FILM STUDY GROUP

REPORT

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Part III

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* ZWB - Zentrale Fur Wissenschaftliches Berichtswesen Uber Luftfahrt - (Office of Aviation Research Reports - Under DVLφ auspices)

** These subitem numbers are taken from the German Index.

φ DVL - Deutsche Versuchsanstalt Fur Luftfahrt - (German Aviation Research Institute)

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* FKFS - Forschungs Institut Fur Kraftfahrwesen Und Fahrzeugmotoren an der Technischen Hochschule Stuttgart - (Fuel and Engine Research Institute at Stuttgart Tech)

** FB - Forschungsbericht - Research Report, issued by ZWB.

ϕ PB - Pruefungsbericht - Test Report

ϕϕ UM - Untersuchungen Und Mitteilungen - Investigations and Communications, issued by ZWB

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* DVA - Druckversuchsanlage - Pressure Pilot Units

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U. S. Government Technical Oil Mission Microfilm Reel 52
(Original Identification Reel 20B)

Bag No. 3445 Target 30/5.01

Item 2 - Collected Reports of Deutsche Luftfahrtsforschung (with Index)

Subitem 24 - Report of 6-17-1941

Report on the Session on "Knock Behavior of Fuels" of June 16 and 17, at Berlin-Adlershof.

Pages 7-15*

(A) Fundamental Considerations About the Determination of Knock Behavior of Fuels
Dr. A. J. Phillipovitch, DVL

I. Purpose of Knock Behavior Testing

This is an introduction which briefly mentions the dual usefulness of knock rating studies in determining the suitability of a fuel for a given engine and in improving fuel quality.

II. Methods of Knock Rating Determinations

a. Chemico-Physical

A general discussion of the two types of physico-chemical properties of fuels, namely "integral" (constants such as specific gravity, molecular weight, refractive index) which are additive for fuel mixtures and "differential" (complex properties such as auto-ignitibility, ease of oxidation, etc.) where the special properties of a small component may affect the mixture appreciably.

Factors affecting behavior of the fuel in the engine are then considered, also subdivided into two groups, namely, those which produce the same effect in all engines (compression ratio, air temperature, coolant temperature, cylinder volume) and those which affect different engine types or individual engines differently (RPM, valve overlap, exhaust backpressure, construction of inlet and exhaust, fuel mixing).

Two methods of correlating fuel properties (ignition value (zuendwert) and ignition delay) to engine test values are mentioned: the "well known" method of Jentsch, and the method of Jost and Teichman of observing ignition delay in adiabatic compression by means of an observation window in a cylinder. This latter method is said to show some promise of satisfactory laboratory determination of knock behavior of fuels.

* These are the frame numbers which appear on the reel. Most frames contain two pages of the original document.

b. Engine Testing of Fuels

The difference in significance of engine tests for motor and aviation fuels is explained by the fact that knocking in the auto engine is easily remedied and therefore the knock rating may be allowed to represent a median value, whereas knocking in the aviation engine may lead to engine failure and therefore the rating should take into consideration the most unfavorable conditions under which the fuel may be used. This serves as introduction to:

c. Octane Number and Its Modifications

The CFR motor rating is discussed with respect to influence of carburetor setting, air-fuel ratio, and mixture temperature. It is not considered satisfactory, and a satisfactory modification is not expected.

d. Overload Rating

The degree of overload until knocking occurs is coming into general use as a test of motor performance. The remainder of the report presents a number of graphic correlations and discussions of the influence of various factors on this test. All tests are based on results obtained by DVL, on the BMW 132 motor.

e. General Factors Influencing the Overload Rating

These are compression, temperature, spark advance, and volume increase. Air:fuel ratio has the same effect, when using a single operating procedure, for different engines. Other special variables are more unpleasant in effect because they cannot be normalized. This goes particularly for revolution, exhaust back pressure, valve overlap, etc.

Fundamental changes in operating procedure, specifically partial fuel injection, cause fundamental changes in the results obtained and will have to be studied.

f. Standard Fuels

The factors to be considered in choosing a standard fuel are very briefly discussed.

Pages 16-18

(B) Physico-Chemical Considerations in the Determinations of Knock Ratings of Fuels - Dr. W. Jost, University Leipzig

I. Fundamental Considerations

Fundamentally there is no correlation between simple physical constants and knock rating of fuels. There is a possibility, however, of correlating general physico-chemical, particularly reaction kinetics, studies with knock ratings. This presupposes that

1. The knock process is completely understood.

2. The knock reaction can be determined experimentally for any fuel.

3. The variables affecting knocking can be evaluated for a given engine.

The current information available on these three points is discussed.

II. Practical Considerations

The status of work is discussed which has as its purpose the thorough study of all variables of an engine with two fundamentally different standard fuels and the possibility of applying such results to different engines.

The work is in its initial stages.

Pages 19-21

(C) Chemico Physical Significance of the Overload Behavior of Fuels - Dr. Hans Fromherz - I.G. Ludwigshafen

This report is a short survey of two studies in progress at I.G. Ludwigshafen, High Pressure Lab.

I. Theoretical Significance of Knock Limit Curves

To explain the characteristic knock limit curves theoretically, the basic consideration was used that the highest temperature attained in the unburned fuel in a cylinder is responsible for initiating the knock. This temperature varies with intake air temperature and air excess value in a manner which can be calculated from compression and combustion temperatures.

A series of knock limit curves was calculated for different air intake temperatures, for iso-octane and benzene. Good correlations with experimental results were obtained, in spite of some simplifying assumptions. No detailed discussion or data are presented.

II. Calculation of Knock Limit Curves of Fuels from the Octane Number of the Base Fuel (Restbenzin) and the Aromatic (or Naphthene) Content

This is a method currently in development. It permits calculating the maximum and minimum of knock limit curves to within 1 atm. of MEP, based on the addition of a standard knock limit curve for aromatics to an empirical correlation of the knock limit curve of the base fuel with its motor octane number.

Pages 21-30

(D) Knock Measurement by the DVL Overload Method - Dr. Seeber, DVL

I. Introduction

This briefly mentions the history of the DVL overload method of testing.

II. Limit of Error of Overload Curves

This section presents in detail some of the practical factors which must be watched if consistent results are to be obtained. Maintenance of engines, care in sample handling, magneto versus battery ignition, etc., are discussed. The limit of error is found to be ± 2 per cent of MEP for paraffinic and ± 4 per cent for aromatic fuels.

III. Reproducibility of Knock Limit Curves Using Identical Fuels on Different Engines

A number of co-operative tests are presented by means of graphs, and discussed. It is concluded that the above-mentioned limits of error should also be applicable to tests carried out at different locations or with different engines.

IV. Conclusions

This presents a number of conclusions, mostly specifically applicable to the DVL testing setup. Among other recommendations is one to the effect that fuel be leaded just before testing, or else that the TEL content be checked at the time of the test.

Pages 31-32

(E) Reproducibility of Results from the DVL Overload Test - Dr. H. Wenzel - Intava-Hamburg

A deviation in MEP of ± 10 per cent was found when retesting the same fuel over a period of two months.

Pages 33-38

(F) Reproducibility and Accuracy of the Overload Test
Dipl.-Ing. Witschakowski, IG

Results of tests at IG are given in some detail, together with a discussion of some of the possible causes of error.

It is concluded that agreement of results obtained on different engines is at present somewhat unsatisfactory, but fuels can be definitely evaluated if the same reference fuel is always used. It was found that, depending on the fuel, band-widths (i.e., maximum range of deviation of curves) up to 2 atm. may be found. To improve accuracy of results from different engines, more detailed instructions as to construction features, such as exhaust line and muffler, are recommended.

Pages 38-43

(G) Experiments with Liquid Cooled Cylinders - Dipl.-Ing. Penzig
Tech. Pruefstand Oppau. IG

As introduction some of the factors affecting reproducibility of overload test results are discussed. Since it is thought that the heat load of the cylinder, being very high in the larger engines, affects the results significantly, a series

of experiments were made at Oppau using two different liquid cooled engines and the standard air cooled one. The engines used were the BMW 132 (standard), DB 6001 (the one cylinder model of the DB 601), and a single cylinder Jumo 211. The conditions used were:

Compression Ratio	1:8
Intake Air Temperature	130° C.
Revolutions	n = 2000/Min.
Lube Out at	70° C.
Coolant Out at	80° C.
Exhaust Counterpressure	3-400 mm. H_2O at 1500 mm. Hg Intake Press.
Fuels Used	B_4, CV 2b, ET 100

There are several photographs of the engines, graphs of test results, and considerable discussion. The following facts or conclusions are mentioned:

It is shown that the liquid cooled engine produces more reproducible results.

Different engines evaluate fuels differently. The DB rated fuels, particularly aromatic ones, higher than the BMW. The Jumo gave lower ratings; this was largely corrected by improving the coolant circulation to the cylinder. High cylinder temperatures were presumably the cause.

Valve timing was another factor found to affect the ratings appreciably.

Several methods of observing knocking at a distance from the engine are discussed briefly.

Pages 44-46

(H) Knock Testing by Pressure Rise Indicators - H. Wende, DVL

The testing procedure is based on the exact basis of the pressure rise and fall in the cylinder, which is suitably determined by a quartz indicator. This diagram shows no great difference between knocking and non-knocking operation. In particular, the maximum pressures are not very different. By electrical differentiation of the pressure, i.e., recording dp/dt, the reading is more sensitive to knock, but still not sufficiently so. Even greater sensitivity is obtained by employing the second derivative d^2p/dt^2. In physical terms, the second derivative is a measure of degree of curvature. Since the degree of curvature of the indicator diagram peak is changed markedly between knocking and non-knocking operation, this shows up well in the second derivative diagram. This is illustrated on the film.

