly lower than those obtained with Harmon and McGean soaps. Absence of the curing effect is a highly desirable property of thickeners that are to be used in preparing flame thrower fuels.

The same general properties were exhibited in fuels prepared with the various gasolines and hydrocarbons (Tables 3 and 4 appended) with the exception of:

- (1) Cyclohexane (Sample No. 1) which gave fuels that within the precision of the test method, did not change in consistency on aging.
- (2) Toluene (Sample No. 3) and the relatively aromatic hydroformed naphtha (Sample No. 16) which yielded fuels exhibiting rather limited changes in consistency on aging.

The consistencies of fuels prepared in various fractions of test gasoline (Samples 13, 14 and 20, Table 3 appended) were found to be similar to those obtained with the whole gasoline (Sample No. 11) which indicated that variations in the volatility of gasolines used in the field would have negligible effect on fuel characteristics.

C O N F I D E N T I A L

C O N F I D E N T I A L

Table C

EFFECT OF HYDROCARBONS AND GASOLINE QUALITY
ON THE CONSISTENCY OF NAPALM FUELS

Soap Conc. Wt. %	Consistency (Grams Gardner)								
	Pure Hydrocarbons			All Gasolines			80 Octane Gasolines		
	Min.	Max.	Devia.	Min.	Max.	Devia.	Min.	Max.	Devia.
4	75	390	315	40	250	210	40	155	115
8	550	1060	510	580	900	320	610	790	180
12	1300	2230	930	1160	1700	540	-	-	-

Variables (1) Three soaps.

(2) Aging from 2 days at 70°F. to 16 days @ 125°F.

(3) Four pure hydrocarbons. Toluene
Cyclohexane
Isooctane
Diisobutylene

(4) Twelve uninhibited gasolines representing Straight Run, Cracked, Hydroformed and Mixed process products. Also highly naphthenic, paraffinic and aromatic types of hydrocarbons.

(5) Eleven 80 octane general purpose (pool) gasolines containing various inhibitors and representing six refineries located in the east, midwest, south and west coast. The products represent various methods of processing from 100% straight run to 100% cracked and mixed products from cracking, straight run, reforming and hydroforming.

Standard Oil Development Company

RLB:gs - 6/30/44 - PDN 2575a

C O N F I D E N T I A L

C O N F I D E N T I A L

-12-

In Table C, opposite, and in Figure 1, following, the overall variation in the consistency of thickened fuels is shown, including variations due to:

- (1) The three thickener samples,
- (2) The curing effect as shown by the change in consistency on aging from 2 days at 70°F. to 16 days at 125°F.,
- (3) Hydrocarbon composition.

In Figure 1, the broken lines define the variation in the consistency of Napalm fuels which was caused by variations in the properties of all thickeners and gasolines studied (pure hydrocarbons excepted) and aging of the fuels until they had reached their ultimate, stable consistency. For example, a fuel prepared with 8% by weight of a high thickening power soap in a gasoline which tended to give high viscosity fuels would yield a product having a consistency of 1060 grams Gardner whereas a fuel prepared with a low thickening power soap in a gasoline giving low viscosity fuels would yield a product having a consistency of 480 grams Gardner. The solid lines define the range of consistency caused by similar variables except that only the Harmon, McGean and Imperial soaps were employed. These data (Table C and Figure 1) show that:

- (1) The pure hydrocarbons tested exhibited a higher maximum and a greater deviation in consistency than the regular gasolines.
- (2) The consistency of Napalm fuels was markedly affected by the composition of the hydrocarbon in which the thickener was dispersed (Table 3 appended). The high consistency gels were obtained with cyclic hydrocarbons such as cyclohexane and toluene, while n-heptane (8% gels) gave low values with the branch chain paraffin iso-octane and the unsaturated di-isobutylene giving fuels of intermediate consistency.
- (3) The deviation in consistency due to variations in the properties of gasolines was about two-thirds of that found with pure hydrocarbons and when consideration is limited to the general purpose 80 octane gasolines which are most likely to be encountered in the field, the deviation was only about one-third. For example, with 8% gels, the deviation in consistency was 510 grams for pure hydrocarbons, 320 for all gasolines and 180 grams for general purpose gasolines. The results obtained with the general purpose gasoline No. 25 (Table 2) were not included because this material was found to be contaminated with a rust preventive oil which would affect the consistency of Napalm fuels.

C O N F I D E N T I A L

CONFIDENTIAL

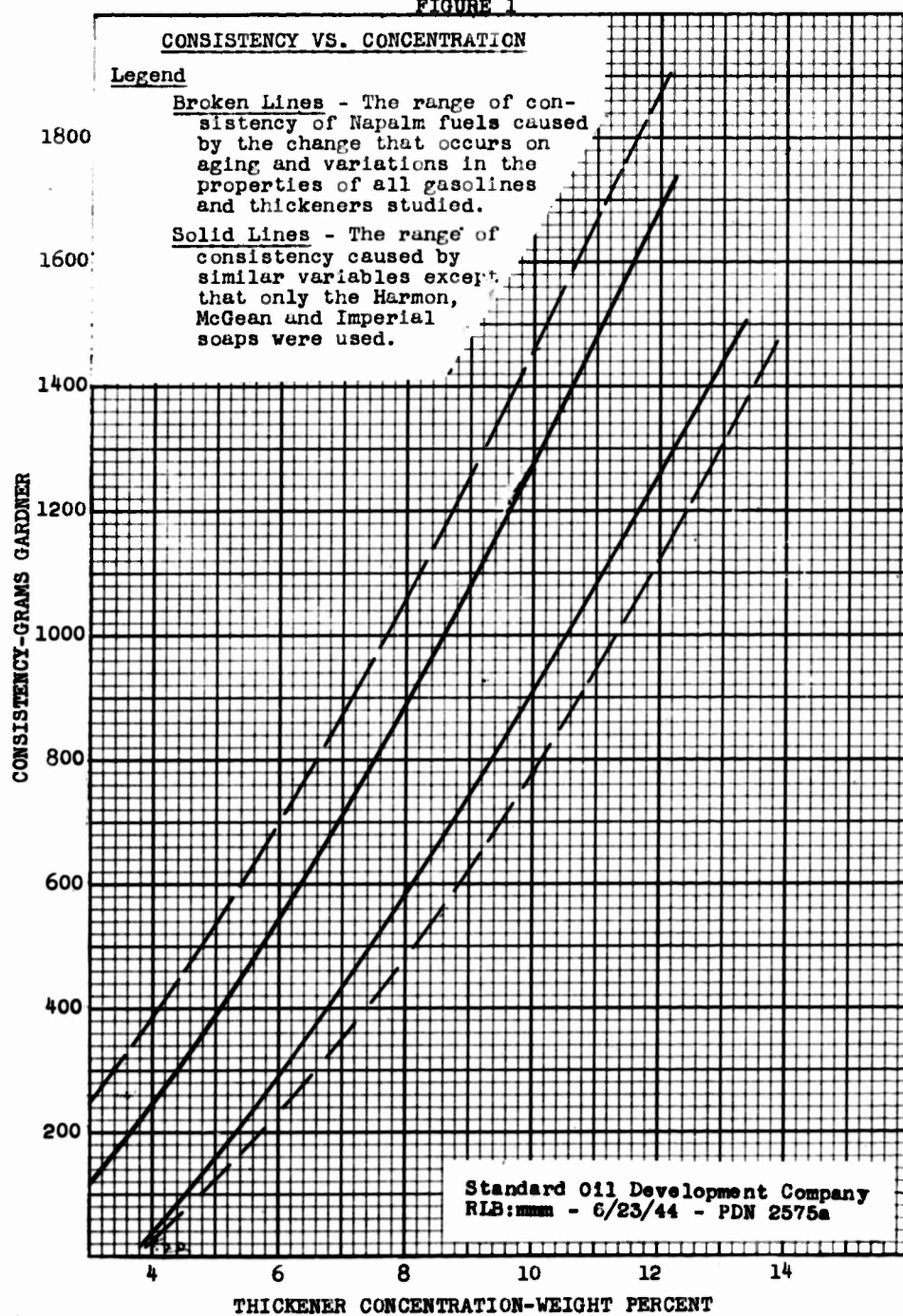
FIGURE 1

CONSISTENCY VS. CONCENTRATION

Legend

Broken Lines - The range of consistency of Napalm fuels caused by the change that occurs on aging and variations in the properties of all gasolines and thickeners studied.

Solid Lines - The range of consistency caused by similar variables except that only the Harmon, McGean and Imperial soaps were used.



