DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 32

STANDARDS FOR GAS SERVICE

[Fourth Edition]

DECEMBER 7, 1920

PRICE, 20 CENTS

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FOREWORD

The large demand for the three earlier editions of this circular and the favorable comment which they have called forth have clearly demonstrated the value of a publication of this kind. Economic conditions, gas-making practice, and the purposes for which gas is used, change from time to time with the development of the industry, and with such changes should come changes in the various State and city regulations. To be most valuable, therefore, a publication such as this must be revised from time to time to take cognizance of these new conditions. The three previous editions of this circular were issued in 1912, 1913, and 1915, respectively. The preparation of the fourth edition has been delayed on account of the increased demands upon the Bureau incident to the war.

In this new edition the Bureau presents a very complete résumé of State and city regulations now in force defining gas service; and brings up to date the discussion of technical requirements, and its recommendations of rules and ordinance forms. In order to take full advantage of the recent experience of members of its staff and of others throughout the United States with whom it has cooperated, it has been found necessary to extend greatly or wholly to rewrite certain sections of this circular. Those who have used the earlier editions are therefore urged to note with care the more important portions of the discussion, in order that they may have clearly before them the significance of these additions and changes. It is hoped that this revision will increase the usefulness of the publication.

Although a full discussion of the important phases of gas-service standards is included in this circular, there are many minor points, and some items of considerable importance in certain local cases, that have not been comprehensively discussed. The Bureau is glad to make its experience and information available in any such cases at any time by correspondence or conference. Upon request of public officials, gas company representatives, or others interested in any case, the Bureau will be glad to furnish available information, examine proposed rules for service or ordinances, or participate in any proper way in the improvement of gas service, in the adjustment of misunderstandings, or in the clarification of uncertain technical points which lie within its field of activity.

In such work it should be clearly understood as the wish of the Bureau that its suggestions and recommendations be received as only advisory in nature, for the Bureau has no authority and does not desire to assume responsibility either in fixing requirements of this kind or in their enforcement. It is serving solely as a disinterested and impartial agency which holds itself in readiness to assist when desired. Its effort is to serve as a clearing house and medium of cooperation among those who are interested in gas-service standards because of their position in local or State agencies or connection with the public-utility companies.

A careful consideration of existing regulations and the results of their enforcement has furnished much valuable information, as indicating the probable degree of success with which similar rules could be enforced elsewhere. They have thus been a guide in the preparation of this circular, but at the same time summarized data of this character have been used with caution. The opinions and conclusions expressed in the various sections have been reached after many conferences with gas engineers and inspectors who are qualified to express opinions on these subjects. In each case care has been exercised to confirm the statements made and reconcile differences of opinion.

The Bureau has recommended requirements less severe in some respects than prevail in some cities and more severe than prevail in others; not, however, with the idea of striking an average, but rather of specifying the conditions most favorable for maximum economy. If any reader feels that in any part of the following discussion or recommendations for gas regulations the Bureau has departed from this principle, we shall be glad to receive his criticism, and any suggestions for improving such discussion or recommendations will be carefully considered.

S. W. Stratton,
Director.

STANDARDS FOR GAS SERVICE

I. INTRODUCTION

1. MEANING OF STANDARDS FOR GAS SERVICE

In order to insure satisfactory gas service the public authorities have usually found it desirable to establish regulations governing the quality of the gas to be supplied, and setting forth the privileges, duties, and responsibilities of the company in the conduct of its business. These regulations should cover the three general requirements of good service, which are: First that gas of satisfactory and reasonably uniform quality and pressure be available to the consumers at all times and that such gas be correctly metered; second, that the price of gas be reasonable, though adequate to permit the maintenance of the company's equipment at a high state of efficiency and the earning of a fair return on the investment; and, third, that all portions of the municipality or district which are sufficiently populous to warrant it be supplied with gas.