The novelty of the DVL process is the method of evaluation, in which not the peak-amplitudes at two engine settings are compared, but the first knocking is determined as a well-marked point in an operating curve. For this purpose, the peaks of d^2p/dt^2, which may be determined at any desired constant sensitivity, are

plotted as ordinates against an abscissa of any variable whose increase promotes knocking. All other factors affecting knocking must be held constant. The plot so obtained contains a marked break. This break has been found in all such tests run over a period of several years. The break indicates the point at which knocking begins. Intake pressure and compression ratio have been used as abscissa for the curves. In engines in which intake pressure or compression ratio are not easily varied, this method can still be applied by plotting the knock-amplitude versus fuel consumption. The knocking range is then marked by two breaks in the plot. This system of testing is also applicable to full scale engines. The Zeiss-Ikon-Knock tester is the preferred instrument for this testing method.

The last two pages of the paper are devoted to a description of the main features of the Zeiss-Ikon instrument.

Pages 47-48

(I) Knocking in Engines with Large Valve Overlap and in the DVL Process of Delayed Fuel Intake - Dr. P. Kornacker

A brief general discussion states that overload test curves are more favorable in engines with large valve overlap, particularly when using aromatic fuels. The second part states essentially the following: It is known that, for auto-ignition, a certain induction period is required which varies in an exponential relation with the temperature and with the pressure of the uncombusted gas in the combustion chamber. In addition, the knocking is affected by the mixture ratio. In the normal process of fuel intake during the suction stroke, the time required for auto-ignition is quickly attained with increased overload, and knocking takes place. To operate an engine with increasing overload without knocking, the fuel intake was modified so that only a small amount of fuel was injected during the suction stroke, with the consequence that there is only a slight tendency to knock because of the great air excess. The remainder of the fuel required to give the desired mixture was injected during the compression stroke, and some even in the power stroke; this reduces the combustion time below that required to initiate knocking.

Experiments in several engines indicated that the MEP before knocking can be raised 2-4 Kg/cm^2 (28-56 p.s.i.) particularly when using excess air. The overload curve is considerably flatter in this case than when using normal injection.

Pages 48-54

(J) Overload Tests in the NSU Motor of the Ruhrbenzin, A.G., Oberhausen, Holten - Dr. Fr. Schaub

This paper presents the development work of a small aviation test engine. Instead of the usual 20-30 l (5-8 gal.) of gasoline, this engine requires only 2-3 l (less than 1 gal.), thus permitting tests on laboratory prepared synthetic fuels.

The engine is a modified NSU 501 OSL engine. This is an air-cooled four-stroke motorcycle engine with 80 mm. bore and 99 mm. stroke. Air intake is through a filter and gas meter; the air is compressed and passes through an oil separator

and electric heater to the engine. Intake air pressure and air volume are regulated by a by-pass valve between compressor suction and outlet. Fuel is injected into the intake line, in contrast to the BMW-B2 single cylinder (standard test engine), where it is injected directly into the cylinder.

The remainder of the report discusses in some detail part of the development work on this engine, and the performance in absolute terms and compared with the standard DVL engine.

Pages 54-58

(K) Fuel Evaluation in a Small Single Cylinder Engine Ing. Singer, I.G. Ludwigshafen, Technischer Pruefstand

The "Oppau procedure" of knock testing is explained and discussed. This is a testing method at conditions intermediate between Motor and Research method.

The test engine is an "IG Motor" with the following modifications:

(1) Addition of an air tank with gas meter and air regulator to permit use of plant compressed air.

(2) Addition of a pressure tight carburetor with measuring bulb for fuel measurement.

(3) Knock indication by means of a quartz box.

(4) Use of spark plug with higher "Gluehwert."

(5) Calibration of the octane dial to correspond to the new condition.

(6) Installation of the necessary thermometers and manometers.

The following changes were made from the normal IG Motor conditions.

(1) RPM = 600 (as in RM (research method?))

(2) Preignition = 22° (unchanged)

(3) Cooling temperature = 100° C. (as in RM)

(4) Mixture temperature = 125° C.

(5) Intake pressure = 1000 mm. Hg

(6) Carburetor setting: changeable from $\lambda = 0.7$ to 1.2 (λ = air excess)

The test method is as follows:

The compression ratio is changed until there is slight knocking, so that the pointer of the knock indicator reaches 50. The carburetor is set for maximum knocking, i.e., approx. $\lambda = 1$. The knock rating of the sample can then be read from the octane dial. To determine the air:fuel ratio the air consumption is measured.

A richer mixture is then fed. The compression ratio is changed until the knock meter again reads 50, and the second octane number is read on the dial. Air: fuel ratio is again determined.

Six to eight octane numbers are so determined between $\lambda = 0.7$ and 1.2. They are plotted as an overload test curve. Such a test takes about $\frac{3}{4}$ hour. About 500 cc. of fuel is required. Accuracy is about ± 1 octane number. Research and Motor method tests can be run on the same installation by modifying conditions.

The remainder of the paper discusses in detail the accuracy of the method, the factors influencing it, and the comparability with the BMW 132 engine.

Pages 58-59

(L) Reference Fuels - Dr. A. v. Phillipovitch, DVL

The qualities desired in reference fuels for various engine tests are very briefly discussed in generalities.

Pages 59-60

(M) Temperature Sensitivity of Reference Fuels in Octane Number Testing
Dipl. Ing. Knaffl, OLEX, Berlin-Rummelsburg

It is shown that variation of the fuel-air mixture preheat causes a considerable change in the octane rating of an aromatic fuel rated against a paraffinic reference fuel, whereas the change is much slighter when it is rated against pure benzene. When rating a paraffinic fuel against a paraffinic reference and against benzene the change in ratings with preheat was practically identical for both reference fuels. The significance of these data is challenged in the discussion section of the report.

Page 60

(N) Application of the Overload Test to Lube Testing
Dr. A. v. Phillipovitch, DVL

Previous work of DVL and other sources indicates that changes in the lube oil are mainly a function of engine temperature. Therefore a rich mixture operation would essentially correspond to operation at higher temperature. Until other data are available there is no need to consider rich mixture testing of lube oils.

Pages 65-66

(O) Chemical Characteristics of Practical Storage
Dr. A. v. Phillipovitch, DVL

A very general discussion of factors considered in planning some DVL storage stability tests. It is concluded that all that can be finally said of a gasoline is that it will be probably stable only under favorable storage conditions or probably stable also under unfavorable ones.

Pages 67-73

(P) Formation of Heavy Material During Storage of Aviation Fuels - Dr. I. Morghen, DVL

Main purpose of the paper is to review the status of laboratory testing for storage stability of leaded fuels. The decomposition of TEL due to oxidation is briefly discussed. In a nitrogen atmosphere, TEL in gasoline was not broken down when kept 5 hours at 180° C.

The "bomb-test" for storage stability, which was developed for unleaded fuels, is also being used for leaded ones, but is considered unsatisfactory. Theoretically, the most desirable test would be one which permits observation of the various breakdown processes (oxidation, polymerization, condensation) separately, but no such test is likely to be devised in the near future. An experimental study is in progress of a stability test using an oxidizing agent similar to oxygen which is not influenced by natural inhibitors.

A detailed analysis is made of a series of co-operative "bomb-tests" carried out by several laboratories. It is concluded that (1) a difference in age of even a few days, of two identically leaded fuels, can change the results significantly; (2) this difference is easily increased by transportation; (3) the evaporation step of the test can influence the results markedly, and the storage temperature also exerts some influence.

Seven suggestions are given to make the DVL bomb-test more reproducible.

Pages 73-76

(Q) Storage of Fuels - Dr. H. Velde, Ruhrbenzin, A.G.

This paper reports experiences in storage of synthesis products and cracked products.

A series of storage tests were made of the following: primary synthesis product, cracked gasolines made from the lighter synthesis products, and mixtures of the two. Of these, samples were stored as is, and with 0.2 g/l of cresol, 11.5 volume per cent fuel alcohol (Treibstoffsprit), and 0.5 cc./l of TEL. The samples were stored in galvanized and plain iron barrels. They were examined after two years' storage. The following observations were made:

(1) Change in Octane Number

Octane numbers had dropped considerably, that of primary synthesis gasoline from 58 to about 40, that of cracked gasoline from 66 to about 43. The cresol inhibitor prevented this drop almost completely. The alcohol prevented octane number loss of the primary gasolines and held that of cracked gasoline to about 4-6 units. Surprisingly, the TEL addition prevented octane number decrease for both primary synthesis (72 O.N.) and cracked gasoline (80 O.N.), but only for the samples stored in galvanized barrels. Those stored in iron barrels lost 7 (synthesis) and 12 (cracked) octane units.

The octane number loss is mainly caused by considerable peroxide formation (reference: Schildwaechter in Brennstoffchemie, 1938; peroxide content of 700 reduces the octane number 11 points). Increase in active oxygen: primary gasoline 600-700 mg/l; cracked gasoline - 1000-1400 mg/l; primary gasoline plus inhibitor - <10 mg/l. The effect of inhibitor is not so pronounced in case of the cracked gasoline, but increases are held to 30-60 mg/l in cresol inhibited samples, and as little as 10 to 20 where cresol and alcohol were added.

(2) Resin Content

Two tests were used: The evaporation test (Abblasetest) and the bomb-test with seven atmospheres O_2 at 70° C.

Primary synthesis gasoline remained entirely stable, as indicated by maximum evaporation tests of 6 mg/100 cc. and bomb tests of 7 mg. The induction times are in all cases over 4 hours, indicating that the peroxides do not cause gum formation although they do affect the octane number. The gasoline remained water white. The uninhibited cracked gasoline gave evaporation tests up to 385 mg. and induction times of 100-120 minutes. The inhibited samples gave favorable results. Of the leaded samples, only those stored in galvanized barrels remained stable.

Pages 76-77

(R) Storage Stability of Fuels - Dipl.-Ing. Wallner, Testing Station Travemünde

Storage tests were carried out on the following:

(1) Aviation fuels

(2) Cat. cracked gasoline alone and blended in aviation benzene.

(3) Czech aviation gasoline and its blends with Czech aviation benzene, TEL, and iron carbonyl.