CONFIDENTIAL

CONFIDENTIAL

Table D
EFFECT OF GASOLINE QUALITY ON THE PROPERTIES OF NAPALM FUELS

Thickener Conc. Wt. %	Consistency (Grams Gardner) Using Three Soaps and Aging from 2 Days at 70°F. to 16 Days at 125°F. in the Gasolines											
	Naphthenic* (8)		Hydroformed* (16)		"Test" Gaso.* (11)		C.W.S.* (19)		Min.	Diff.		
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.				
4	90	250	160	130	235	105	60	250	190	50	225	175
8	685	955	275	630	755	125	630	810	180	615	810	195
12	1430	1695	265	1380	1680	300	1320	1590	270	1350	1605	255

* Numbers refer to Table 1.

Standard Oil Development Company
RLB:mmm - 6/30/44 - PDW 2575a

CONFIDENTIAL

CONFIDENTIAL

- 13 -

- (4) Variations in the thickening power of the soap greatly increased the deviation in the consistency of Napalm fuels. The deviation for 8% gels prepared with three soaps and all gasolines was 320 grams whereas the deviation was increased to 580 grams when all soaps were considered (Figure 1).

The effect of gasoline quality is more specifically illustrated by the data of Table D, opposite, and Figures 2, 3 and 4, following, in which soap concentration is plotted against consistency. The dotted lines show the consistency range of fuels prepared in "test" * gasolines and the solid lines represent the overall range for all gasolines studied. These data illustrate that:

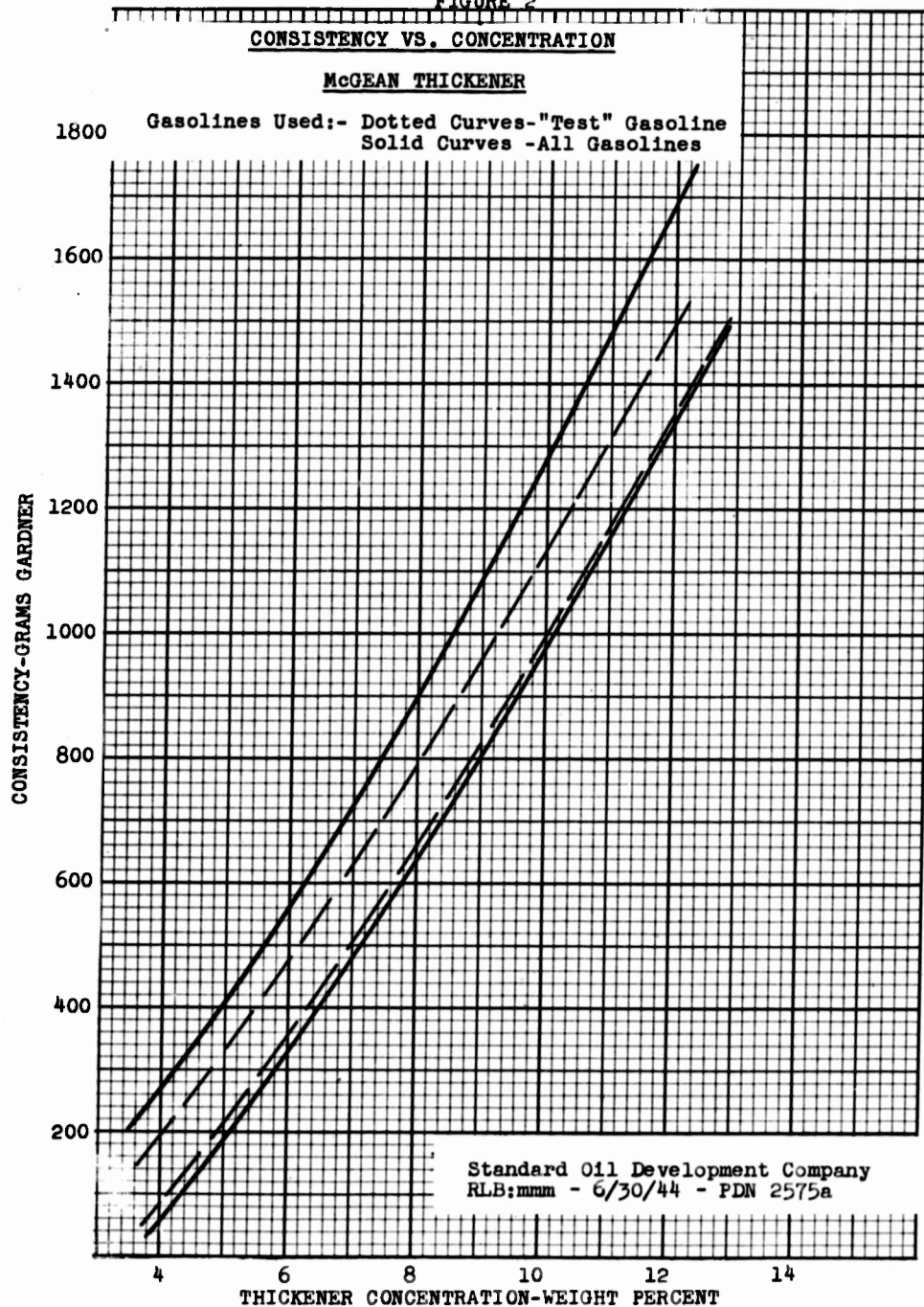
- (1) With one soap and very similar "test" gasolines there is an appreciable variation in consistency at any given concentration, as illustrated in Figures 2, 3 and 4.
- (2) There are no significant differences between the minimum consistency values obtained with various gasolines, but there is a very pronounced difference in the maximum values (Figures 2, 3, and 4). This latter deviation is due largely to the high consistency values obtained with one naphthenic gasoline.
- (3) In comparison with the Harmon and McGean soaps, the Imperial thickener yielded fuels exhibiting a wide range of consistency at high concentrations and a relatively narrow range at low concentrations.
- (4) The aromatic hydroformed naphtha yielded fuels which exhibited a smaller change in consistency on aging than those obtained from any other gasoline (Table D).

