

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

THE MEANING OF SPECIFICATIONS FOR GASOLINE AND KEROSENE¹

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Introduction

Anyone whose work brings him in close relation to petroleum products, and the specifications for petroleum products, must be struck by the lack of knowledge by the "man on the street" of what are the items usually included in specifications for various petroleum products, and what is the significance of the several items in a specification for a given petroleum product. And yet the average citizen is very much interested in this subject, insofar as gasoline is concerned, at least, and is possessed with a number of more or less valid notions in regard to what constitutes a good gasoline, and how a good gasoline can be identified. He is for the most part, utterly unaware that it is at least as difficult to identify a good gasoline as a good diamond or a good race-horse.

The object of a purchase specification, is to inform the supplier in regard to what the purchaser wants, and what he does not want, and to make wants correspond to needs. Often the purchaser does not know definitely what he wants; and what he says he wants, is not what he should have for his needs. To this state of things is due the great variety of inadequate, capricious, and arbitrary specifications for gasoline and kerosene, which are a thorn in the flesh of the conscientious supplier.

In the early days of the petroleum industry in this country, about the only thing the consumer knew about the gasoline he purchased, was the gravity, and the refiner knew little more. For kerosene, the fire test was about all that was required. This was satisfactory when only one type of crude was used, and the principal commercial product was kerosene. Gasoline then was not likely to contain anything that should have been put into the kerosene portion. The coming of the automobile, and the increased use of gas and electricity for illumination, caused an increased demand for gasoline, and a relatively decreased demand for

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kerosene. New oil fields were discovered, and the oils from these fields were found to yield products which were not comparable on a basis of gravity with the products of the Eastern fields. It was found that gravity was now no criterion of quality of either gasoline or kerosene, and that other factors, which had hitherto been unimportant, were now of first importance. For example, gravity was found not to have the same relation to volatility, in the oils later discovered, as in the Eastern oils. Also, the increased demand for gasoline, with coincident decreased demand for kerosene, made it profitable to mix kerosene or heavy naphtha and natural-gas gasoline (a comparatively new product) to obtain a product equal in gravity to gasoline made in the regular way. Some of the newly discovered crudes contained enough sulphur compounds so that it was necessary to eliminate these substances from the finished product. For these reasons, distillation tests, sulphur tests, and corrosion tests came into specifications, and these and other tests gradually are supplanting the gravity test.

As an example of the development of specifications it is proposed to discuss the Government specifications for motor gasoline, and for kerosene. Until comparatively recently, there was no uniformity in Government specifications for petroleum products. Each purchasing agency was a law unto itself in regard to what should be required for purchase. This state of affairs was confusing and probably acted to restrict competition for Government business to those who made a practice of keeping informed of the various requirements of Government purchasers and who were familiar with the routine.

As a result of conditions brought about at the time of the World War, attention was drawn to the large number of different U. S. Government specifications which were in force, for products which should have been uniformly specified. The Bureau of Mines and other Government agencies, made studies of the industrial situation with respect to the most important petroleum products, especially gasoline. As a result of these studies, considerable progress was made in the direction of rationalization and unification of Government specifications.

Development of Federal Specifications

President Wilson, under date of July 31, 1918, issued an order to the U. S. Fuel Administrator to prepare specifications for petroleum products, and to proceed to this end by means of a Committee on Standardization of Petroleum Specifications. The first bulletin of this Committee which was published in October, 1918, contained among others, a specification for motor gasoline. This gasoline specification of October, 1918, consisted principally of a distillation test and a general statement on quality. This is what has been generally known as the "Navy Specification," because it was originated by the Navy Department, and had been in use by that Department for some time previous to its adoption by the Committee.

The specification of October, 1918, was revised, effective November 25, 1919. This revision also contained only one test, namely the distillation range, and the requirements were made somewhat more lenient in this respect. In the revision effective December 29, 1920, which was published as Bulletin 5, a color requirement was included in the general statement, but no numerical limit for the

color was set, and no method of test for color was specified. The phraseology of the distillation requirement was more definite than formerly, and the requirements were much more clearly stated.