The samples were stored in 30-l. storage containers, not painted inside, and provided with a breather pipe protected by silica gel. Storage was over a period of two years with summary tests every 3 months.

The following was concluded:

All unleaded fuels and leaded fuels with low aromatic content store well. Leaded highly aromatic fuels are unstable but no strict correlation could be made between aromaticity and stability. Stability decreases as lead content increases. Out of sixteen storage tests, only three correlated well with result of an aging "bomb test" on the fresh fuel. The bomb test is therefore considered unreliable and more data will be collected in an attempt to confirm this.

Pages 77-78

(S) Inhibitors - Dr. I. Morghen, DVL

Good results obtained with two unnamed inhibitors recommended by DVL are briefly presented.

Pages 78-80

(T) Experiences with Aromatics Tests and Iodine Numbers - Dr. H. Velde, Ruhrbenzin AG, Oberhausen-Holten

The aromatics test discussed here is the chemical determination by means of the difference between amount soluble in Kattwinkel reagent ("aromatics plus olefins") and in 90 per cent H_2SO_4 (olefins). This method is not considered very reliable, and some suggestions are made for improvement. It is finally recommended that determinations be made only on narrow cut fractions, where physical data can also be used. The merits of several iodine number methods are also discussed.

Pages 80-82

(U) Aromatics Determination According to the "Bauvorschriften Fur Flugmotoren (BVM) 1940 - Dr. Mayer - Bugstroem, DVL

This very briefly discusses the accuracy of aromatics determination by the old DVL method using H_2SO_4 and the new BVM method, using Kattwinkel reagent. Tables of comparative results are given.

Pages 82-83

(V) Aromatics and Olefin Determination in Gasoline, According to the "Bauvorschriften 1940" - Dr. W. Hirschberger, IG

A number of instances of very misleading olefin determinations by the Kattwinkel method are given. It is concluded that the method as specified is decidedly unsatisfactory and that some doubt remains as to its accuracy or reproducibility even if very detailed instructions are given for carrying out the test.

Pages 84-87

(W) Aromatics Content of Gasolines by the Anilin Point Method - Dr. W. Hirschberger, I.G.

The anilin point method is an old one (Journ. Soc. Chem. Ind. 40, 20 (1921) Tizzard and Marshall) but is not widely used. It is in use at IG, mainly for hydrogenation product gasolines of 40-165° C. boiling range with 30-50 per cent below 100° C. It is specially suitable for plant control.

The development of the aniline point method into a practical tool for aromatics determination is described in detail and several calibration graphs and formulas are given.

Pages 88-93

(X) FKFS - Rapid Determination of Lead in Aviation Fuels - Dr. O. Widmaier, FKFS Stuttgart, Untertuerkheim

Two different methods of TEL determination are given in detail and another is mentioned in passing. The last is a rapid method developed at "Institut Kamm" by Dipl.-Ing. Gross, in which the lead content of fuels is determined quickly and accurately by X-ray absorption.

Rapid Method No. 1:

Time Required for Determination: 15 minutes. Six fuels can be analyzed within ½ hour.

Equipment: 1 microburette, 1 pipette, 3 flasks, 1 graduated cylinder, 1 iodine number flask

Method: 25 cc. of sample are shaken 5 to 10 minutes (5 for low lead content, 10 for high) with 5 cc. of 0.1 N alcoholic iodine solution in a 100 cc. iodine number flask. The excess iodine is back titrated with 0.1 N sodium thiosulfate solution. The iodine solution is prepared by shaking 1 liter of 98 per cent ethyl alcohol and 12.7 grams iodine for ½ hour and decanting from the undissolved potassium iodide.

The lead tetraethyl content in volume per cent is calculated by multiplying the volume of 0.1 N alcoholic iodine solution consumed by 0.0391.

The ethyl alcohol solution of iodine was decided upon after experiments with aqueous and various organic solutions. It attacks the base fuel only when high concentrations of olefins are present, this being of no practical importance in the case of aviation fuels. The maximum error is 3 to 4 per cent, which is insignificant for a plant test method. Tables presenting the accuracy of analysis are given on the film.

The iodine method presents difficulties in cases of high olefin or peroxide content. The following method was therefore developed for such cases:

Method No. 2

In a 30 cc. Erlenmeyer flask provided with reflux condenser, 10 cc. of fuel and 5 cc. of 20 per cent trichloroacetic acid are heated 5 minutes. The Erlenmeyer flask has a ground glass top, by means of which it is then placed on a separatory funnel which is briefly vented by means of the stopcock, and then shaken briefly. The Erlenmeyer flask is removed, and the trichloroacetic acid layer, which contains the lead, is run off into a 100 cc. wide neck Erlenmeyer or beaker. The solution is evaporated to dryness. The flask is kept in motion to prevent spattering. The trichloroacetic acid fumes are removed by mild blowing. Several drops of ammonium hydroxide are added to the residuum to neutralize any trichloroacetic acid which might remain. A maximum of 3 cc. of 5 per cent acetic acid and some sodium acetate are added and the solution brought to a boil. Lead is precipitated from the solution as lead chromate by the addition of potassium dichromate. The solution is boiled once more, cooled quickly, and filtered through a fritted glass filter into a 250 cc. suction flask. There 0.2 g. KI and 5 cc. analytically pure HCl are added and the solution is back titrated with 0.05 N sodium thiosulfate.

The volume of potassium dichromate consumed, multiplied by 0.0324, equals the volume per cent of lead tetraethyl.

Data are presented indicating the accuracy of the method. The time required is ½ hour. Accuracy for all gasolines tested at that time is 1-2 per cent.

Pages 97-117

(8) FB-912 2-16-1938

Determining the Thermal Stability of Various Aviation Lubricating Oils

Scope: A study of the thermally caused changes (observed in a nitrogen atmosphere) of several natural and synthetic lubricating oils.

The first 12 pages of the report present a review of the literature about the importance of thermal stability, the possible processes causing breakdown (cracking; effect of paraffins, olefins and tertiary carbon atoms; oxidation as a secondary reaction), and previous work in the field. Thirty-four literature references are discussed.

Original Work

The heat stability of an oil consists of two important components, namely (a) resistance to thermal decomposition and (b) resistance against thickening (considering also the volatility). The test temperature is of greatest importance. At lower temperatures, more cracked fragments of medium size are formed. At higher temperatures, liquid products and gas are formed in the absence of air, high molecular products and coke in the presence of air. Time is also an important variable. Only one time and temperature were used in all experiments. Eleven aviation oils from various sources were tested.

Apparatus: The test apparatus is shown in Figure 1 on the film. It consists essentially of a 500 cc. round bottom flask whose 330 mm. long neck acts as reflux condenser. The top is connected to a receiver. Nitrogen is introduced into the flask through a side-neck.

Test Procedure: 150 g. of oil is heated in ½ hour to 300° C. while a nitrogen stream is passed through the flask. The "reaction temperature" of 400° C. ± 5° is attained within another half hour. Total reaction time is 6 hours, inclusive of heating time. After 6 hours, the flask is cooled, the oil weighed, and losses so determined. Any gas formed during the run is received and measured. Tests made on the fresh oil and reaction products are the usual ones such as gravity, viscosity, refraction, acid and saponification number, and Conradson and Ramsbottom coke, molecular weight, and bromine number according to McIlhiney. This method is given in detail in the report.

Results: The changes in all the above properties are tabulated and also presented in a number of graphs. The property changing most significantly is the Engler viscosity at 50° C. (the only one determined). No. 6, a naphthene base oil was the most favorable case, giving a 45 per cent drop, from 21.9 to 11.9. The synthetic oils No. 7, 8, 9, and 10 showed viscosity losses up to 80 per cent, but synthetic oil No. 11, with 60 per cent loss, was in the league of the paraffinic oils. The loss in molecular weight correlated fairly well with viscosity loss, especially for synthetic oils. No correlation of bromine number and viscosity loss could be determined.

The report concludes that the viscosity change, bromine number, and molecular weight are the properties, among those examined, which permit the best conclusions about thermal behavior of lubricants. Of the oils tested, the synthetic oils are thermally inferior to the mineral oils in spite of the synthetics' good aging stability. It was shown, however, that engine performance does not correlate with these thermal tests, so that the synthetic oils actually showed a better engine rating. It may be concluded that the thermal decomposition products of the synthetic oils oxidize to form compounds more favorable to engine performance than the corresponding products from mineral oils. The greatest thermal stability was shown by a naphthene base lube oil, paraffin base being medium and synthetic least stable. Unfortunately the report nowhere states what particular oils were tested, other than tabulating their inspections.

Pages 118-132

(1) PB-384 4-20-1936
Aviation Engine Testing of a New Diesel Fuel

A detailed discussion of the types of reports issued by ZWB (Zentrale für Wissenschaftliches Berichtswesen Über Luftfahrt (a subdivision of DVL)) and of their secrecy regulations precedes this report. Twelve institutes issuing reports through the ZWB are enumerated.

The report itself presents the test data on a Diesel fuel of which the inspections are given but which is not identified other than as a diesel fuel developed by Ruhrchemie and received under number 379/35. The fuel had a cetane number of 140-150 and generally excellent performance characteristics.

Pages 133-150

(35) FB-1697 12-16-1942.
Peroxide Analysis and Influence of Peroxides on Engine Performance

A fairly brief literature survey is given of the effect of peroxides on engine performance. Experimental data on octane number lowering caused by five different peroxides (dioxyethyl peroxide, acetone peroxide, benzoyl peroxide, dibenzaldi peroxide and tetralin peroxide) are given very briefly. It was concluded that particularly the aliphatic peroxides lower the octane number.

The main part of the report is concerned with analysis of peroxides. Two methods were decided upon for use:

(a) The stannous chloride method.

This method is reported by Y. R. Narves, Parfumes de France 10, 225 (1932) and an improved modification by Hock and Schrader, Brennstoffchemie 18, 6 (1937). The method is given on the film in detail, and reported as mainly useful in the analysis of pure peroxides. For fuels, this method gives values considerably lower than the thiocyanate method.