* As prescribed by CWS Specifications 196-131-144 and 196-131-107

CONFIDENTIAL

C O N F I D E N T I A L

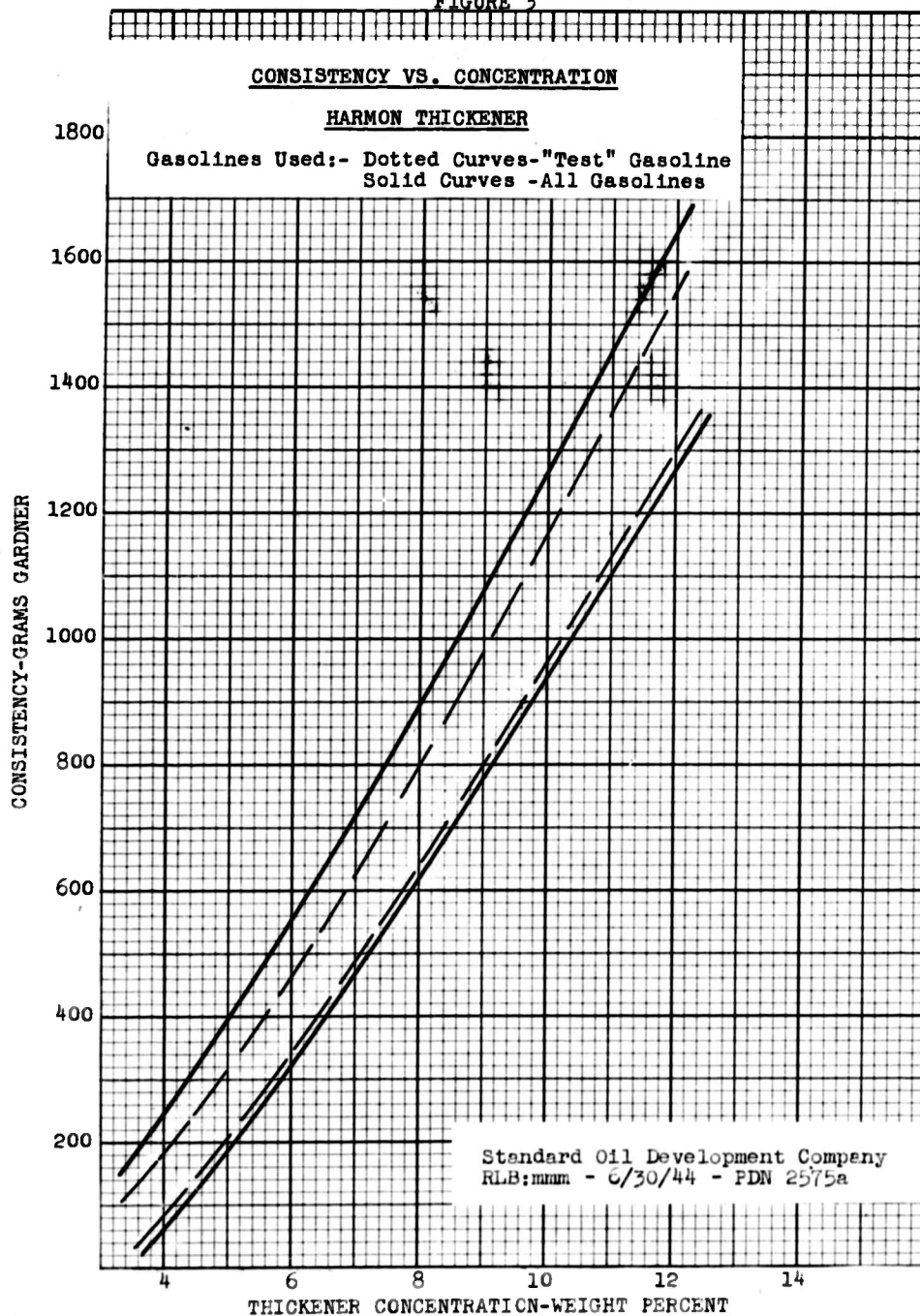
FIGURE 2



C O N F I D E N T I A L

C O N F I D E N T I A L

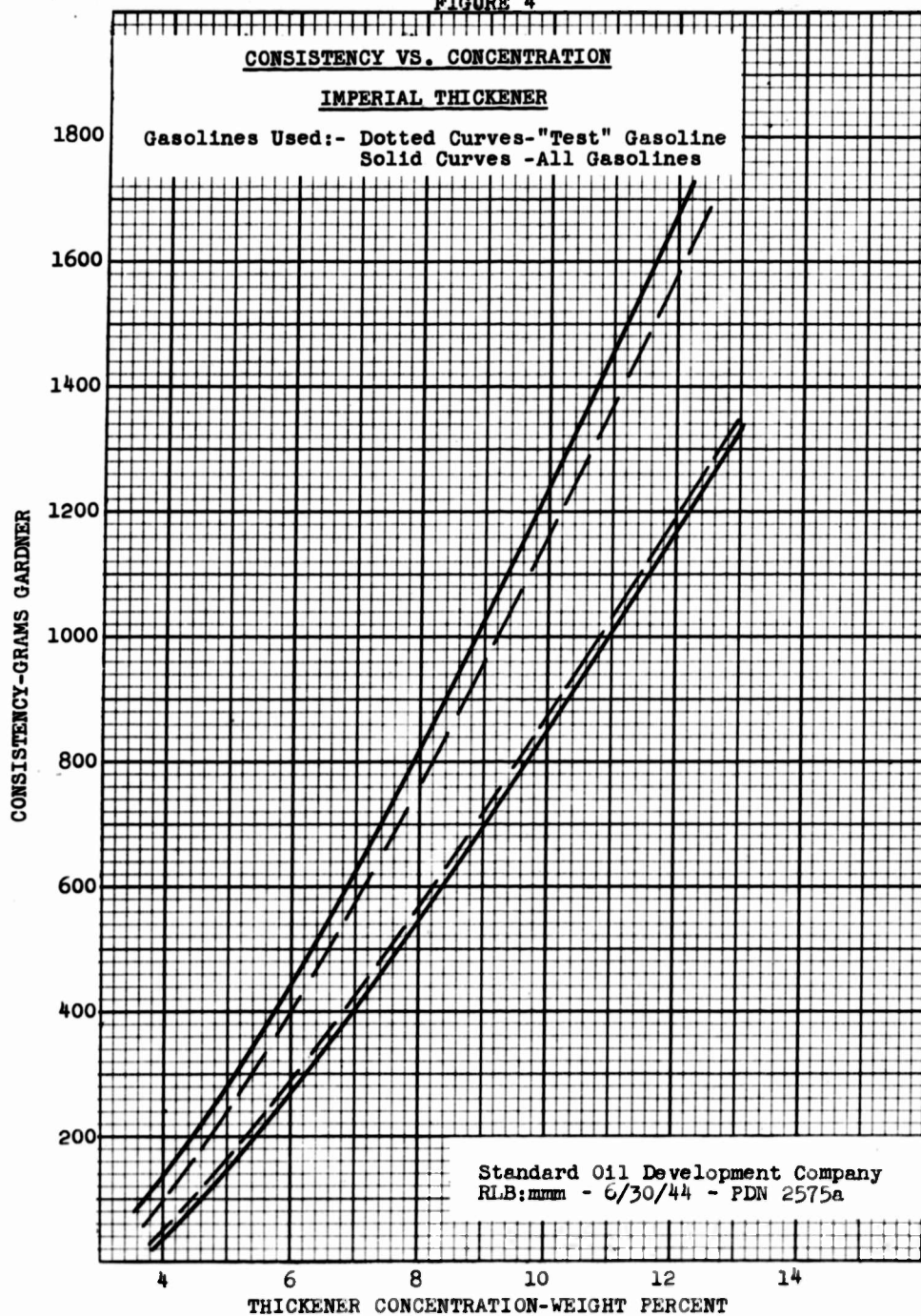
FIGURE 3



C O N F I D E N T I A L

C O N F I D E N T I A L

FIGURE 4



C O N F I D E N T I A L

CONFIDENTIAL

Table E

EFFECT OF THICKENER AND GASOLINE QUALITY ON
THE PROPERTIES OF NAPALM FUELS

Thickener Conc. Wt. %	(a) Consistency (Grams Gardner) Resulting from Combinations of											
	One Soap (b)		One Soap (b)		Three Ave. Soaps (d)		All Soaps (e)					
	One Gasoline (c)		All Gasolines		All Gasolines		All Gasolines					
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
	Diff.		Diff.		Diff.		Diff.		Diff.		Diff.	
4	90	150	60	65	250	185	40	250	210	40	415	375
8	610	820	210	610	885	275	580	955	375	480	1040	560
12	1320	1590	270	1260	1590	330	1150	1700	540	1100	1910	810

- (a) Includes aging effect occurring between 2 days at 70°F. and 16 days at 125°F.
 (b) Harmon Thickener.
 (c) "Test" Gasoline.
 (d) Harmon, Imperial and McGean.
 (e) Maximum value with Oronite and minimum value with Eakins thickener.

Standard Oil Development Company
 RLB:mmm - 6/30/44 - PDN 2575a

CONFIDENTIAL

CONFIDENTIAL

-14-

In order to determine the maximum variation in consistency that may be encountered due to aging and changes in soap and gasoline quality, a study was made of combinations of:

- (1) A high thickening power soap (Oronite) dispersed in the naphthenic gasoline.
- (2) A low thickening power soap (Eakins) dispersed in gasoline No. 23.

When these results are considered, the overall variation in consistency (Table E, opposite, and Figure 1 dotted lines) is nearly twice as great as was obtained with the three average soaps (Harmon, Imperial and McGean). These data also indicate that gasoline quality has a relatively small effect on the consistency of fuels containing 8% or more of thickener in comparison with that caused by variation in thickener quality. The general conclusions from the preceding discussions are:

- (1) The majority of 80 octane all purpose gasolines have a relatively minor effect on fuel consistency, but gasolines may be encountered occasionally that will yield high consistency fuels.
- (2) The greatest change in consistency that may be expected under field conditions is due to variations in the thickening power and curing rates of different lots of soap.
- (3) The percentage variation in consistency due to aging increases rapidly with decrease in the proportion of thickener employed.

(c) Significance of Variation in Fuel Consistency on Performance

Fuels for incendiary bombs are prepared at plants where test methods can be employed to determine the proportions of thickener and gasoline which are necessary to yield fuels having consistencies within specified limits and variations in the gasoline or thickener can be controlled reasonably well. This also applies to flame thrower fuels which can be compounded at plants suitably equipped to exercise the necessary control of product quality. When, however, fuels are compounded in the field using the gasolines and soaps available and in fixed ratio, then the variations in fuel consistency may affect flame thrower performance. Since the variations are greatest at low concentrations, the greatest effect may be expected in the performance of portable flame throwers. According to present information, the consistencies of 4% Napalm fuels should fall within 40 and 150 grams Gardner if portable flame throwers are to approach optimum performance. Since it is impracticable to control the

CONFIDENTIAL

CONFIDENTIAL

-15-

quality of gasolines in the field, it is necessary that variations in soap quality be limited. In view of the fact that the majority of soaps now manufactured yield 8% gels having consistencies between 600 and 750 grams Gardner, it appears feasible to select for field use only those lots that are within this range. It is also necessary to reduce the change in consistency of Napalm fuels which occurs on aging and results recently obtained by Eastman Kodak indicate that this may be accomplished by addition of dehydrating agents to the soap. In order to determine the practicability of these methods it is suggested that:

- (1) The inspection records of the various manufacturers be reviewed to ascertain whether there is sufficient soap capable of giving 8% gels with consistencies between 600 and 750 grams to render soap selection practicable.
- (2) The effect of dehydrating agents on the quality of Napalm fuels should be thoroughly and vigorously investigated.