The first of these general requirements defines "Standards for Gas Service," which comprise the conditions which must be defined in respect to heating value, purity, pressure, and measurement of gas and the relation of the gas company to its customers. These questions will receive the principal consideration in this circular. However, the probable effect of such regulations upon the cost and selling price of gas must be carefully considered, for in general any increase in the cost of manufacturing or supplying gas falls ultimately upon the consumer. Therefore only those rules and regulations should be made which really improve the service enough to justify the cost of meeting them.

In the formulation of service rules and in the enforcement of such requirements it should always be borne in mind that these regulations are really a technical specification covering the quality of the commodity and the service to be supplied under a franchise which is in effect a contract with the people. These specifications should not be looked upon as police regulations of the State or the city, but rather as a part of a business arrangement between purveyor and users of gas; and if properly drawn they will protect the interests of both parties to the contract. To do this they

must not only be fair and equitable, but also clear and comprehensive, defining precisely and without ambiguity all the important conditions which it is expected the gas company shall meet in furnishing gas service. The fact that the company is likely without requirement to fulfill certain important conditions is not sufficient reason for the omission of these conditions from the rules or ordinance. And, on the other hand, it is not reasonable or fair to the gas company to omit rules which afford it protection against unreasonable demands or unjust criticism.

2. APPLICATION OF STANDARDS PROPOSED

The recommendations of this circular are generally applicable to coal gas, carburetted water gas, by-product oven gas, oil gas as made in the western part of the United States, and mixtures of these. Many of the sections are also applicable to natural-gas service, but others are obviously not intended for such application. In general the suggested rules and service standards are in a form suitable for use in regulation of privately owned gas companies operating as public utilities, but they are equally applicable as a guide to the operation of publicly owned and operated gas properties.

As pointed out in the preface, the rules proposed in this circular are intended to have no binding force in any locality, but are simply recommendations for the guidance or use of State and municipal officials who may have local administrative or legislative authority. It is to be expected that the general consideration and application of the proposals of this circular will in the future, as in the past, tend gradually to uniformity in standards; but, of course, this should not be carried so far as to neglect local factors which in some cases may be of greatest importance. The extended discussion in the circular makes clear all of the more important of such local factors and the necessary modification of the general rules to care for them.

II. HEATING VALUE

1. SIGNIFICANCE OF HEATING VALUE

(*a*) Importance of Heat-Producing Quality of Gas.—The ability of gas to give off heat when it is burned is the characteristic upon which its usefulness to the average user depends. Cooking, water heating, mantle lighting, and the operation of gas engines and other industrial appliances are dependent primarily upon the heating quality of the gas. It is because gas affords a convenient,

economical, easily controllable, and ever-ready supply of heat which can be made available wherever needed that it is used so generally and in such great quantity.

In the early days of the industry gas was used almost exclusively for lighting, and at that time the brilliancy of its open flame was the quality which was of greatest importance. In recent years, however, it has come to be used more and more for heating purposes; gas ranges and water heaters, as well as many types of industrial appliances, have come into general use, while mantle lights, which also depend for their effectiveness upon the heat in the gas rather than the brilliancy of its open flame, have in most cases replaced the inefficient open-flame burner. Thus ability to produce heat has come to be the most important characteristic of gas, and its open-flame candlepower is seldom mentioned in recently adopted regulations.

(*b*) Meaning and Significance of Heating Value.—The heating value of a gas is the amount of heat which is given off when a unit quantity of the gas is burned. In this country the British thermal unit (abbreviated Btu) is generally used in the expression of the heating value. It represents the quantity of heat necessary to raise 1 pound of water 1° F, though this definition is subject to certain qualifications to make it more exact, as explained below.

The importance of the heating value is obvious. Since heat is what the user wants, a cubic foot of gas having a heating value of 600 Btu will be more useful than one containing 500 Btu; and if an appliance be adjusted to give equally good service and equal thermal efficiency in both cases, the usefulness would be in simple proportion to the heating value. However, if the price of the latter were proportionately lower, the 500 Btu gas would do the required work for the same total cost. Thus the heating value is as important a factor in the usefulness of the gas as it is in the cost of manufacture, and also the proper price to charge for it.