(b) The thiocyanate method.

This method is based on the equation $3Fe(SCN)_2 + O_2 \rightarrow 2Fe(SCN)_3 + FeO$. The ferrithiocyanate 30 formed is titrated with titanium trichloride. This method is reported by Joule and Wilson, Ind. Eng. Chem. 35, 1254 (1931). It was tested extensively and the following modification found most useful:

10 cc. of the fuel to be analyzed is placed in a flask with 50 cc. of a 1:1 alcohol-water solution containing 5 g. ferrous sulfate, 5 g. ammonium thiocyanate, and 5 cc. conc. H_2SO_4 per liter. The mixture is boiled one minute with reflux. The solution is titrated with 0.0100 N titanium trichloride. The cc. of titanium trichloride solution indicates the peroxide number of mg. equivalents of active oxygen per liter of fuel.

It is further suggested that correction curves as proposed by previous authors be abolished, and that, instead, each fuel be diluted to give a peroxide number of 1 to 1.5, since the method is most accurate in that range.

It is noted that the use of alcohol rather than the acetone used by previous investigators helps to make the method much more accurate and reliable.

(Considerably more detail plus numerous graphs and tables on the film.)

Pages 151-172

(33) UM-695 10-20-1942
Measurement of Piston Temperature in the Running Engine W. Glaser

This paper reports on attempts to adapt methods developed in the U. S. to German practice. The U. S. references are:

P. F. Keyser and E. F. Miller, J. Inst. Pet. Tech. 25, 771-78, (1939)

Power Plant Engineering, 44, 90-92, (May, 1940)

Automotive Industries, 6/15/40, p. 572-74

Pages 173-192

(16) UM-523/5 6-12-1939
Influence of Engine Construction and Operating Conditions on the Knock Tendency of Fuels - 5th Partial Report: Experiments on the BMW VI - Single Cylinder Motor, Series 9, with Carburetor

This is a report on one of a series of studies of two fuels (87 and 100 octane number) in different engines to determine the effect of engine construction and operating conditions on fuel performance. The engine used is described in detail and a number of fuel performance graphs are presented correlating fuel performance with engine variables.

Pages 193-200

(15) UM-574 4-18-1939
Lube Testing in the BMW 132F Single Cylinder Engine, H. Schoekel

This paper presents some work done to adapt the BMW 132 single cylinder engine to a new cylinder of higher compression ratio and better heat conductivity. Evidently the lube testing procedure consists of determining the time required for ring sticking to occur. More severe conditions were required with the new cylinder. Curves and tables are included.

Pages 201-208

(14) UM-573 4-18-1939
Development of a Lube-Fuel-Mixture Performance Test in the NSU Engine, H. Schoekel

In 1939, two DVL lube testing methods were in existence. Tests in the BMW 132 Single Cylinder engine are time-consuming and expensive but accurate. Those in the Siemens-lube testing engine are not very reproducible and furthermore do not permit determining differences of long-time behavior of fuels. Therefore a testing method was developed using a small motorcycle engine. The development of this test is reported. Graphs and tables are included.

Pages 209-213

(13) UM-552
Investigation of Ring Sticking in the Siemens Lube Testing Engine Using Light Metal Pistons, H. Schoekel

Tests were carried out to determine whether it is necessary to replace the cast iron pistons of the Siemens test engine with aluminum ones, since aviation engines use aluminum pistons. It is concluded that the Siemens engine with aluminum pistons operating under modified conditions gives the same run lengths as it does with cast iron pistons. Since results on oils run in the BMW single cylinder engine at entirely different operating conditions check those from the Siemens engine, temperature measurements were made on the three pistons. In spite of the different conditions, all three pistons were at the same temperature. This is said to prove that ring sticking depends only on the temperature near the ring and not on the piston material.

Pages 214-230

(23) FB-1382 4-18-1941
Testing of Laboratory Methods for Determining Lead Content of Fuels, O. Widmaier

This paper presents a critical evaluation of eight different methods of determining the tetraethyl lead content of fuels. The tests were carried out on ten different fuels. The instructions for carrying out each determination are

presented, as well as a discussion of the results obtained with each method. The following methods were used:

1. Chromate Process of Edger and Calingaert*

The lead is precipitated from the fuel as lead bromide by means of a carbon tetrachloride solution of bromine. The lead is dissolved by means of nitric acid, reprecipitated as chromate, and determined gravimetrically. (Detailed instructions on the film)

2. Hydrochloric Acid Method According to Calingaert and Gambrill**

This method is identical with the ASTM method in which the gasoline is refluxed one half hour with hydrochloric acid and the lead determined gravimetrically as lead chromate.

3. Sulfate Method According to Ulrich***

100 cc. of fuel at 20° C. are placed in a 250 cc. separatory funnel and shaken vigorously one half hour with 10 cc. of a 10 per cent solution of bromine in carbon tetrachloride. 5 cc. of 65 per cent nitric acid are added and the mixture shaken until the lead bromide precipitate is completely dissolved. The mixture is permitted to settle and the nitric acid layer run off into a previously heated 50 cc. porcelain crucible. The gasoline in the separatory funnel is washed twice more with 5 cc. of 10 per cent nitric acid and the washings added to the crucible. The crucible contents are evaporated nearly to dryness over a steam bath and then carefully heated with a burner until no more HCl vapors come off. The crucible is ignited until the organic residue is completely burned. Since part of the lead sulfate may be reduced to metal in this operation, the salt is wetted with dilute nitric acid, evaporated to dryness, and then two drops of concentrated sulfuric acid is added and the crucible heated over an open flame until no more sulfuric acid fumes are absorbed. The crucible is then ignited not too strongly, placed in a desiccator until cool and weighed.

To convert the result to volume per cent tetraethyl lead in the fuel, the weight of lead sulfate is multiplied by 0.6427.

4. FKFS Chromate Process Method

This method was unpublished at the date of this paper.

100 cc. of gasoline is shaken with an excess of 30 per cent solution of bromine in carbon tetrachloride and then treated with two 20 cc. portions and one 30 cc. portion of hot 10 per cent nitric acid in a separatory funnel. One cc. of concentrated nitric acid is added to the acid solution which is then boiled 15 minutes, neutralized with concentrated ammonia, treated with 1 cc. of acetic acid and then with 40 cc. of 5 per cent potassium dichromate while near boiling. After

* Edger and Calingaert, Ind. Eng. Chem. Anal. Ed. 1, 321 (1929)
** Oel Und Kohle, 15, 782
*** W. Ulrich Oel Und Kohle 14, 131 (1938)

a short boil, the mixture is filtered through a porcelain filter crucible and washed with hot water. The precipitate is dried one half hour at 110° C., cooled in the desiccator, and weighed.

5. Chromate Titration Method

This method refers to the chromate method of Edger and Calingaert. The lead chromate is precipitated from the lead solution in a slightly different manner, namely, by using 25 cc. of 0.1N potassium dichromate and a small amount of sodium acetate instead of the 5 per cent potassium dichromate solution. The lead chromate precipitant is removed by a fritted glass filter and 1.5 g. of KI and 5 cc. concentrated hydrochloric acid are added to the filtrate which is back titrated with 0.1N soidum thiosulfate.

The volume of potassium dichromate solution in cc. multiplied by 0.00648, gives the volume per cent of lead tetraethyl in the original 100 cc. sample.

6. DVL - Dithizon - Titration Method

This method is presented in detail in FB-1292 "An Exact Rapid Method for Lead Analysis of Fuels" on pages 455-465 TOM Reel No. 52 and is therefore not repeated here.

7. FKFS Chromate Titration Process

This method refers to the FKFS chromate method (Item 4). The lead is precipitated with 25 cc. 0.1N potassium dichromate rather than with the 5 per cent potassium dichromate solution. 1.5 g. KI and 5 cc. concentrated nitric acid are added to the filtrate which is then back-titrated with 0.1N sodium thiosulfate. The calculation is made as in Item 5.

8. FKFS Iodine Method

This method is reported in ZWB research reports FB-1194 and FB-1252 which are not on this reel; it is also given, with improvements, in FB-1859 on pages 437-445 (see translation) and is therefore not repeated here.

Experimental Work

Ten different fuels were tested at 3 different TEL concentrations (0.0326, 0.0653, and 0.1206 volume per cent TEL) by the above eight methods.

One fuel was paraffinic, one olefinic, one naphthenic, and one aromatic, and the others were intermediate. The fuels are discussed in detail in the report and their inspections given in a table.

Experimental Results

The tables included with this report which show the detailed results indicate that all eight methods are satisfactory. Best results are consistently obtained on paraffinic fuels. Aromatics do not interfere with lead determination. Olefins, however, interfere with all of the tests. Therefore the two olefinic fuels were not included in the determination of limits of error.

The results obtained with each method are discussed. In the summary special attention is given to the DVL dithizone and the FKFS iodine method. There seems to be a certain amount of difficulty possible in the dithizone method because of varying crystal structure of the sulfuryl chloride precipitated dichloroethyl lead. The FKFS iodine process (an improved version of which is reported in the later FB-1859 on Reel 52) is very satisfactory with a maximum deviation of -0.5 to +1.2 per cent and a testing time of only 10 minutes. The other methods are also satisfactory but more time consuming.

Pages 231-253

(17) FB-1077 7-12-1938
Chemistry of Formation of Residua in Hydrocarbon Oils (Partial Report)

This report presents work done to determine the type and quantity of oxygenated hydrocarbons in aged or oxidized oils, specifically in lubricating oils.

The methods used are the traditional saponification and acid number, plus a modification of the method of Verley-Boelsing (Ber. 34, 3554 (1901)) (acylation in the presence of pyridine and back-titration of the unused acylating agent), determination of active hydrogen according to Tschugaeff and Zerewitinoff, plus several others. The analytical workup is discussed at very great length.