(d) Effect of Oxidized Gasoline on Napalm Consistency

During the course of a previous investigation* of the effect of gasoline quality on the consistency of Napalm fuels, it was found that a steam cracked distillate tended to give fuels of low consistency. Since this material contained a relatively large amount of unsaturated hydrocarbons and it had been aged to the point where it contained considerable oxidation products, a study was made of the effect of gasoline oxidation on fuel properties. Fuels were prepared in a similar material, part of which was inhibited to prevent oxidation while other portions were uninhibited and allowed to oxidize. At various stages of oxidation as represented by the peroxide number, ** 8% Napalm fuels were prepared and aged 24 hours at 150°F. The results were substantiated by later studies using a sample of gasoline obtained from a plant (Kilgore) engaged in filling and assembling M69 incendiary bombs. This gasoline and two others (Rocky Mountain Arsenal and United Wall Paper) were forwarded by the CWS Technical Command as examples of gasolines which might give low consistency Napalm fuels. These gasolines were included in the surveillance study and showed originally no evidence of adverse effects (Table 3).

* Effect of Gasoline Quality on Napalm Thickened Fuels -
PDN 1418, July 31, 1943.

** Peroxides and Gum in Gasolines, Yule and Wilson, Ind. Eng. Chem.
23, 1254, (1931).

CONFIDENTIAL

CONFIDENTIAL

Table F

EFFECT OF OXIDIZED GASOLINES ON THE
CONSISTENCY OF NAPALM FUELS (8% GELS)

Thickener Source	Nuodex 17962			Imperial NR-232		Harmon R11285		
Gasoline	<u>NDRC</u> <u>"Test"</u>	<u>Steam Cracked Naphtha</u> <u>Inhibited</u>	<u>Uninhibited</u>	<u>NDRC</u> <u>"Test"</u>	<u>Kilgore</u> <u>19</u>	<u>NDRC</u> <u>"Test"</u>	<u>Kilgore</u> <u>19</u>	
Peroxide No. *	0	0	17	47.5	0	39	0	70
Grams Gardner after 24 hours @ 150°F.	635	630	510	175	645	310	670	110

* Gram equivalents of oxygen per 1000 liters of gasoline.

Standard Oil Development Company
RLB:mmm - 6/30/44 - PDN 2575a

CONFIDENTIAL

CONFIDENTIAL

-16-

Three to four months later one of these gasolines was found to be highly oxidized (No. 19, Table 1). Fuels were immediately prepared with this gasoline using the Imperial soap, while two weeks later similar fuels were prepared with the Harmon soap. In both cases it was found that low consistency fuels were obtained (Table F, opposite) and furthermore the decrease in consistency appeared to be proportional to the degree of gasoline oxidation (Figure 5, following).

Results obtained at Eastman Kodak during their psychrometric studies indicated that 0.5% increase in the moisture content (0.44% oxygen equivalent) of the Imperial soap would decrease the consistency of 8% gels to 380 grams Gardner. This effect is roughly comparable to the value of 310 grams obtained with the Imperial soap in a gasoline having a peroxide number of 39 which represents oxygen equivalent to 0.47% by weight of the soap employed in the preparation of 8% fuels.

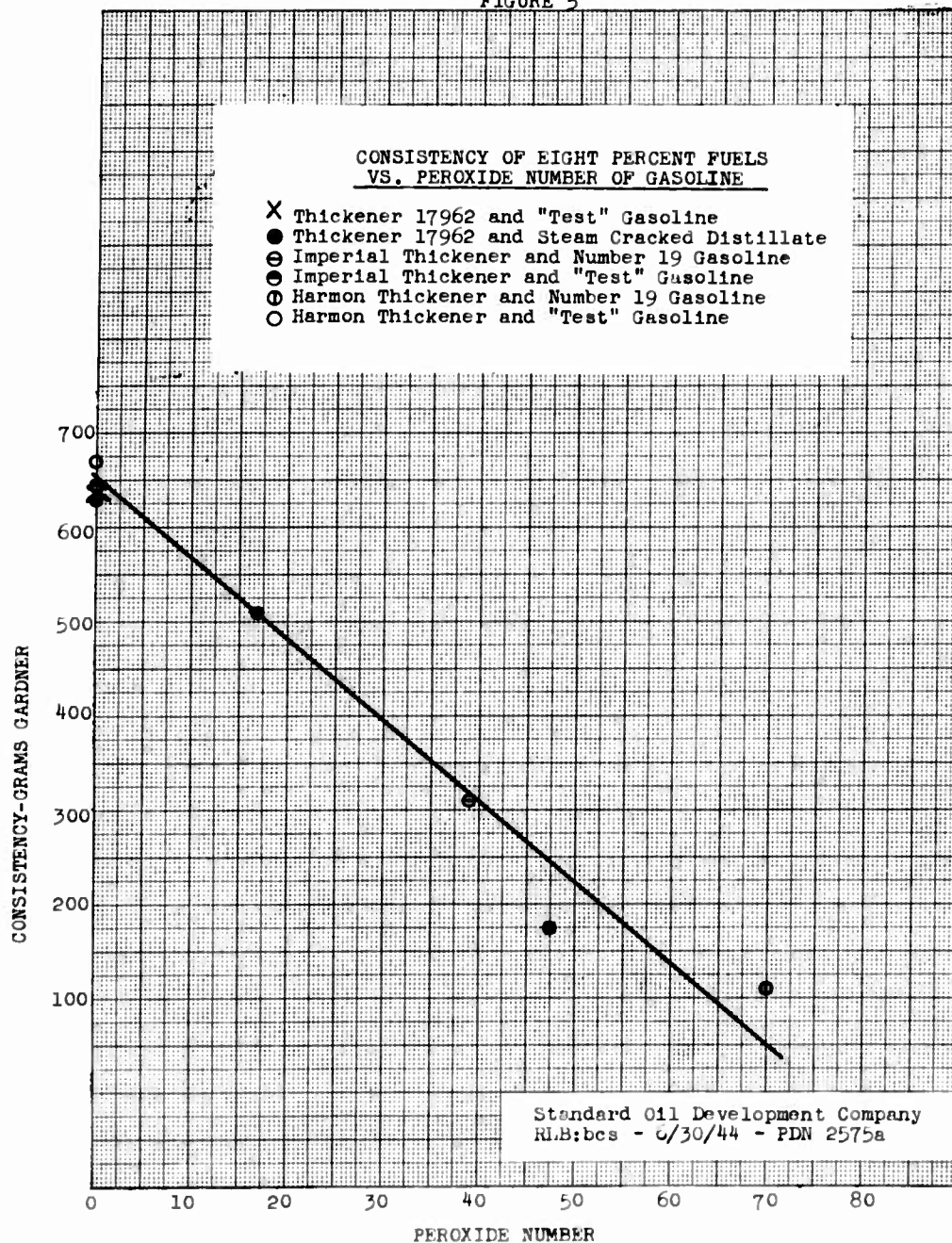
In view of these results, it is just as important to prevent undue oxidation of the gasoline as it is to control the moisture content of the soap. Fortunately, motor gasolines used by the armed forces are well inhibited, consequently very little difficulty due to oxidized gasoline may be expected in field compounding. Where fuels are prepared at plants either for incendiaries or flame throwers, it is strongly recommended that the gasoline be inhibited to give a minimum breakdown of 400 minutes ASTM as specified for 80 octane general purpose motor gasoline.

Since oxidized gasolines had such a pronounced effect on fuel consistency, consideration was given to moisture and phenols present in the gasolines, but there was no apparent relationship between phenol or dissolved water content and the consistency of Napalm fuels.

CONFIDENTIAL

C O N F I D E N T I A L

FIGURE 5



C O N F I D E N T I A L

CONFIDENTIAL

Table G
EFFECT OF TEMPERATURE ON SETTING TIME OF 8% FUELS (a)

Thickener Manufacturer	Lot Number	Setting Time in Minutes at Temperatures, of, Shown						
		40°	50°	60°	70°	77°	90°	100°
Ferro	184	405	96	2.5	0.4	0.3	1.0	2.5
Pfister	N-3-2432-94	600	100	25	2	1.4	1.0	1.3
Harmon	R11285	330	93	16	4	3.0	3.0	2.5
Imperial	NR-232	180	60	7	5	7.0	3.0	3.8
Nuodex	19889	315	25	11	8	9.0	5.0	11.2

(a) Tests carried out with "Test" Gasoline (Sample 11, Table 1.)

Standard Oil Development Company
RLB:mmm - 6/30/44 - PDN 2575a

CONFIDENTIAL

CONFIDENTIAL

-17-

(c) Effect of Temperature on Setting Time

Some of the soaps have been examined to determine the effect of temperature on their solvation rates in test gasoline (Sample 11, Table 1) using 8% by weight of the thickener. With two of the soaps (Imperial and Nuodex) a peculiar variation was found at temperatures between 70 and 90°F. (Table G, opposite, and Figure 6, following). This relationship was reproducible but it has never been observed in any previous work. The behavior of the remaining soaps (Figure 6) was found to be in agreement with past experience, namely:

- (1) Napalm from various manufacturers exhibited rather wide variations in solvation rate.
- (2) In most instances the setting time was at a minimum between 70 and 90°F.
- (3) At low temperatures (below 60°F.) the setting time increased very rapidly with decreasing temperature.