The Interdepartmental Petroleum Specifications Committee was formed under authority of the Bureau of the Budget, under date of November 8, 1921, as an agency of the Federal Specifications Board. This Committee issued a group of specifications and methods for testing petroleum products, effective January 23, 1922, and amended March 1, 1922. This report did not revise the distillation requirement for motor gasoline which had been in effect since November 25, 1919, but for the first time in the specifications issued by the Committee on Standardization of Petroleum Specifications and its successors, definite requirements in regard to color test and corrosion test appeared in the specification for motor gasoline. This specification was issued as Bureau of Mines Technical Paper 305, and the methods for testing were published as Bureau of Mines Technical Paper 298.

The next group specification for petroleum products, was issued as revised October 31, 1922, as Federal Specifications Board Standard Specification Number 2. This was published as Bureau of Mines Technical Paper 323, and included specifications and methods for testing. In this publication, there were two changes in the specification for motor gasoline, as follows: (1) the initial boiling point (first drop) was lowered from 140°F. to 131°F. (2) the 90 per cent point was raised from 374°F. to 392°F. Specification Number 2 was revised as Number 20, March 18, 1924, and published as Bureau of Mines Technical Paper 323A. In this specification an attempt was made to suppress the persistent practice of alluding to the Federal Specifications Board specification for motor gasoline as the "Navy Specification" and it was provided that "Gasoline purchased under this specification shall be described as 'U. S. Government Motor Gasoline' with the understanding that this specification always refers to the current specification of the Federal Specifications Board."

In Bureau of Mines Technical Paper 323A a sulphur test by the lamp method was first introduced for motor gasoline. Otherwise this specification was identical with that contained in Technical Paper 323. This is the specification which is now in force, with the exception of the color requirement, as will be explained later.

Table 1 summarizes in tabular form, the successive Federal Specifications for gasoline, showing the changes which have been made in these specifications.

Table I - Showing Changes in Federal Specifications
for Gasoline

Tests	Date Effective					
	Oct. 2, 1918	Nov. 25, 1919	Dec. 29, 1920	Mar. 1, 1922	Oct. 31, 1922	Mar. 18, 1924
COLOR	*	-	white	16	16	16 *
CORROSION	-	-	-	neg.	neg.	neg.
DISTILLATION						
Initial	140°F.	140°F.	140°F.	140°F.	131°F.	131°F.
20%	221°	221°	221°	221°	221°	221°
50%	275° (45%)	284°	284°	284°	284°	284°
90%	356°	374°	374°	374°	392°	392°
End point	428°	437°	437°	437°	437°	437°
Recovery	95%	95%	95%	95%	95%	95%
SULPHUR	-	-	-	-	-	0.10%
PUBLISHED IN	Bull. #1	Bull. #3	Bull. #5	Tech. Paper 305	Tech. Paper 323	Tech. Paper 323A

* Deleted by Federal Specifications Board, March 9, 1926

Details of the Specification

The specification for gasoline may be used as typical, for a discussion of the details of a specification. The specification usually is headed by a descriptive title, as for example, "United States Government Motor Gasoline." This is followed by a General Statement which discusses briefly the commodity involved, and states how it is intended to be used. There are sometimes included general statements in regard to grades, or in regard to more or less indefinite qualities not satisfactorily covered in the details of the specification. The next section, "Properties and Tests" includes the meat of the specification. In the specification for U. S. Government Motor Gasoline for example, the first item under Properties and Tests is the following:

"Color - Method 10.11 - The color shall not be darker than No. 16 Saybolt." This item has now been removed from this specification, but it is included in this discussion, for the reason that color is still a part of a number of specifications for gasoline. This requirement was deleted as a result of a recommendation by the U. S. Public Health Service, that all gasoline containing tetra-ethyl-lead should be given a distinctive color as a safety precaution.

As a result of the investigations of tetra-ethyl-lead gasoline, it was recommended that all such gasoline be colored distinctively and that enough dye be added to lessen the likelihood of using the gasoline for cleaning. It was also recommended that all mixing of gasoline with the tetra-ethyl-lead fluid be done at refineries or large scale distributing stations, so as to have it done under the best conditions.