It is concluded that, regardless of the character of the oil (mineral or synthetic), the following takes place upon "aging":

(1) Free hydroxyl groups in the order of magnitude indicated by the regular "saponification number"; and

(2) "Neutral" oxygen compounds, very probably ketones, in the order of magnitude of twice the hydroxyl number

are formed, so that the oxygen content of the oil by the method of this report amounts to three times that usually determined by means of the saponification number.

Pages 254-271

(26) FB-1442 7-20-1941
Thermoelectric Method for Comparative Friction Testing of Lubricants in Boundary Lubrication, V. Vieweg, J. Kluge, F. Maske

This report describes in detail the development of an instrument and method for comparative friction tests of lubricants in boundary lubrication. The development was carried out by the Physikalisch-Technische Reichsanstalt (PTR).

The principle of the method is the fact that two metals in boundary lubrication form a thermocouple and the measurement of the thermoelectric potential gives a measure of the degree of heating, which is in some proportionality to the effectiveness of the lubricant in suppressing friction. Contact between metals in boundary lubrication is sufficient to provide good conductance.

The equipment consists essentially of a flat resolving disk upon which a small rod or pin is pressed with a controllable force. The disk and pin are made of the pair of substances whose friction is to be determined with various lubricants. Two operating methods are proposed: When two metals are being tested, the direct thermoelectric method is used in which the two metals in contact form the thermocouple with which the boundary temperature is read. When one substance is a nonmetal, the indirect thermoelectric method is used, in which the pin is made of the metal and its temperature measured by thermocouples at two spots along its length. The temperature distribution along the pin can be used to calculate the boundary temperature.

Attention is given to the method of polishing the disc, an important factor for reproducible results. Synthetic corundum in petroleum was used. The final surface roughness was below $1/\mu$.

The apparatus is shown on the film in a dimensionless drawing, and its construction discussed in the text.

A number of experimental results are discussed and some graphs of boundary temperature records shown.

It is concluded that the instrument is very satisfactory for measuring relative lubricating ability in boundary lubrication. A quantitative measurement of friction coefficient cannot be made but is being worked on (see UM-726, Pp. 446-455 on TOM Reel 52). Advantages of the instrument are said to be that it is simple, free of inertia (if different lubricants are used on separate sectors of one plate simultaneously, different temperature levels are reached in a matter of seconds), and that the boundary temperature increases only a few degrees at most, so that experiments can be carried out at various controlled temperatures.

Pages 272-285

(27) FB-1500 11-19-1941
Proof and Analysis of Decomposition Products of Tetraethyl Lead in Fuels - I. Morghen

This report presents a method of proving the presence of various TEL decomposition products in naturally or synthetically aged gasolines and a procedure for the quantitative determination of triethyl lead compounds in the presence of diethyl lead and divalent lead compounds. A method for the direct determination of the titer of dithizon solution is given as a supplement to FB-1292 (Pp. 456-465, Reel 52).

It was shown that, both in natural and synthetic aging, the lead sediment (Bleischlamm) consists only to a very minor extent of lead (2) compounds, and that the fuel contains partially oxidized TEL in solution. In the lead sediment, diethyl lead compounds predominate (in the report, "triethyl" and "diethyl" lead compounds refer to tri- or divalent lead with one or two "free valences," respectively), while triethyl lead compounds predominate in solution. These materials are largely present as salts of CO_2 and of the acids present in the fuel. Their solubility in the gasoline decreases rapidly in the order: triethyl, diethyl, and divalent lead compounds.

All tetraethyl lead compounds are ionizable in water. Diphenylthiocarbozone (dithizone) was used for their analysis. The method is similar to that reported for TEL in FB-1292. The three types of TEL decomposition products are determined titrimetrically on the basis of their forming different colored compounds with dithizone. The experimental work and method are described in great detail.

Pages 286-297

(9) UM-518 3-21-1938
Constitution and Properties of Lubricating Oils and Their Changes by Oxidation - O. Selter

This report is mainly devoted to the application of the specific refraction method of Vlugter, Waterman, and Van Westen - J. Inst. Pet. Tech., 21, 661, 707 (1935) and the molecular refraction, to the determination of the hydrocarbon type composition of lube oils. An attempt to check the method by means of reported data on a large number of synthetic hydrocarbons prepared by Mikeska - Ind. Eng. Chem., 28, 970 (1936) was unsuccessful. It is speculated that possibly a wave length other than the D-line was used to determine the refractive indices reported by Mikeska.

The experimental part consisted of determining the composition of four oils - two paraffin base, one naphthene base, and one "fixed" - and again determining the composition after the oils were severely oxidized and the oxidation products removed. The only definite conclusion is that the aromatics content of all oils is decreased by oxidation. It was also found that removal of oxidation products made the oil much more unstable to further oxidation.

The compositions determined for the "paraffinic" and "naphthenic" oils are of interest because of the comparatively small difference in paraffin content.

Oils	Aero H (Paraffinic)	Deropol (Naphthenic)
Paraffins	73.0	67.5
Naphthenes	15.0	25.5
Aromatics	12.0	7.0

Pages 298-311

(36) FB-1815 6-19-1943
FKFS Process for Determining Bromine Content of Aviation Fuels

In general, ethylene bromide is contained in the TEL fluid added to gasolines. It serves to prevent lead sediments in the engine by causing formation, during combustion, of the more volatile lead bromide rather than lead oxide. Since ethylene bromide freezes at +8° C., it has some tendency to settle out of fuel at low temperatures and thus cause lead-oxide trouble in the engine. Therefore, a quick, accurate method of analyzing fuels for bromine content was desired.

The report reviews a number of established methods of bromine analysis which might be applicable to this problem. Several methods were tried, and the method of treating the gasoline in a bomb at 200° C. with potassium alcoholate was finally adopted as most satisfactory.

Method: The bomb used is shown in a working drawing on the film. It is a cylindrical metal container 14.5 cm. long, 4.8 cm. O.D., 4 mm. wall thickness, with a tightly fitting screwed top and a removable inside lining of glass. The test procedure is as follows: 50 cc. of fuel are placed in the bomb liner, 1 cc. of concentrated potassium ethylate* is added, and the bomb is closed and heated for 30 minutes at 200° C. The solution is cooled and washed into a 300 cc. Erlenmeyer flask, using about 100 cc. of water, and acidified with nitric acid.

The potassium bromide in the solution is precipitated with excess 0.10 N silver nitrate, and the excess of silver nitrate back titrated with 0.1 N ammonium thiocyanate, using ferric ammonium sulfate as indicator. Multiplying the volume of 0.10 N silver nitrate solution used by 0.01878 gives the weight per cent ethylene bromide in the fuel; a factor of 0.01598 gives the weight per cent bromine.

"Resin"-containing and olefinic fuels are pretreated by shaking 80 cc. of fuel with 50 cc. 70 per cent H_2SO_4 for one minute in a separatory funnel, removing the H_2SO_4, and washing thoroughly with water.

Pages 312-325

(2) FB-680 8-27-1936
Testing a New Diesel Fuel (RLH 5009)

This report presents some engine test data of a Fischer Tropsch product diesel fuel (Ruhrchemie RCH 5009) of especially high heat value and low viscosity and gravity.

Oil	Derop-Gasoil (Reference Fuel)	RCH 5009
Gravity	0.859 Kg/l	0.759 kg/l
Vis./20° C., °E	1.44	1.16
Abs. Vis., CP	4.67	1.84
Upper Heat Value	10,928 Kcal/kg	11,445 Kcal/kg
Lower Heat Value	10,235 Kcal/kg	10,684 Kcal/kg
Cetene Number (By DVL Ignition Delay Method)	64	>100

Engine tests are reported in some detail. It is concluded that the RCH 5009 is an excellent fuel for high RPM diesel engines, if the special properties of the fuel are taken into consideration. Its excellent ignition properties might permit decreasing the compression ratio and possibly permit lower weight engines. However, an engine especially designed for this fuel would not permit the use of regular diesel fuel without causing complications.

Pages 326-364

(18) FB-1144 12-22-1939
Influence of Impurities on Storage Stability of Fuels - K. Frank

The main purpose of the experiments was to test the effects on gasolines in storage, of impurities likely to occur in gasolines. Each gasoline was tested by means of the BVM-bomb-test (four hours at seven atm. oxygen pressure at 100° C.) in addition to the 26-month storage.

* 15 g. potassium per 100 cc. 98 per cent ethyl alcohol.

Three base fuels were used; one was paraffinic, one naphthenic, and one a hydrogenated gasoline. Several fuel components were mixed with the gasolines; they were benzene, ethanol, methanol, and tech. iso-octane. The "additives" whose effect was to be tested were: sulfur, sulfur compounds, olefins, acids, alcohols, ketones, and aldehydes.

The gasolines were stored clear, in admixture with the other fuel components, and all combinations of gasolines and fuel components were stored with all of the "additives," both leaded and unleaded. The storage vessels were 30-l. cylindrical tin cans with "breathers" protected by silica gel driers. Twenty liters of sample were stored. Each sample was tested, at the start, for evaporation residuum, acid number, and most of them for CFR octane number, and again so tested after 26 months of storage. Each sample was also tested by the DVL bomb test at the beginning.

The results of the tests are reported in 50 tables on the film. Some of the additives caused deterioration of the gasolines even before the storage period. The following conditions were considered criteria of satisfactory storage.

Mixture Before Storage:	Evaporation Residuum	10 mg./100 cc.
	Acid Number	0.10
Mixture After Storage:	Increase in Evaporation Resid.	5 mg./100 cc.
	" " Acid Number	0.10
	Induction Time	240 Min.
	Pressure Loss	0.0 Atm.
	Octane Number Loss	2

The essential results were as follows:

The plain gasolines were practically unchanged, except for some loss of light components. All plain gasolines and their mixtures with other pure fuels, clear as well as leaded, were satisfactory before storage. On storage, the evaporation residuum of some blends, particularly of the leaded samples, increased moderately (up to 0.10 mg.) but no specific component could be named as specially susceptible. Octane number losses occurred in some three-component blends with methyl alcohol and aviation benzene, and in unleaded blends with di-isopropyl ether. No peroxides were found in the latter. In general, storage characteristics of all blends are good.