A study is in progress to determine the relationship between temperature and solvation rate at lower concentrations of thickener. While this investigation is incomplete, experience to date indicates that within the temperature range of 70-90°F., 4% fuels must be mixed about three times as long as 8% fuels if reasonably uniform products are to be obtained. It follows, therefore, that soaps having a setting time of 10 minutes at 77°F. would have to be mixed at least 30 minutes at temperatures above 70°F. in order to compound fuels containing 4% of thickener. It is concluded that:

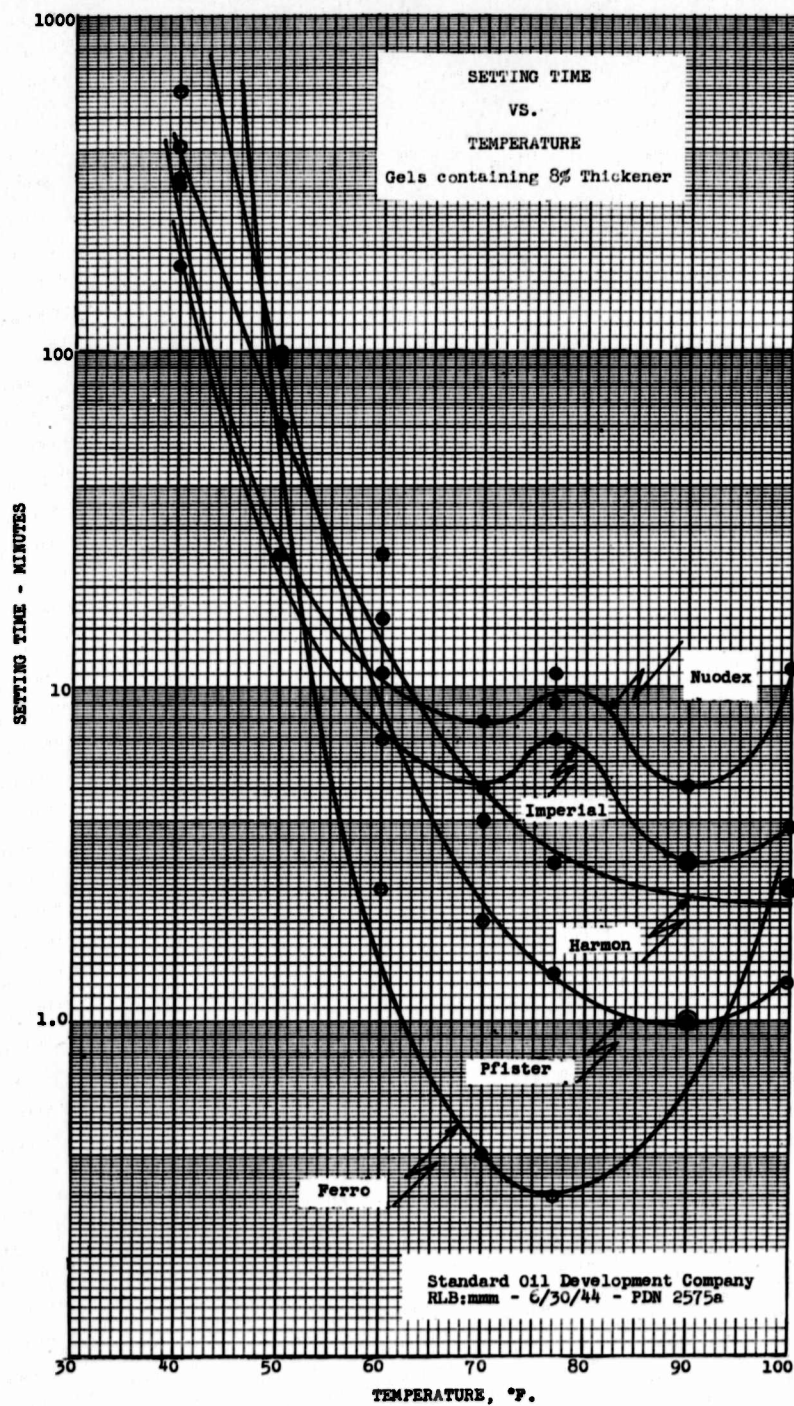
- (1) For the compounding of fuels at various concentrations, the setting time (8% gels) should be within the limits of 2 to 7 minutes.
- (2) Compounding should be done at temperatures above 70°F.
- (3) A further study of methods of reducing the variability in solvation rates exhibited by various soaps is required. Such an investigation should include the development of (a) simple, improved methods for compounding low consistency fuels and (b) equipment suitable for mixing higher consistency fuels required for mechanized units quickly and in sufficient volume. The latter phase is under study at the Standard Oil Development Company using equipment designed for servicing the mechanized flame thrower.

RLB/egs:mmm

CONFIDENTIAL

CONFIDENTIAL

FIGURE 6



CONFIDENTIAL

CONFIDENTIAL

TABLE 1
GASOLINE INSPECTIONS

Sample No. Hydrocarbon or Gasoline	3 Toluene	1 Cyclo- hexane	4 Diiso- butylene	5 Iso- octane	5 N- Reptane	7 (e) Ref. Fuel MS	8 (b) Sug- ger- lend Naphtha	10 Motor Gas	11 Tested #14 0-100%	20 Tested #14 0-80%	13 Tested #14 50-80%	14 Tested #14 60-90%	18 Tested #15	16 Hydro- formed Naphtha	19 Kilgore Plant	21 United Wallpaper Plant	23 Rocky Mountain Arsenal	Steam Cracked Naphtha
Distillation - I.B.P., °F.	230.8	-	-	208	207	135	125	99	93	82	189	239	95	127	107	105	97	104
10% off at °F.	231.4	178	-	209	207	137	125	127	104	-	167	250	105	160	136	135	135	140
50% off at °F.	-	-	-	210	207	273	287	225	201	135	176	273	215	216	235	244	244	224
90% off at °F.	231.6	178	-	210	206	352	340	339	348	188	198	313	347	250	285	341	341	355
F.B.P., °F.	231.8	181	-	219	228	398	350	390	401	237	223	334	392	309	442	376	360	394
Gravity, 60°F.	31.2	60.5	54.8	71.8	74.5	61.2	55.1	51.0	58.4	77.6	54.5	49.7	51.0	64.6	61.5	51.0	51.3	48.4
Aniline Point, °F.	-	85	111	175	157	140	125	115	97	110	102	82	98	77	97	109	113	5
Acid Value, mg./100 ml.	-	-	-	-	-	2.9	4.5	6.5	11.8	17.2	4.5	0.0	11.9	6.6	9.0	10.7	9.7	1.4475
Acid Vapor Pressure, psi	1.4953	1.4270	1.4116	1.3914	1.3879	1.4120	1.4229	1.4140	1.4121	1.3832	1.4047	1.4392	1.4214	1.4228	1.4170	1.4150	1.4109	-
Refractive Index, D ₂₀ °C.	1.535	95.8	87.9	99.3	98.3	103.4	101.0	104.8	108.5	99.4	104.2	115.9	113.8	128.6	107.4	105.7	103.8	460
Specific Dispersion	22	-	334	1.0	-	0	0	65	125	155	106	81	114	18	141	96	135	181
Acid Heat, °F.	0.4	0.0	139	0.8	-	0.2	0.0	21.0	39.0	45	34.4	26.1	36.4	4.2	37.4	34.4	41.8	121
Phenol No. (f)	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mercaptan Sulfur (g)	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Reactive Sulfur (h)	-	-	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sulfur - Lamp %	-	-	-	-	-	0.014	0.100	0.03	0.03	0.017	0.05	0.051	0.030	0.008	0.043	0.046	0.034	0.035
ASTM Gum, mg./100 ml.	-	-	-	-	-	1.5	1.4	0.5	0.5	0.5	2.8	1.2	1.2	3.0	4.0	6.0	1.4	79
ASTM Octane - Clear	-	-	-	-	-	22	77	65	0	77	72	71.2	72	71	70	70	57	-
ASTM Octane + 5 ml. TEL/gal.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peroxide No. (i)	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.9	1.3	0.4	0.0	0.005	1.0(m)	3.7(m)	0.5
Water - Vol. %	-	-	-	-	-	0.002	0.002	0.002	0.002	0.002	0.9	1.3	0.002	0.007	0.005	0.002	0.003	27
Aromaticity - % (j)	994	0	0	1-	0	8	8	10	12	2.5	7	22	18	35	11.0	10.0	10.0	27

- (a) Highly paraffinic naphtha from Michigan Crude.
 (b) Highly naphthenic straight run naphtha.
 (c) Sample of gasoline used in the Kilgore filling plant for M69 bombs.
 (d) Sample of gasoline used in the United Wallpaper filling plant for M69 bombs.
 (e) Sample of gasoline used at the Rocky Mountain Arsenal.
 (f) Milligrams of tertiary amyl phenol per 100 ml. of gasoline.
 (g) Milligrams of mercaptan sulfur per 100 ml. of gasoline.
 (h) Milligrams of reactive sulfur per 100 ml. of gasoline.
 (i) Gram equivalents of active oxygen per 1000 liters of gasoline.
 (j) Estimated from specific dispersion and bromine number. Approximate precision $\pm 2\%$.
 (k) With 2 ml. TEL per gallon.
 (m) Determined on sample aged for 3-4 months.