Several states have enacted legislation making the current U. S. Government specification for gasoline official in the state, and making revisions of the Government specification apply also in the local specification. For this reason it was necessary to reconcile the Surgeon General's recommendations with the specifications, and since it has been the opinion of many people for some time that the color requirement could be replaced by a more suitable one, the action of the executive committee of the Federal Specifications Board was taken upon the recommendation of the Technical Committee on Lubricants and Liquid Fuels.

It will be noted that in stating this requirement in regard to motor gasoline, and in the statement of the other items under Properties and Tests, the method of test is stated and the color limit is stated in definite terms. This course should always be followed in writing a specification for petroleum products. Statements that gasoline shall be "water white" or that kerosene "shall not flash below 100°F." and similar statements, are not definite and invite controversy. Whenever a test is mentioned, the apparatus and method by which the test shall be carried out, should be described.

The next item in the motor gasoline specification has been the subject of considerable controversy. The statement in Technical Paper 323A is as follows: "Corrosion Test" - Method 530.21 - A clean copper strip shall not be discolored when submerged in the gasoline for 3 hours at 122°F." The strict interpretation of this statement would act to reject a gasoline which would undoubtedly be entirely satisfactory from the standpoint of corrosion. The Technical Committee has under consideration a modification of this statement so that gasolines which show only slight discoloration of the copper strip will be accepted. The object of this item in the specification is to exclude from Government purchase gasolines which are likely to be corrosive to metallic containers such as tanks, feed lines, carburetors, etc.

The next item is the distillation range. Briefly this requires that the first drop shall fall into the receiver before the thermometer in the distillation flask reaches a reading of 131°F.; 20 per cent shall distill before a temperature of 221°F. is reached; 50 per cent shall distill under 284°F; 90 per cent under 392°F; and that the end point "shall not be higher than 437°F." It is also required that "95 per cent shall be recovered as distillate in the receiver from the distillation." In this instance, as in the others, the apparatus and method by which the test shall be conducted is minutely described as Method 100.12.

The present standard for the distillation range was determined as a result of a study and analysis of a number of factors which naturally enter into the specification for a commodity which is as extensively used as motor gasoline, and which is produced in a number of ways, from a variety of raw materials. Questions of utility, supply, cost, industrial standards, and others, were carefully studied,

and the specification is the result of the weighing of these influences. An unduly stringent requirement might act to restrict the number of bidders for Government contracts, and increase the cost of gasoline, without compensating increase in effective quality of the product. Although the government does not wish to buy what the commercial purchaser rejects, it is also not desirable to write a specification in such terms that only products of a certain crude oil, or of a single method of manufacture will meet the requirements.

The "tailor-made specification" should especially be avoided in setting up standards for general use, or use over a wide range of territory. The individual consumer, or corporation, may, if desired, with entire propriety make such a specification that only the product of one company will meet the requirements. It may be inquired, however, if this course is followed, why the goods is not bought by brand name in the first place. Sometimes purchasing agents are persuaded by overzealous or uninformed salesmen, to write a specification in terms that restrict the available supply to the extent that only a small number of manufacturers can comply with the specification.

In order to keep informed in regard to the kind of gasoline the industry is supplying to its retail trade, the Bureau of Mines has for seven years conducted semi-annual gasoline surveys. The information obtained in these surveys is useful to the Technical Committee in considering revisions of specifications for it is possible by a study of these surveys to judge the extent to which proposed new requirements can be fulfilled with the regular stock-in-trade of the industry. This is the primary reason for the semi-annual publication of the motor gasoline surveys by the Bureau of Mines.

Several people, in and out of the petroleum industry have recently proposed other means than the present distillation test for gaging the effective volatility of a motor fuel. These proposed methods are based on the idea that the results of the present distillation method are obtained, by means which do not parallel the process by which the gasoline is used in the automobile motor, nor the means by which gasoline is produced. These new methods are still in the formative stage, and it may be that ultimately the quality of a motor fuel will be determined by methods fundamentally different than those now used.