The blends with 0.01 per cent sulfur, clear and leaded, were good before storage. Of course, the evaporation residuum was too high even before storage. Their condition after storage was, in general, unsatisfactory.

The blends with sulfur compounds were satisfactory before storage. Storage stability was good for the blends containing dibutyl sulfide and thiophene, worse for those with butyl mercaptan. The leaded paraffinic gasoline was particularly good, even with butyl mercaptan.

All leaded and unleaded blends with unsaturates (octylene, diallyl) were satisfactory before storage. After storage, some blends with one per cent octylene showed too much increase in evaporation residuum or octane number. Blends with 0.1 per cent octylene or 0.1 per cent diallyl were satisfactory after storage.

Addition of organic acids caused increase of evaporation residuum and acid number far above the permissible in most cases, even before storage. Leaded blends showed poor storage stability, particularly those with paraffinic gasoline. Unleaded blends with low acid addition (0.1 per cent) were satisfactory on storage, but higher acid concentrations (0.5 to 1 per cent) caused them to go bad. Blends with acids, particularly benzoic acid, caused sediments in the carburetor after they had been stored.

The storage stability of blends with higher alcohols (butyl-, isoamyl- and hexyl alcohol), clear and leaded, was satisfactory.

Of the blends with ketones (methyl ethyl ketone, diethyl ketone, dipropyl ketone) the blends with five per cent diethyl ketone had high acid numbers before storage. Aside from that, properties before storage were satisfactory. Only in the case of the hydrogenated gasoline were the permissible changes upon storage exceeded slightly (3 out of 36 samples).

The blends with small quantities of aldehydes (butyraldehyde, benzaldehyde, oenanthol) were good before storage, and, except for leaded blends in hydrogenated gasoline, satisfactory after storage. The blends with higher aldehyde content (one per cent or more) generally had high acid numbers or evaporization residua (paraffinic gasoline showed up best) and their storage stability was poor. Unleaded blends in paraffinic gasoline were relatively good, but the other unleaded and all leaded blends were very bad. The oenanthol blends could not be engine tested because of high viscosity, and the five per cent benzaldehyde blends because of crystal formation at the fuel nozzle.

The effect of the bomb test on the blends differed in many cases considerably from the effect of storage. These differences are also discussed in the report, and a large number of tables show all data in detail.

Pages 365-376

(34) FB-1722 12-8-1942
Effect of Lubricating Oils on the Performance Curves of Aromatic Fuels - K. Franke

Previous experiments by DVL in an air-cooled BMW 132N cylinder, using the standard DVL overload test method for aviation fuels, had shown that the type of lubricating oil used affects the performance curve of aromatic fuels. To check these results on a more up to date engine, these tests were repeated on a liquid cooled DB 601 cylinder with high compression ratio and large valve overlap.

Three types of oils were used:

Source	Deutsche Vacuum Oel, AG, Bremen	Wifo Stassfurt Leopoldshall	Wifo Niedersuchswerfen
Name	Rotring D	Stanavo 100	Aero Shell 100
Sp. Gr.	0.8913	0.886	0.8889
Refraction	1.4923	1.4918	1.4907
Vis./20° C., °E.	120	103	119.2
Vis./50° C., °E.	18	17.3	17.7
Vis./100° C., °E.	2.82	2.75	2.88
Pole Height	1.88	1.68	1.90
Flash, °C.	272	259	270
Acid Number	0.04	0	0.02
Sap. Number	0.19	0.09	0.1

Five fuels were used, with aromatics content varying from about 20 per cent to 85 per cent, the latter in a mixture of nonaromatic gasoline and aviation benzene.

The experiments were run under carefully controlled conditions to assure maximum accuracy. It is shown that the lubricating oil exerts a definite influence on the performance curve of gasolines, the effect increasing with increasing aromaticity. There is no change in effect on the performance curve due to varying amounts of lead in the fuels.

The "Rotring" oil gave a higher performance curve (plot of intake pressure against "excess air") than the Aero Shell 100, and the Stanavo 100 gave a lower performance curve. In the case of the gasoline-benzol blend, the difference was as much as 90 mm. Hg intake pressure each way at the minimum point in the curve.

Pages 377-415

(32) FB-1657 9-15-1942
Effect of Valve Overlap on the Knock Limit of Various Fuels in the DB 601 Engine - K. Franke

The first 15 pages of this report are devoted to an extensive general discussion of knock testing. The theories of the cause of knocking are reviewed, the importance of accurate knock testing for aviation fuels is discussed, and the relative merit of the DVL overload test over a one-point test such as the CFR is mentioned. It is still desirable to derive a method that permits drawing the fuel performance curve for any engine from the data obtained on another engine. As it is, knock testing on full scale engines is still necessary; its difficulties, particularly in determining the beginning of knocking, are discussed. In this connection, the method being developed by A. W. Schmidt, of catching the total engine noise by microphone, filtering out all frequencies not due to knocking, and observing the knock by means of an oscillograph, is considered promising. The variables in operating conditions and engine construction which affect fuel performance are given. The one with which this report is concerned is valve overlap. When the valve overlap on a DB 601 single cylinder engine was increased, it was found that the fuel performance curves changed remarkably. The processes taking place in a cylinder at various stages of valve overlap are discussed in detail. Finally, the meaning of the overload test fuel performance curve is also explained in some detail.

The experimental work was carried out in the DB 601 single cylinder engine. The operating conditions chosen were 1900 RPM (compared to the 1600 RPM required in the DVL test), air intake temperature range from +30 to +190° C., and spark setting of 35° "V.O.T." (advanced). The compression ratio was 6.5. The DB 601 engine proved very favorable for these experiments; the performance curves could be carried near the ignition limit of the fuel in the rich-mixture region without causing the engine to miss, and smooth operation was also attained in the lean region with considerable excess air. The fact that the engine is liquid cooled permitted close control of the engine temperature and a consequent very good reproducibility of results (variation of ± 10 mm. Hg intake pressure).

Credit for very clean engine condition at the end of the runs is given to the use of synthetic lubricating oil P 16 (IG).

The results of the experiments are discussed in much detail and documented by a large number of performance curves. They are summarized as follows:

Under certain operating conditions, for example, high valve overlap or low air intake temperature, when using fuels not sensitive to temperature, a peculiar knock-range was observed on the DB 601 engine. The fuel performance curves vary considerably from the usual DVL curve in that they have a minimum in the rich-mixture range from which the knock rating increases steadily. This phenomenon is due to the fuel mixing. The effect of inlet air temperature and valve overlap on the amount of unevaporated fuel droplets and consequent increased peroxide formation was proved experimentally. With increasing intake air temperature or decreasing valve overlap, the mixture improved and the minimum in the rich zone disappeared, leaving a fuel performance curve of the standard type. With temperature-sensitive fuels (benzol and alcohol) the minimum was not observed.

The characteristic of the knock limit curves, which is determined by mixture temperature, and the effect which changing valve overlap exerts on it, could be determined approximately. The thermal load (heat output in the cylinder) which decreases with increasing valve overlap, can be compensated for, as far as its effect on the shape of the fuel performance curve is concerned, by a corresponding increase in the intake air temperature. An intake air temperature increase of about 80° C. will compensate for an increase in valve overlap from 40° to 80°. A further increase in valve overlap from 80° to 120° corresponds to an intake air temperature increase of about 30° C. The change in the height of the knocklimit curve is not considered in the above effect.

The variation in knock rating (literally "knock proofness" - Klopffestigkeit) of fuels varies with their chemical composition and the degree of valve overlap. Fuels with low content of temperature sensitive components showed an increase in knock-rating over the whole range (up to 120° valve overlap). Fuels with high benzol or alcohol content do not react uniformly. In most cases there was a significant increase in knock rating between valve settings of 40° and 80°. Further increase of valve overlap to 120° caused no change in the performance of some fuels and a loss of knock rating in some others, depending largely on the proportion of temperature-sensitive components.

There is a limited possibility of adopting the DVL overload process to the conditions in modern aviation engines. It seems possible that the order of rating of fuels will be maintained when the valve overlap is changed slightly. Any considerable change in the DVL test to adapt it to changed engine operating conditions such as large valve overlap, higher compression, etc. must await experimental work to study these effects.

Pages 416-422

(40) UM-757 2-21-1944
Process for Producing Liquids Whose Physical Properties Are Largely Independent of Temperature - H. Harms

The principle of this method is the selection of liquid heterogeneous system whose mutual solubilities vary with temperature in such a manner that the property which it is desired to hold constant in one phase over a temperature range will remain constant as a consequence of the change in composition of the phase.

The emphasis in this article is placed on viscosity. It is shown that liquids can be prepared whose viscosity will remain unchanged over large temperature ranges. This could be of immense value if applicable to practical lubrication.

As an example, the system: 1 part glycerine and 3 parts dioxane is described. This system exists in two phases up to 60° C. (phase A (dioxane rich) and B (glycerine rich)). Phase B has a considerably greater viscosity coefficient than A. With increasing temperature, more of phase B enters phase A. Between 20° and 35° C. there is a very slight drop in the viscosity coefficient of phase A, between 35° and 45° C. a constant value, and from 45° to 60° C. a slight increase. Above 60°, all of phase B has merged with phase A. Between 20° and 90° C., the viscosity coefficient of phase A does not vary by more than ± 10 per cent from the average of 1.5 centistokes.

For comparison, the variation of the viscosity coefficient of 100 per cent undecane (same viscosity at 20° C. as phase A above) and 100 per cent hexadecane (same viscosity at 90° C. as phase A above) are plotted on one graph with the unchanging viscosity coefficient plot of the above phase A. The ratio of largest to smallest viscosity coefficient over the range of 90° C. is 2.5:1 for undecane and 3.1:1 for hexadecane.