Standard Oil Development Company
RLB:mmm - 6/30/44 - PDN 2575a

CONFIDENTIAL

CONFIDENTIAL

TABLE 2
GASOLINE INSPECTIONS
(80 OCTANE GENERAL PURPOSE GASOLINES)

Sample No.	24	25	26	27	28	29	30	31	32	33	34	35
Origin of Gasoline	Indiana	Illinois	Texas	Texas	Cal.	Texas	Texas	Texas	New Jersey	So. America	So. America	So. America
Refining Area	Mid-Cont.	Mid-Cont.	Mid-Cont.	E. & W. Texas	Cal.	La.	La.	La.	Mid-Cont.	Venezuela	Venezuela	Venezuela
Crude Source			West Texas	New Mexico								
Gasoline Composition, Vol. %												
Straight Run	15	8	-	-	100	58.5	100	-	50	-	-	-
Cracked	85	92	15	75	-	31.5	100	100	50	-	-	-
Reformed	-	-	75	-	-	-	-	-	-	-	-	-
Hydroreformed	-	-	10	10-C ₄ +C ₅	-	-	-	-	-	-	-	-
Casing Head	-	-	D.P. 5	UOP 5	UOP 4	UOP 4	UOP 4	UOP 4	Alpha Naphthol	Triforel	Triforel	D.P. 5
Inhibitor Present	-	25	12	13	11.5	38.4	36	14.4	35	65	145	24.5
Inhibitor Conc., lbs./1000 bbls.	10	25	2.8	1.5	2.7	2.0	2.0	2.0	2.5	2.4	2.4	2.4
TEL, ml./gal.	3.0	3.0										
Inspections												
Distillation - I.B.P., °F.	104	100	109	96	105	108	112	114	105	110	110	108
10% off at °F.	180	142	144	130	141	145	143	150	142	139	139	143
50% off at °F.	230	231	200	220	222	221	212	230	216	202	202	206
90% off at °F.	310	325	292	335	342	313	281	286	318	312	312	305
F.B.P., °F.	365	368	360	392	378	334	332	326	378	365	355	360
Gravity, API	51.5	59.5	54.4	57.0	59.5	59.5	61.7	58.1	62.6	52.1	62.1	62.2
Aniline Point, °F.	107	105	113	74	97	92	92	88	110	98	98	97
Reid Vapor Pressure, psi/100°F.	7.2	5.8	5.2	8.0	5.4	5.8	5.8	5.9	7.1	5.7	5.7	7.0
Refractive Index, D ₂₀ ²⁰ C.	1.4129	1.4141	1.4055	1.4252	1.4155	1.4151	1.4138	1.4197	1.4089	1.4114	1.4113	1.4117
Specific Dispersion	104.2	105.1	104.5	115.1	102.8	105	104.5	111.1	106.9	105.7	103.7	105.1
Acid Heat, °F.	102	105	104.5	123	144	132	159	105	72	129	139	117
Bromine No., cc./100 ml.	40.3	35.0	22.5	39.8	51.8	48.9	55.4	38.3	25.5	42.5	44.0	41.7
Phenol Number	85	100	75	108	100	80	80	80	90	160	160	170
Mercaptan Sulfur	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sulfur - Lamp - %	0.035	0.040	0.048	0.062	0.080	0.042	0.041	0.017	0.080	0.080	0.080	0.077
ASTM Gum	3.2	9.8	4.4	8.5	3.8	6.8	3.4	3.4	4.2	4.2	2.0	2.2
ASTM Octane	80	81	80	82	81	80	79	82	80	80	80	80
Peroxide Number	0.6	1.5	0.0	2.2	0.2	0.5	0.9	0.8	0.1	5.6	5.6	0.0
Water - Vol. %	0.04	0.002	0.005	0.004	0.004	0.008	0.007	0.002	0.002	0.006	0.004	0.007
Aromatics - %	5	7	7	15	4	6	6	13	8	7	5	7