The third item under "Properties and Tests" for Motor Gasoline is sulphur, and the statement is as follows: "Sulphur - Method 520.1. Sulphur shall not be over 0.10 per cent." Representations have been made to the Technical Committee from several sources, that this requirement is unduly stringent and that the limit for sulphur by method 520.1 could be considerably increased without adversely effecting the quality of the gasoline. The Technical Committee has heretofore taken the stand that it has not been definitely proved that this is true, and also that a sufficient quantity of gasoline is available which meets the present requirement in regard to sulphur. This question is being studied in several organizations inside and outside of the Government Service and results in the future may reasonably be expected to shed some light on the question.

Specifications for Kerosene

Conditions with respect to Government specifications for burning oils have been similar to those which have been indicated in connection with gasoline. The same lack of uniformity, and indefinite statement was prevalent in these specifications, as was the case with gasoline.

Bulletin No. 2 of the Committee on Standardization of Petroleum Specifications, dated December, 1918, contained specifications and methods for testing of burning oils. This bulletin contained the following introduction:

"The specifications for illuminating oils which have been heretofore used by the different departments of the Government, including the Railroad Administration, have been, at times, so drawn that they could be met only when the oil was manufactured from the crude oil from some particular section of the United States, notwithstanding the fact that oils from other districts could produce an illuminating oil equally as desirable.

"The Committee on Standardization of Petroleum Specifications early in its activities, recognized that this resulted in increased cost, not only to the Government, but to the railroads, when they purchased oils in one part of the country and transported them to another part, when a perfectly satisfactory product could have been obtained much nearer to the point of consumption. As a result of this condition new specifications have been drawn so as to allow these products to be made from any satisfactory crude petroleum, thereby saving not only unnecessary rail transportation but making the oil available at point of consumption at less cost."

The specification for water-white kerosene in Bulletin No. 2 contained the following specific requirements: flash, color, sulphur content, floc, end point, cloud test, reaction test, and burning test. The apparatus and methods for making these tests were not very definitely described in comparison with the detailed descriptions which are to be found in use today.

In the report of the committee which was issued as Bulletin No. 5, effective December 29, 1921, there was only one change in the specification for water-white kerosene, but some of the methods for testing were more definitely described than in Bulletin No. 2 of December, 1918. The reaction test of the 1918 specification was replaced by the doctor test in the new specification.

Bureau of Mines Technical Paper 305, was the next publication in the series. This was effective January 23, 1922, amended March 1, 1922. The specification for water-white kerosene in this paper was identical with that published in Bulletin No. 5, but more progress was made in the direction of definite and detailed description of methods for testing. The specification for water-white kerosene up to and including this paper had been briefly; Color 21 Saybolt, flash 115°F. Tag closed ester; sulphur 0.06 per cent, lamp method; floc, negative; distillation, end point not higher than 600°F.; cloud test not higher 0°F.; doctor test, negative; burning test, 18 hours. The procedure and apparatus for most of these tests had been by this time (March, 1922) about as definitely described as was practicable.

Technical Paper 305 contained a specification for prime white kerosene, as well as the one for water-white kerosene. The prime white kerosene differed from the water-white kerosene in the following particulars: Color 16 Saybolt instead of 21 Saybolt, sulphur 0.09 per cent instead of 0.06 per cent, maximum distillation end point 625°F. instead of 600°F., cloud point 5°F. instead of 0°F. and burning test 8 hours instead of 18 hours. Prime white kerosene was intended primarily for use as fuel and for cleaning, whereas water-white kerosene was intended primarily as an illuminant. The specifications were so written, however, that the two kinds of kerosene could be used interchangeably, in case of necessity.

The next revision of Federal specifications was effective October 31, 1922, and was published as Bureau of Mines Technical Paper 323. In this specification, the requirements for water-white kerosene were changed by raising the limit for sulphur by the lamp method from 0.06 per cent to 0.075 per cent. The requirements for prime white kerosene were also changed by raising the limit for sulphur from 0.09 per cent to 0.10 per cent.

The present Federal Specifications for lubricants and liquid fuels have been in effect since June 13, 1924, and are published as Bureau of Mines Technical Paper 323A. In this specification a change was made in the classification of kerosene. There is a specification for kerosene, and one for marine kerosene, which differ only in that the minimum flash point for kerosene is 100°F. and for marine kerosene it is 115°F. Tag closed tester.