Pages 423-436

(39) FB-1905 2-10-1944
Evaluation of the Vapor Lock Tendency of Fuels - O. Widmaier

In the first seven pages, the previous status of vapor pressure testing of fuels and of determining vapor lock tendency is thoroughly reviewed. Since no method is considered sufficiently easy and accurate at the same time, a new apparatus was developed. The objection to the widely used Reid vapor pressure method is that the vapor pressure is determined in the presence of air, thus leading to a possibility of erroneous results.

The new apparatus is shown in photograph and diagram, but no dimensions are given. It consists of a brass cylindrical bomb in a thermostat bath. The top of the bomb has four taps, one serving as fuel inlet, one as thermometer well (for a -60° to +60° C. mercury thermometer), one as connection to a vacuum gage and one as connection to a vacuum pump. The test procedure is described as follows: The bomb and a fuel sample are separately cooled to -50° C. by means of an alcohol-dry ice mixture. The bomb is then evacuated with a high vacuum pump, and the line to the vacuum pump clamped off. About 200 cc. of the fuel is carefully sucked into the bomb from a separatory funnel. The vapor pressure is read directly at the various desired temperatures. The air retained in the fuel and in the bomb causes a small but insignificant error. It is essential that enough fuel is used to permit all of the volatile components to be present in the liquid phase.

Data obtained on several pure organic liquids and on fuels are presented. Due to limitation of the manometer, pressures were not read very accurately below 100 mm. Hg.

The advantage of this apparatus over the Reid bomb consists in the fact that pressures are read at several temperatures, vapor pressure curves being determined very quickly.

An apparatus for observing vapor lock is also described and shown. A small Erlenmeyer flask is filled with the cooled fuel up to the stopper. The flask is then heated to the test temperature, a trap at -60° C. condensing all evaporated components. Vacuum from a vacuum pump is then slowly applied through a clamped tube, and read on a mercury manometer. The pressure at which the fuel bubbles up into the glass tube connection to the vacuum pump corresponds to the altitude at which the fuel will vapor-lock.

Pages 437-445

(38) Extended Applicability of the FKFS Rapid Lead Analysis of Fuels - O. Widmaier

(The FKFS method is given in detail on Pp. 88-93, Reel 52. See translation.)

Previous reports on this analytical method are enumerated, namely:

FB-1194 (Not on Reel 52)
FB-1252 (Not on Reel 52)
FB-1382 (On Reel 52, Pp. 214-230)

This paper reports on work done to extend the applicability of the FKFS method to fuels containing olefins, "resins," or peroxides.

The interfering effect of unsaturates is discussed. High results are obtained due to iodine addition. This is preventable to some extent by adding sufficient KI to form an I-KI complex which slows down the addition reaction considerably. Peroxides interfere by liberating iodine from the KI in solution and cause low results.

The experimental work to determine the influence of various factors on the accuracy of results is discussed in some detail, and the following points are enumerated as significant:

a. The reaction temperature should be between 15° and 20° C.

b. The 70 per cent H_2SO_4 recommended for removal of interfering olefins should not be in contact with the gasoline for more than 20 seconds.

c. The alcoholic iodine solution must contain a minimum of 1.25 per cent KI.

d. The iodine solution is allowed to react with the fuel exactly six minutes while standing in the dark without shaking.

e. Titrate without starch if possible.

f. Titrate as quickly as practicable.

Recommended Procedure for General Application of FKFS Method

A. Alcohol-Free Aviation Fuels (A3, B4, and C3)

Pipette 25 cc. of the sample at 15° to 20° C. into a 100 cc. iodine number flask. Add 5 cc. of standardized 0.10N alcoholic iodine-KI solution (12.7 g. CP iodine, 12.5 g. CP KI, 1 liter water-free ethyl alcohol) and let stand exactly six minutes in a dark place. Immediately back-titrate the excess iodine with 0.10N sodium thiosulfate from a microburette. Do not use starch indicator.

cc. 0.10N Iodine Solution x 0.0391 = Vol. % TEL

B. Alcohol-Free Fuels of Iodine Number >10

Place 50 cc. of sample in separatory funnel. Shake exactly 20 seconds with 10 to 50 cc. of 70 per cent H_2SO_4 (in case of strong brown coloration 50, of weak coloration 10 cc.) and draw off the H_2SO_4. Wash twice with water. Dry the sample with anhydrous sodium sulfate, by vigorous shaking. Analyze the dry sample by Procedure A. above.

C. Alcoholic Fuels

The alcohol is removed from the sample by waterwashing, and the sample is dried and then analyzed by Procedure A. or B. as required.

Because of their speed, ease, and minimum of equipment required, this method is recommended particularly for field laboratories. In a cited example of cracked gasoline analyzed by this method, the TEL found varied from 0.0989 to 0.0996 volume per cent for a theoretical TEL content of 0.100 volume per cent. Other data are in the same order of magnitude of error.

Pages 446-455

(37) UM-726
Measuring Friction Coefficients on the PTR Apparatus

The PTR apparatus was developed at the "Physikalisch - Technische Reichsanstalt" and has been described in the ZWB research report FB-1478 (8-1-1941) which is not on this reel. The boundary lubricating value of fuels is determined by measuring the force with which a weighted steel pin, gliding on a lubricated revolving plate, is pulled in the direction of motion. The apparatus is not redescribed in detail. Several improvements over the original apparatus are reported, among them the use of 328 Kg/cm^2 pressure instead of 185 Kg/cm^2; the use of a very thin regular oil film distributed by a wiper carefully cleaned between runs; the use of a coarser grinding medium (Optolit 6 instead of Optolit 2); and the use of a 2 cm. long pin. Also, a sector method of testing is described in which the test oil and a reference oil are used simultaneously, each on one-half of the test plate.

It was found that the friction coefficients of several mineral oils of identical viscosity, but different origin, did not vary significantly. Additives such as graphite, tricresyl, phosphate, and calciumchlorostearate did not affect the friction coefficient. Oils with fatty additives gave lower values.

Pages 456-465

(21) FB-1292 10-14-194
An Exact Rapid Method for Lead Analysis of Fuels - I. Morghen

This paper presents an accurate method which permits determination of the lead content of aviation fuels in about 30 minutes, using 2 cc. of sample.

Principle

The process consists of two steps: (1) The transformation of lead tetraethyl into a water soluble ionizable lead compound, and (2) titrimetric determination of the lead content.

Preparation of the aqueous lead solution: The usual methods of transforming the tetraethyl lead into an aqueous lead solution are too time-consuming. Since mono- and dichloroalkyl lead compounds are water soluble, it was attempted to transform the tetraethyl lead into dichloroethyl lead by means of a mild chlorinating agent such as sulfuryl chloride, which would not react with the fuel to form appreciable amounts of resinous, gasoline-insoluble compounds.

When sulfuryl chloride is added to lead and gasoline, heating causes a flocculent white precipitate which is practically insoluble in petroleum ether and gasoline but is easily soluble in water and alcohol. This was proved to be dichloroethyl lead. The schematic reaction is therefore:

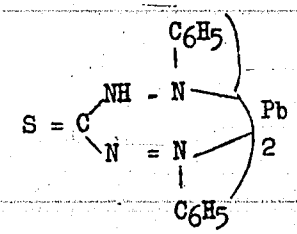
$$Pb(C_2H_5)_4 + 2SO_2Cl_2 \rightarrow (C_2H_5)_2PbCl_2 + 2SO_2 + 2C_2H_5Cl$$

Any reaction of SO_2 formed with the TEL was not observed in practice. When using longer reaction times while heating, some lead chloride was formed. The formation of lead chloride is affected also by the type of fuel and diluent. The $Pb_2(C_2H_5)_6$ which is present in slight amounts is probably also transformed into dichloro diethyl lead. The reaction was not further investigated since for analytical purposes it is only necessary that the TEL in the leaded fuel is transformed into divalent ionizable lead. It is further essential that the amount of lead obtained is independent from the type of fuel and the TEL concentration. The main source of error here would be solubility of the precipitate in the fuel and effects of the fuel on the time and form of precipitate (supersaturation or colloidal precipitates). In the developed analysis, the precipitation conditions were so chosen that the two above-named conditions are met and that the same type of precipitation is found for all types of fuel. Only fuels with above 40 per cent benzol content require dilution with a paraffinic gasoline. With very highly unsaturated or gum forming cracked gasolines, the sulfuryl chloride could possibly react so strongly that insoluble resinous materials are precipitated (dehydrogenation by chlorine) which would later prevent solution of the lead precipitate. This can be largely avoided by adding considerable quantities of pure chloroform. When using this method, standard runs must also be made with chloroform since there may be some increased solubility of the lead precipitate in the chloroform-fuel mixture.

The fuels tested must not contain alcohol or undissolved water.

Determination of lead content of aqueous solution: The method developed by H. Fischer* for determination of lead and other metals by use of dithizon (diphenylthiocarbazon) was applied and modified for this analysis.

H. Fischer reports that, with weakly alkaline lead solution, diphenylthiocarbazon forms an inert complex lead dithizonate which is derived from the keto form of dithizon.



One mol of dithizon in its tautomeric iso form would be required per mol of divalent lead salt.

The lead dithizonate of a pure inorganic divalent lead salt is soluble in carbon tetraethylchloride with brick red color. The divalent lead ion obtained with sulfuryl chloride from TEL forms, with dithizon, an orange red compound which is considerably more easily soluble in carbon tetrachloride than the inorganic dithizon compound. The same equivalent of dithizon is, however, required for both compounds. Following is the modified Fischer method which was developed for this work.

* H. Fischer, Angew. Chemie 50, 919 (1937)

The settled dithizon carbon tetrachloride solution is added to an aqueous, weakly alkaline lead solution with repeated shaking until the initially colorless clear aqueous solution has a yellowish coloration due to excess alkali dithizonate.

The accuracy of the analysis is obviously improved by using less excess dithizon (therefore the volume of aqueous lead solution should be as small as possible) and with increased amounts of lead and increasing concentration of the dithizon solution. Then, also, the accuracy is better the less dithizon is soluble and the more lead dithizonate is soluble in the solvent (carbon tetrachloride). For the most accurate determination, the distribution equilibrium between alkaline dithizonate and carbon tetrachloride lead dithizonate would have to be considered. This, however, is not necessary for purposes of this test.