Standard Oil Development Company
RLB:mma - 6/30/44 - PDN 2575a

CONFIDENTIAL

CONFIDENTIAL

TABLE 2
CONSISTENCY OF NAPALM FUELS PREPARED WITH VARIOUS HYDROCARBONS AND COMMERCIAL GASOLINES

Hydrocarbon or Gasoline	Sample Number (a)	Source	45° Cel.				55° Cel.				65° Cel.				75° Cel.				85° Cel.				95° Cel.				105° Cel.				115° Cel.				125° Cel.				135° Cel.				145° Cel.				155° Cel.				165° Cel.				175° Cel.				185° Cel.				195° Cel.				205° Cel.				215° Cel.				225° Cel.				235° Cel.				245° Cel.				255° Cel.				265° Cel.				275° Cel.				285° Cel.				295° Cel.				305° Cel.				315° Cel.				325° Cel.				335° Cel.				345° Cel.				355° Cel.				365° Cel.				375° Cel.				385° Cel.				395° Cel.				405° Cel.				415° Cel.				425° Cel.				435° Cel.				445° Cel.				455° Cel.				465° Cel.				475° Cel.				485° Cel.				495° Cel.				505° Cel.				515° Cel.				525° Cel.				535° Cel.				545° Cel.				555° Cel.				565° Cel.				575° Cel.				585° Cel.				595° Cel.				605° Cel.				615° Cel.				625° Cel.				635° Cel.				645° Cel.				655° Cel.				665° Cel.				675° Cel.				685° Cel.				695° Cel.				705° Cel.				715° Cel.				725° Cel.				735° Cel.				745° Cel.				755° Cel.				765° Cel.				775° Cel.				785° Cel.				795° Cel.				805° Cel.				815° Cel.				825° Cel.				835° Cel.				845° Cel.				855° Cel.				865° Cel.				875° Cel.				885° Cel.				895° Cel.				905° Cel.				915° Cel.				925° Cel.				935° Cel.				945° Cel.				955° Cel.				965° Cel.				975° Cel.				985° Cel.				995° Cel.				1005° Cel.				1015° Cel.				1025° Cel.				1035° Cel.				1045° Cel.				1055° Cel.				1065° Cel.				1075° Cel.				1085° Cel.				1095° Cel.				1105° Cel.				1115° Cel.				1125° Cel.				1135° Cel.				1145° Cel.				1155° Cel.				1165° Cel.				1175° Cel.				1185° Cel.				1195° Cel.				1205° Cel.				1215° Cel.				1225° Cel.				1235° Cel.				1245° Cel.				1255° Cel.				1265° Cel.				1275° Cel.				1285° Cel.				1295° Cel.				1305° Cel.				1315° Cel.				1325° Cel.				1335° Cel.				1345° Cel.				1355° Cel.				1365° Cel.				1375° Cel.				1385° Cel.				1395° Cel.				1405° Cel.				1415° Cel.				1425° Cel.				1435° Cel.				1445° Cel.				1455° Cel.				1465° Cel.				1475° Cel.				1485° Cel.				1495° Cel.				1505° Cel.				1515° Cel.				1525° Cel.				1535° Cel.				1545° Cel.				1555° Cel.				1565° Cel.				1575° Cel.				1585° Cel.				1595° Cel.				1605° Cel.				1615° Cel.				1625° Cel.				1635° Cel.				1645° Cel.				1655° Cel.				1665° Cel.				1675° Cel.				1685° Cel.				1695° Cel.				1705° Cel.				1715° Cel.				1725° Cel.				1735° Cel.				1745° Cel.				1755° Cel.				1765° Cel.				1775° Cel.				1785° Cel.				1795° Cel.				1805° Cel.				1815° Cel.				1825° Cel.				1835° Cel.				1845° Cel.				1855° Cel.				1865° Cel.				1875° Cel.				1885° Cel.				1895° Cel.				1905° Cel.				1915° Cel.				1925° Cel.				1935° Cel.				1945° Cel.				1955° Cel.				1965° Cel.				1975° Cel.				1985° Cel.				1995° Cel.				2005° Cel.				2015° Cel.				2025° Cel.				2035° Cel.				2045° Cel.				2055° Cel.				2065° Cel.				2075° Cel.				2085° Cel.				2095° Cel.				2105° Cel.				2115° Cel.				2125° Cel.				2135° Cel.				2145° Cel.				2155° Cel.				2165° Cel.				2175° Cel.				2185° Cel.				2195° Cel.				2205° Cel.				2215° Cel.				2225° Cel.				2235° Cel.				2245° Cel.				2255° Cel.				2265° Cel.				2275° Cel.				2285° Cel.				2295° Cel.				2305° Cel.				2315° Cel.				2325° Cel.				2335° Cel.				2345° Cel.				2355° Cel.				2365° Cel.				2375° Cel.				2385° Cel.				2395° Cel.				2405° Cel.				2415° Cel.				2425° Cel.				2435° Cel.				2445° Cel.				2455° Cel.				2465° Cel.				2475° Cel.				2485° Cel.				2495° Cel.				2505° Cel.				2515° Cel.				2525° Cel.				2535° Cel.				2545° Cel.				2555° Cel.				2565° Cel.				2575° Cel.				2585° Cel.				2595° Cel.				2605° Cel.				2615° Cel.				2625° Cel.				2635° Cel.				2645° Cel.				2655° Cel.				2665° Cel.				2675° Cel.				2685° Cel.				2695° Cel.				2705° Cel.				2715° Cel.				2725° Cel.				2735° Cel.				2745° Cel.				2755° Cel.				2765° Cel.				2775° Cel.				2785° Cel.				2795° Cel.				2805° Cel.				2815° Cel.				2825° Cel.				2835° Cel.				2845° Cel.				2855° Cel.				2865° Cel.				2875° Cel.				2885° Cel.				2895° Cel.				2905° Cel.				2915° Cel.				2925° Cel.				2935° Cel.				2945° Cel.				2955° Cel.				2965° Cel.				2975° Cel.				2985° Cel.				2995° Cel.				3005° Cel.				3015° Cel.				3025° Cel.				3035° Cel.				3045° Cel.				3055° Cel.				3065° Cel.				3075° Cel.				3085° Cel.				3095° Cel.				3105° Cel.				3115° Cel.				3125° Cel.				3135° Cel.				3145° Cel.				3155° Cel.				3165° Cel.				3175° Cel.				3185° Cel.				3195° Cel.				3205° Cel.				3215° Cel.				3225° Cel.				3235° Cel.				3245° Cel.				3255° Cel.				3265° Cel.				3275° Cel.				3285° Cel.				3295° Cel.				3305° Cel.				3315° Cel.				3325° Cel.				3335° Cel.				3345° Cel.				3355° Cel.				3365° Cel.				3375° Cel.				3385° Cel.				3395° Cel.				3405° Cel.				3415° Cel.				3425° Cel.				3435° Cel.				3445° Cel.				3455° Cel.				3465° Cel.				3475° Cel.				3485° Cel.				3495° Cel.				3505° Cel.				3515° Cel.				3525° Cel.				3535° Cel.				3545° Cel.				3555° Cel.				3565° Cel.				3575° Cel.				3585° Cel.				3595° Cel.				3605° Cel.				3615° Cel.				3625° Cel.				3635° Cel.				3645° Cel.				3655° Cel.				3665° Cel.				3675° Cel.				3685° Cel.				3695° Cel.				3705° Cel.				3715° Cel.				3725° Cel.				3735° Cel.				3745° Cel.				3755° Cel.				3765° Cel.				3775° Cel.				3785° Cel.				3795° Cel.				3805° Cel.				3815° Cel.				3825° Cel.				3833° Cel.				3845° Cel.				3855° Cel.				3865° Cel.				3875° Cel.				3885° Cel.				3895° Cel.				3905° Cel.				3915° Cel.				3925° Cel.				3933° Cel.				3945° Cel.				3955° Cel.				3965° Cel.				3975° Cel.				3985° Cel.				3995° Cel.				4005° Cel.				4015° Cel.				4025° Cel.				4033° Cel.				4045° Cel.				4055° Cel.				4066° Cel.				4077° Cel.				4088° Cel.				4099° Cel.				4110° Cel.				4121° Cel.				4132° Cel.				4143° Cel.				4154° Cel.				4165° Cel.				4176° Cel.				4187° Cel.				4198° Cel.				4209° Cel.				4220° Cel.				4231° Cel.				4242° Cel.				4253° Cel.				4264° Cel.				4275° Cel.				4286° Cel.				4297° Cel.				4308° Cel.				4319° Cel.				4330° Cel.				4341° Cel.				4352° Cel.				4363° Cel.				4374° Cel.				4385° Cel.				4396° Cel.				4407° Cel.				4418° Cel.				4429° Cel.				4440° Cel.				4451° Cel.				4462° Cel.				4473° Cel.				4484° Cel.				4495° Cel.				4506° Cel.				4517° Cel.				4528° Cel.				4539° Cel.				4550° Cel.				4561° Cel.				4572° Cel.				4583° Cel.				4594° Cel.				4605° Cel.				4616° Cel.				4627° Cel.				4638° Cel.				4649° Cel.				4660° Cel.				4671° Cel.				4682° Cel.				4693° Cel.				4704° Cel.				4715° Cel.				4726° Cel.				4737° Cel.				4748° Cel.				4759° Cel.				4770° Cel.				4781° Cel.				4792° Cel.				4803° Cel.				4814° Cel.				4825° Cel.				4836° Cel.				4847° Cel.				4858° Cel.				4869° Cel.				4880° Cel.				4891° Cel.				4902° Cel.				4913° Cel.				4924° Cel.				4935° Cel.				4946° Cel.				4957° Cel.				4968° Cel.				4979° Cel.				4990° Cel.				5001° Cel.				5012° Cel.				5023° Cel.				5034° Cel.				5045° Cel.				5056° Cel.				5067° Cel.				5078° Cel.				5089° Cel.				5100° Cel.				5111° Cel.				5122° Cel.				5133° Cel.				5144° Cel.				5155° Cel.				5166° Cel.				5177° Cel.				5188° Cel.				5199° Cel.				5210° Cel.				5221° Cel.				5232° Cel.				5243° Cel.				5254° Cel.				5265° Cel.				5276° Cel.				5287° Cel.				5298° Cel.				5309° Cel.				5320° Cel.				5331° Cel.				5342° Cel.				5353° Cel.				5364° Cel.				5375° Cel.				5386° Cel.				5397° Cel.				5408° Cel.				5419° Cel.				5430° Cel.				5441° Cel.				5452° Cel.				5463° Cel.				5474° Cel.				5485° Cel.				5496° Cel.				5507° Cel.				5518° Cel.				5529° Cel.				5540° Cel.				5551° Cel.				5562° Cel.				5573° Cel.				5584° Cel.				5595° Cel.				5606° Cel.				5617° Cel.				5628° Cel.				5639° Cel.				5650° Cel.				5661° Cel.				5672° Cel.				5683° Cel.				5694° Cel.				5705° Cel.				5716° Cel.				5727° Cel.				5738° Cel.				5749° Cel.				5760° Cel.				5771° Cel.				5782° Cel.				5793° Cel.				5804° Cel.				5815° Cel.				5826° Cel.				5837° Cel.				5848° Cel.				5859° Cel.				5870° Cel.				5881° Cel.				5892° Cel.				5903° Cel.				5914° Cel.				5925° Cel.				5936° Cel.				5947° Cel.				5958° Cel.				5969° Cel.				5980° Cel.				5991° Cel.				6002° Cel.				6013° Cel.				6024° Cel.				6035° Cel.				6046° Cel.				6057° Cel.				6068° Cel.				6079° Cel.				6090° Cel.				6101° Cel.				6112° Cel.				6123° Cel.				6134° Cel.				6145° Cel.				6156° Cel.				6167° Cel.				6178° Cel.				6189° Cel.				6200° Cel.				6211° Cel.				6222° Cel.				6233° Cel.				6244° Cel.				6255° Cel.				6266° Cel.				6277° Cel.				6288° Cel.				6299° Cel.				6310° Cel.				6321° Cel.				6332° Cel.				6343° Cel.				6354° Cel.				6365° Cel.				6376° Cel.				6387° Cel.				6398° Cel.				6409° Cel.				6420° Cel.				6431° Cel.				6442° Cel.				6453° Cel.				6464° Cel.				6475° Cel.				6486° Cel.				6497° Cel.				6508° Cel.				6519° Cel.				6530° Cel.				6541° Cel.				6552° Cel.				6563° Cel.				6574° Cel.				6585° Cel.				6596° Cel.				6607° Cel.				6618° Cel.				6629° Cel.				6640° Cel.				6651° Cel.				6662° Cel.				6673° Cel.				6684° Cel.				6695° Cel.				6706° Cel.				6717° Cel.				6728° Cel.				6739° Cel.				6750° Cel.				6761° Cel.				6772° Cel.				6783° Cel.				6794° Cel.				6805° Cel.				6816° Cel.				6827° Cel.				6838° Cel.				6849° Cel.				6860° Cel.				6871° Cel.				6882° Cel.				6893° Cel.				6904° Cel.				6915° Cel.				6926° Cel.				6937° Cel.				6948° Cel.				6959° Cel.				6970° Cel.				6981° Cel.				6992° Cel.				7003° Cel.				7014° Cel.				7025° Cel.				7036° Cel.				7047° Cel.				7058° Cel.				7069° Cel.				7080° Cel.				7091° Cel.				7102° Cel.				7113° Cel.				7124° Cel.				7135° Cel.				7146° Cel.				7157° Cel.				7168° Cel.				7179° Cel.				7190° Cel.				7201° Cel.				7212° Cel.				7223° Cel.				7234° Cel.				7245° Cel.				7256° Cel.				7267° Cel.				7278° Cel.				7289° Cel.				7300° Cel.				7311° Cel.				7322° Cel.				7333° Cel.				7344° Cel.				7355° Cel.				7366° Cel.				7377° Cel.				7388° Cel.				7399° Cel.				7410° Cel.				7421° Cel.				7432° Cel.				7443° Cel.				7454° Cel.				7465° Cel.				7476° Cel.				7487° Cel.				7498° Cel.				7509° Cel.				7520° Cel.				7531° Cel.				7542° Cel.				7553° Cel.				7564° Cel.				7575° Cel.				7586° Cel.				7597° Cel.				7608° Cel.				7619° Cel.				7630° Cel.				7641° Cel.				7652° Cel.				7663° Cel.				7674° Cel.				7685° Cel.				7696° Cel.				7707° Cel.				7718° Cel.				7729° Cel.				7740° Cel.				7751° Cel.				7762° Cel.				7773° Cel.				7784° Cel.				7795° Cel.				7806° Cel.				7817° Cel.				7828° Cel.				7839° Cel.				7850° Cel.				7861° Cel.				7872° Cel.				7883° Cel.				7894° Cel.				7905° Cel.				7916° Cel.				7927° Cel.				7938° Cel.				7949° Cel.				7960° Cel.				7971° Cel.				7982° Cel.				7993° Cel.				8004° Cel.				8015° Cel.				8026° Cel.				8037° Cel.				8048° Cel.				8059° Cel.				8070° Cel.				8081° Cel.				8092° Cel.				8103° Cel.				8114° Cel.				8125° Cel.				8136° Cel.				8147° Cel.				8158° Cel.				8169° Cel.				8180° Cel.				8191° Cel.				8202° Cel.				8213° Cel.				8224° Cel.				8235° Cel.				8246° Cel.				8257° Cel.				8268° Cel.				8279° Cel.				8290° Cel.				8301° Cel.				8312° Cel.				8323° Cel.				8334° Cel.				8345° Cel.				8356° Cel.				8367° Cel.				8378° Cel.				8389° Cel.				8400° Cel.				8411° Cel.				8422° Cel.				8433° Cel.				8444° Cel.				8455° Cel.				8466° Cel.				8477° Cel.				8488° Cel.				8499° Cel.				8510° Cel.				8521° Cel.				8532° Cel.				8543° Cel.				8554° Cel.				8565° Cel.				8576° Cel.				8587° Cel.				8598° Cel.				8609° Cel.				8620° Cel.				8631° Cel.				8642° Cel.				8653° Cel.				8664° Cel.				8675° Cel.				8686° Cel.				8697° Cel.				8708° Cel.				8719° Cel.				8730° Cel.				8741° Cel.				8752° Cel.				8763° Cel.				8774° Cel.				8785° Cel.				8796° Cel.				8807° Cel.				8818° Cel.				8829° Cel.				8840° Cel.				8851° Cel.				8862° Cel.				8873° Cel.				8884° Cel.				8895° Cel.				8906° Cel.				8917° Cel.				8928° Cel.				8939° Cel.				8950° Cel.				8961° Cel.				8972° Cel.				8983° Cel.				8994° Cel.				9005° Cel.				9016° Cel.				9027° Cel.				9038° Cel.				9049° Cel.				9060° Cel.				9071° Cel.				9082° Cel.				9093° Cel.				9104° Cel.				9115° Cel.				9126° Cel.				9137° Cel.				9148° Cel.				9159° Cel.				9170° Cel.				9181° Cel.				9192° Cel.				9203° Cel.				9214° Cel.				9225° Cel.				9236° Cel.				9247° Cel.				9258° Cel.				9269° Cel.				9280° Cel.				9291° Cel.				9302° Cel.				9313° Cel.				9324° Cel.				9335° Cel.				9346° Cel.				9357° Cel.				9368° Cel.				9379° Cel.				9390° Cel.				9401° Cel.				9412° Cel.			
-------------------------	-------------------	--------	----------	--	--	--	----------	--	--	--	----------	--	--	--	----------	--	--	--	----------	--	--	--	----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	-----------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--	------------	--	--	--