Otherwise, both kerosenes have the following specification: Color, not darker than 16 Saybolt; sulphur, not more than 0.125 per cent; floc, negative, maximum distillation end point, 625°F.; cloud point, not higher than 5°F; burning test 16 hours. These are the specifications which are now in force for government purchase.

Table II summarizes in tabular form, the successive Federal specification for kerosene, showing the changes which have been made in these specifications.

Table II - Showing Changes in Federal Specifications
for Kerosene

Tests	Date Effective				
	Dec. 9, 1918	Dec. 29, 1920	March 1, 1922	Oct. 31, 1922	March 18, 1924
COLOR	21	21	21	21	16
FLASH	115°F.	115°F.	115°F.	115°F.	100°F.
SULPHUR	0.06%	0.06%	0.06%	0.075%	0.125%
FLOC	negative	negative	negative	negative	negative
DISTILLATION	600°F.	600°F.	600°F.	600°F.	625°F.
CLOUD	0°F.	0°F.	0°F.	0°F.	5°F.
REACTION	negative	-	-	-	-
DOCTOR	-	negative	negative	negative	-
BURNING	18 hours	18 hours	18 hours	18 hours	16 hours
PUBLISHED IN	Bull. #2	Bull. #5	Technical Paper 305	Technical Paper 323	Technical Paper 323A

The reports above mentioned, contained specifications for other burning oils, or illuminating oils, such as, long-time burning oil, 300-degree mineral seal oil, and signal oil. These oils are intended for special uses, and are not of general interest.

In regard to the details of the specification for kerosene: Color is probably of more importance in kerosene than in motor fuel, where the kerosene is to be burned as an illuminant by means of a wick. Although accidental contamination resulting in a color darker than 16 Saybolt may not be important, if the oil would otherwise have had a good color, a kerosene which without having been contaminated, has darkened to below 16, is a doubtful illuminating oil. Oils which undergo such a change in color are likely to cause charring of the wick, or a smoked chimney, and, if the color change is due to sulphur compounds may give off a disagreeable odor when burned.

The flash point requirement is strictly a safety measure, and has no other function. The flash point should be placed high enough for safety, and not so high that it becomes difficult or practically impossible to comply with the flash point requirement, and still produce a satisfactory burning oil.

The sulphur requirement is intended to eliminate kerosenes which will cause charring of the wick, smoky chimneys, or disagreeable odor when burned. This requirement also should not be made unduly stringent, so as to restrict the supply. The tendency in recent years, in Federal specifications, has been to increase this limit, as it has been found that burning oils are being marketed which are apparently successfully meeting the competition of kerosenes with lower sulphur content. The floc test is intended to give assurance that the oil is free from impurities derived from the chemicals used in the process of refining.

The distillation test is used to exclude unduly heavy, high boiling ends in the kerosene. Such heavy ends are likely to interfere with the wick-feeding qualities of the oil. The cloud point is intended to eliminate oils which might congeal in very cold weather. Instances have been known of kerosenes which solidified in extremely cold weather, in the states along the Canadian border.

It might be thought that, since kerosene is intended primarily as an illuminating oil, the burning test is all that is needed to assure a suitable oil. It would also appear that the burning test is easily made and since it requires inexpensive apparatus, is a very desirable test.

The fact is that to carry out the burning test properly is one of the most difficult operations of all of the usual tests made on petroleum products. Its apparent simplicity is one of the major pitfalls. Actually, very small irregularities may have great influence on the result of the test, and may be the cause of rejection of a burning oil which should have been passed. Consequently, whenever an oil passes reasonable specifications in other respects and fails on the burning test, the results should be carefully checked before the oil is rejected. If it is found that no error has been made in the results of the other tests, the burning test should be repeated with the closest scrutiny of all details of the apparatus and procedure. Some of the most common sources of erroneous results in lamp tests are the following: Mechanical injury to the burner, bending it out of shape, and thus distorting the flame. A burner made of stiff metal should be used. Irregularity in the chimney, causing eddies in the draft. It is best to use a chimney with circular cross section, rather than one which is flattened. Foreign matter in the wick, such as cotton seed oil, may cause a smoky flame. The wick should fit properly in the wick tube, neither too tight nor too loose, as either of these conditions may cause the oil to burn poorly. Strong or irregular draft in the room, often causes a smoky flame. Insufficient air supply may result in a smoky flame and charred wick.