When carrying out the above titration in practice, the accuracy of the titration is ±0.25 per cent. The titrating solution is approximately 5×10^{-4} molar. The amount of lead solution is about 2.75 ml. with a content of approximately 2.5×10^{-6} mol (0.84 mg.) lead (as dichloro diethyl lead).

To avoid emulsion formation when shaking, to destroy traces of remaining chlorine, and to serve as antioxidant, sodium thiosulfate is added. Rochelle salt is added to facilitate solution of any lead chloride or lead sulfate formed (the lead complex salt so obtained is sufficiently ionizable to react practically quantitatively with dithizon). Finally, potassium cyanide is added to avoid interference by formation of stable complexes of other metals (except Sn, Bi, and Tl).

Method

1. Preparation of the Titrating Solution

600 cc. of carbon tetrachloride* are heated to about 40° C., placed in a 750 cc. separatory funnel with a considerable excess of pulverized dithizon (approximately 0.5 gm.) shaken vigorously 15 minutes, and quickly** filtered into a one liter separatory funnel. 300 cc. of 0.25 per cent ammonia is added to the dark green solution and the funnel shaken 3 to 5 minutes. The dithizon is thus largely transferred to the aqueous layer. After brief settling, the dirty green carbon tetrachloride solution which contains the impurities (oxidation products) of commercial dithizon is withdrawn. The aqueous solution is again quickly washed with about 30 cc. of carbontetrachloride. 750 cc. of pure carbon tetrachloride are then added, and the dithizon is liberated from the ammoniacal solution by addition of 100 cc. of 10 per cent sulfuric acid and absorbed in the carbon tetrachloride by vigorous shaking. The colorless aqueous layer is now removed by means of suction or a second separatory funnel, the carbon tetrachloride solution again shaken with 200 to 300 cc. of sulfuric acid, the aqueous layer again removed, and finally the dithizone solution shaken three times with portions of 200 to 300 cc. of distilled water. After the last wash, the carbon tetrachloride solution is permitted to settle thoroughly and

* Other solvents in which dithizon is more soluble (for example, chloroform) may be used and, of course, less solvent is required. (The solvents must be chemically pure.)

** Dithizon and its salts are sensitive to light and oxygen.

then drained off to a dry separatory funnel, shaken with some freshly ignited barium sulfate for about 10 minutes and quickly filtered. The approximate strength of this dithizon solution is now determined by using it according to the procedure described below on a solution of known lead content, preferably in paraffinic gasoline. The dithizon solution is now diluted with carbon tetrachloride so that 0.55 cc. of a gasoline of 0.10 volume per cent lead content corresponds to 9 to 10 cc. of standard solution. The solution is then placed in an amber 1½ liter bottle (sketch on film) (sufficient for about 100 determinations). The outlet siphon is inserted and some 1 per cent sulfuric acid carefully placed in a layer above the carbon tetrachloride; the bottle is then closed air tight and sealed with wax. A burette is attached by means of a cork and wax sealed. The air is now flushed out of the equipment by means of nitrogen, and a breather flask filled with pyrogallol solution or other oxygen absorber is attached and the burette stopcock[x] closed. The outlet tube is painted black or otherwise protected from light. For safety a black cloth is placed over the amber bottle. It is best to let the solution stand 8 to 10 days before use, since the titer sometimes changes slightly during this time. The solution is then standardized with a freshly prepared lead solution. Bottle and burette should be stored in a cool, fairly dark place. (The titer of the solution in the unprotected burette does not change significantly in one day.) Another method of standardizing the dithizon solution is presented in FB-1500 (Reel 52, Pp. 272-285).

Analysis

2.0 cc. of the leaded fuel are placed, by means of an accurate pipette, into a dry distillation flask (pictured on film). 3.0 cc. of a mixture of one part chloroform* and two parts of paraffinic gasoline are added as diluent. After 1 cc. of sulfuryl chloride** is added, the long neck of the distillation flask is put in place by means of a ground glass connection. The solution is boiled*** for 2½ minutes over a small flame, cooled one minute in running water, again heated for one minute and cooled, and then the liquid is filtered[†] off from the precipitate through the fritted glass filter which is built into the side arm of the distillation flask. The flask is washed out three times with 2 to 3 cc. petroleum ether and then dried by sucking air through the filter for a short time. The precipitate is then dissolved

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[x] Stopcocks must be lubricated with carbon tetrachloride proof grease. For example, according to Kapsenberg: "Grind up 25 to 30 gm. dextrinum puriss, in a porcelain dish with 35 cc. concentrated glycerine, adding the latter gradually. Heat over a flame while stirring with a glass rod. Let the solution come to a boil twice. Store in a glass stoppered flask since the grease is hygroscopic."

* Alcohol must be removed from the commercial chloroform by shaking with $CaCl_2$.

** Sulfuryl chloride is very hygroscopic, hydrolyzing to sulfuric acid and hydrogen chloride. The sulfuric acid so formed can attack the fuel and the lead compound. The sulfuryl chloride must therefore be stored in a closed vessel over mildly ignited barium chloride, and occasionally shaken. The stopper must be kept dry and the bottle quickly closed after use. The 1 cc. must be removed with a pipette without stirring up the settled $BaCl_2$.

*** The flask is placed on an asbestos plate with a 20 to 25 mm. hole. The solution should boil but not very strongly. The simultaneous emission of SO_2 should not be mistaken for boiling, however.

[†] Only very little suction should be used. When the fritted glass filter becomes plugged it must be cleaned with warm cleaning solution. Each flask is good for about 100 analyses.

with 3 cc. of an aqueous solution containing 0.1 per cent ammonia, 0.5 per cent Rochelle salt and 0.5 per cent sodium thiosulfate. This solution is then carefully removed into a 10 cc. volumetric flask (shown on film) by suction. The distillation flask is rinsed three times with 2 cc. of solution which is each time removed through the filter. The volumetric flask is finally filled up to the mark, the solution thoroughly mixed and 2.50 cc. of this solution placed in a shaking flask (shown on film). After addition of 0.25 cc. of a 2.5 to 5 per cent potassium cyanide solution, the titration is made.

The titration is carried out as follows: The amount of titer solution which corresponds to the lower limit of the expected lead content is added and the mixture shaken one minute (the water layer must be entirely clear). 0.2 to 1 cc. portions of titer solution are added and the mixture shaken 15 seconds each time until the aqueous layer shows a yellow or brownish coloration. For the accurate determination, a new 2.5 cc. sample is used to which the maximum amount of titer solution is added which gave no coloration in the preliminary run. 0.05 cc. portions of titer solution are then added until the end point is attained. The end point is best taken as that point where yellow coloration is just observed. For control purposes an additional 0.1 cc. of dithizon solution should always be added which must then cause a definite brown coloration.

Calculation

The lead content is calculated from the equation TEL = $Y \times \frac{A}{X}$ cc./100 cc. where A is the lead content of the standard lead solution, X is the volume of dithizon solution required per 0.50 cc. of the standard lead solution, and Y is the volume of dithizon solution required for titration of the unknown.

The results obtained by applying this method to 18 different types of leaded fuel are included in the report.

Pages 466-480

(12) UM-546 8-30-1938

Improvement and Simplification of Lube Testing on the BMW 137 Single Cylinder Engine - H. Schoekel

The BMW 132 Single Cylinder Engine seems to be a standard engine for German lube testing. It required 50 Kg of oil per test, and considerable time, since the engine had to be dismantled after each test to clean out all remaining oil. This paper describes in detail a number of mechanical changes on the engine and changes in testing procedure which permit running a test with only 20 Kg of oil and at a considerable time saving since the engine could remain essentially assembled, only the piston having to be replaced after each run.

This paper again shows that the German method of testing lubricating oils consists of running the engine until ring sticking takes place, the running time indicating the quality of the oil. In addition to the seemingly standard method of

considering a sudden drop in output horsepower as indicative of ring sticking, this paper mentions an instrument (described in detail in FB-943, 1938, "Ein Neues Gasmengen Messgeraet zur Beobachtung des Gasdurchtrittes in das Kurbelgehaeuse") which records the amount of gas blowing by the piston into the crankcase; a sudden increase in this blowby is also an indication of ring sticking.

Pages 481-508

FB-939 5-31-1938
Ignitability of Diesel Fuels in the Engine

This report presents work done in comparing a number of laboratory and engine tests methods of diesel fuels.

The following is concluded:

(1) The chemico-physical tests such as diesel-index and flame length enable no entirely satisfactory correlation with engine test data. Parachor determinations gave high values, particularly in the range of high cetene numbers. There is, however, a certain parallel between parachor and evaluation on the diesel engine.

(2) The test in the CFR carburetor engine according to Dumanois, at 600 or 900 RPM, gave the lowest cetene numbers. Also tests in the old CFR diesel engine (initial ignition) gave doubtful values.

The values obtained in the DVL motor by three methods (initial ignition, point of no ignition, and ignition delay) agree very well with each other. Results in the Koerting engine of Olex (Berlin) are very similar.

Improvement of the engine performance of diesel fuels may be obtained by addition of ignition accelerators.

It is recommended that aviation diesel fuels be tested by the ignition delay or "point of no ignition" methods in the DVL engine.

Pages 509-549

FB-952 12-14-1937
Physico-Chemical Studies of Combustion in the Engine - W. Jost

This is a 48-page theoretical treatment of experimental work about combustion in the internal combustion engine.

M. S. Baer:art

SUBJECT INDEX

U. S. Government Technical Oil Mission

Microfilm Reel 52

* FB - Forschungsbericht - Research Report

ZWB (Zentrale Fuer Wissenschaftliches Berichtswesen Ueber Luftfahrt)
REPORTS (Contd.)

* PB - Pruefbericht - Testing Report
ø UM - Untersuchungen and Mitteilungen - Investigations and Communications