C O N F I D E N T I A L

TABLE 4

CONSISTENCY OF NAPALM FUELS PREPARED WITH 80 OCTANE GENERAL PURPOSE MOTOR GASOLINE

Gasoline Sample Number	Soap	4% Gela						24 hrs. @ 150°F.	8% Gela					
		Days @ 70°F.			Days @ 125°F.				Days @ 70°F.			Days @ 125°F.		
		2	16	32	2	16	32		6	16	32(a)	6	16	32(a)
24	McGean Harmon							690	660 715	745 735	760 715	635 630	715 660	670 610
25	McGean Harmon							470	790 625	645 615	680 600	620 580	510 555	660 460
26	McGean Harmon							650	765 610	715 620	745 650	645 615	- 620	725 670
27	McGean							685	710	685	690	755	780	875
28	McGean Harmon	155	110	104	90	70	50	670	700 705	710 695	685 680	755 700	780 685	875 835
29	McGean Harmon	135	95	85	80	50	50	670	680 690	635 665	620 660	710 660	725 620	750 530
30	McGean Harmon	150	105	100	90	50	35	690	720 705	715 690	785 665	- 660	690 630	630 595
31	McGean Harmon	140	135	130	125	80	75	730	730 705	815 695	785 695	730 740	- 745	915 750
32	McGean Harmon	120	110	110	90	70	80	700	735 750	730 720	740 710	770 700	725 -	850 705
33	McGean Harmon	80	80	65	55	40	50	685	730 680	715 645	730 680	735 610	745 730	1000 520
34	McGean Harmon	140	100	95	70	55	65	645	730 740	695 670	800 685	820 660	1280 710	1200 720
35	McGean Harmon	110	76	65	45	40	45	690	720 675	695 720	820 685	755 680	810 620	785 610

(a) Because of imperfectly sealed containers, evaporation occurred occasionally resulting in high consistency values.

Standard Oil Development Company
RLB:mmm - 6/30/44 - PDN 2575a

C O N F I D E N T I A L

REEL - C

1344

A.T.I.

3 1 5 1 5

CONFIDENTIAL

ATI-31515

TITLE: Effect of Thickener and Gasoline Quality on the Properties of Napalm Fuels

AUTHOR(S): Betts, R. L.

ORIGINATING AGENCY: Standard Oil Development Co.

PUBLISHED BY: Office of Scientific Research and Development, NDRC, Div 11

REVISION

(None)

ORIG. AGENCY NO.

(None)

PUBLISHING AGENCY NO.

OSRD-4522

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
Jan '45	Conf'd	U.S.	Eng.	34	tables, graphs

ABSTRACT:

An investigation was carried out to determine the quality of Napalm thickener and the effect of gasoline quality, moisture content of the soap, and thickener concentration on the properties of Napalm thickened fuels. The majority of thickeners received were of uniform quality, 70% giving 8% gels having consistencies between 600 and 750 grams Gardner. Cyclic hydrocarbons tended to give high consistencies while the paraffin, n-heptane, gave the lowest consistency values. The majority of Napalm thickener samples when employed at lowest consistency values, e.g., 4% by weight, yielded fuels which tended to decrease in consistency on aging. Considering the variation in thickener and gasoline qualities and the curing effect, the ratio of the maximum to minimum consistency values was found to be about 1.7:1 for fuels containing 12% of the thickener and 10:1 for low (4%) concentration fuels.

DISTRIBUTION: Copies of this report obtainable from Air Documents Division; Attn: MCIDXD

DIVISION: ~~Ordnance and Armament (22)~~SECTION: ~~Chemicals and Incendiaries (11)~~

SUBJECT HEADINGS: Fuels, Incendiary - Fortifying (42657);
Incendiaries - Physical properties (50961.5)

ATI SHEET NO.: C-22-11-64

Air Documents Division, Intelligence Department
Air Materiel Command

AIR TECHNICAL INDEX

CONFIDENTIAL

Wright-Patterson Air Force Base
Dayton, Ohio

CLASSIFICATION CANCELLED

Ⓡ By authority OSRD List #3,
Dated 2-11 January 1946
By *Wick Ligon*, USCO

18 P 19/1/1 1950

② * Incendiary Mixtures

Napalm Bombs
Fuel thickeners