The Federal Specifications Board

The procedure by which a new specification is authorized by the Federal Specifications Board is as follows:

Specifications and methods for testing are recommended to the Federal Specifications Board by several committees, one of which is the Technical Committee on Lubricants and Liquid Fuels. This committee is at present composed of representatives of twelve government agencies which are purchasers of petroleum products

When the need arises for a specification for a petroleum product or lubricant for which there has not formerly been a satisfactory specification, the Technical Committee on Lubricants and Liquid Fuels is requested by the Federal Specifications Board to draw up a suitable specification. This committee then gathers available data on the subject, and sets up a tentative specification. This tentative specification is referred to the Advisory Board of the Technical Committee for comment, criticism and suggestions. This Advisory Board is made up of representatives of several associations of manufacturers, marketers, and consumers of petroleum products. When the suggestions and criticisms of the Advisory Board have been received by the Technical Committee, these are considered by the Committee and final action taken in regard to the recommendation to be made to the Federal Specifications Board. Before the Federal Specifications Board authorizes a new specification the proposed specification is sent to the American Engineering Standards Committee which reports back its recommendations to the Federal Specifications Board, which then either accepts or rejects the material, as seems desirable.

It will be seen, therefore, that a Federal Specification for petroleum products, is not the work of a single government bureau, but represents the best thought of technical men of twelve government agencies, as well as two advisory organizations outside the government service.

It is only after a study of the recommendations of these manifold interests that the Federal Specifications Board publishes a specification to be used as a basis for the purchase of petroleum products by the Government.

This procedure has helped to eliminate ill-considered requirements, written without full knowledge of all conditions.

Revisions of Specifications

From a study of the outline herein presented, of the successive changes in government specifications for motor gasoline and kerosene, it will be seen that the usual stages have been passed through, which are experienced in any progressive development. In the early days of the petroleum industry in this country gravity was the standard of quality in gasoline. The first government specification for gasoline was simple, and merely stated a few distillation requirements. Successively other requirements were added, and the specification was made more and more definite in respect of methods and apparatus. Probably the apex of this development has been reached, and the tendency now is to eliminate requirements formerly considered essential. The same thing has been true of kerosene, with the exception that in this instance on account of the relatively low price of kerosene and the comparatively low class of service in which it is now used, the tendency has been to liberalize the requirements.

It should also be borne in mind, that slight changes in specifications, usually have an enormous effect in either increasing or decreasing the volume of product which will meet the requirements, and also greatly effect manufacturing costs, and manufacturing losses. Probably millions of barrels of petroleum distillate have been lost in the process of treating gasoline so that it would hold a color of 21 Saybolt or lighter. There is considerable evidence that this portion of the gasoline distillate which was removed to comply with trade demands, was a valuable portion of the distillate.

The changes which have been made in Government specifications have been made as a result of almost continual study of results of the use of products obtained under the specifications, and of conditions in the petroleum industry which effect supply and demand. The exceptional opportunity which the Technical Committee and the Federal Specifications Board have to obtain information of this nature, enables the revision of specifications when the information of the committee has indicated the need for a change.

It might seem that it is a simple matter to set up a suitable specification for gasoline or kerosene, and that once a specification has been written the job is completed. Neither of these assumptions is in accord with the facts. So many factors enter into the drafting of a specification for gasoline, for example, that it is strictly a problem for the specialist, or a group of specialists. Gasoline today is being produced in twenty eight states in the United States. It is made from a great variety of crude oils. Manufacturing processes differ in many respects. The simple straight distillation process which was used exclusively in the early days of the industry, is still in use, but other methods have grown up with it. Instead of one type of crude oil there are now a number of kinds. The cracking process and natural gas gasoline have added new and different conditions to the problems of the refiner, and also to those who are charged with the duty of writing specifications for petroleum products.

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