Gas rates are usually fixed by franchise or city ordinance or by State commissions, and the heating value of the gas to be furnished has generally been specified also. The consumer is thus assured of a certain definite quality of product, while the company, if meeting the specified standard, is protected from the charge of supplying an inferior quality of gas.

The fixing of the heating-value standard at such a point as to give the most satisfactory service to the consumer, considering

quality and quantity, is no easy matter. It is, in fact, a problem requiring careful consideration and expert judgment. Economic conditions, practical manufacturing considerations, and the character of various gas appliances in use are a few of the determining factors. Although there are many very important questions to be considered besides the heating value of the gas, nevertheless the initial determination of what heating value should be fixed is usually the most difficult question a regulating body has to decide in the adoption of a set of gas-service rules. It is with a view of explaining some of the factors which should be considered in this connection that this section has been prepared.

2. DEFINITIONS

The heating value of gas in the United States is usually expressed in total Btu per cubic foot. The following definition of this term is sufficiently precise for purposes of industrial and engineering tests:

The *total heating value* of a gas, expressed in the English system of units, is the number of Btu produced by the combustion, at constant pressure, of the amount of the gas which would occupy a volume of 1 cubic foot at a temperature of 60° F if saturated with water vapor and under a pressure equivalent to that of 30 inches of mercury at 32° F and under standard gravity, with air of the same temperature and pressure as the gas, when the products of combustion are cooled to the initial temperature of gas and air, and *when the water formed by combustion is condensed to the liquid state.*

The net heating value of a gas differs from the total heating value in that the water formed during combustion remains in the state of vapor. The net heating value accordingly is less than the total heating value by an amount equal to the heat of vaporization, at the initial temperature of the gas and air, of the water formed in the combustion of the gas. From the observed heating value, as defined below, one may obtain the net heating value by making a correction depending upon the amount of water condensed in the calorimeter.

In addition to the terms "total heating value" and "net heating value," the term "observed heating value" may be used as a matter of convenience in discussing experimental data. The observed heating value for a flow calorimeter may be understood to be the value obtained by multiplying the mass of water which flowed through the calorimeter during the test by the corrected

rise in temperature of the water and dividing by the volume of gas burned, the latter being referred to the standard conditions of 60° F and 30 inches pressure. While it has been the general practice to regard the observed heating value as identical with the total (sometimes called "gross") heating value, this practice is not permissible if an accuracy greater than 2 or 3 per cent is required. However, by the application of a correction, which can be taken from a table of corrections when the atmospheric humidity and the room temperature are known, it is practicable to correct this observed value to the total. In routine testing under average conditions this correction is frequently ignored, but when very accurate results are desired it can easily be applied. Since the observed heating value is almost invariably lower than the total heating value, neglect to apply this correction simply results in reporting a little lower heating value for the gas than it has.

Being a fair measure of the usefulness of the gas to a consumer in comparison with other fuels, which are all rated on their total heating value, the total heating value of the gas, which is the customary standard, is recommended by the Bureau as the most suitable for use in technical specifications.

3. METHOD OF TESTING

The instruments generally used for the determination of the heating value of gases are of the flow calorimeter type, of which the Hinman Junkers is a well-known example. Various makes of this type of calorimeter have found wide use in the gas industries in this country, and practically all of these will meet the present-day requirements of industrial testing. The different instruments give results in excellent agreement with one another when operated with certain easily taken precautions in their use. There are various sources of error that may affect the result found for the heating value to the extent of several per cent, but means have been found to reduce these errors by the exercise of suitable precautions. The various forms of apparatus and directions for their operation are given in Circular No. 48 of this Bureau, entitled "Standard Methods of Gas Testing."

4. EFFECT OF GAS-METER TEMPERATURE AND PRESSURE ON HEATING VALUE

It is customary to make all regulations as to the heating value of the gas on the basis of the heat which can be obtained from 1 cubic foot of gas when measured under so-called standard con-

ditions—namely, 60° F and 30 inches of mercury pressure. The ordinary gas meter, however, registers the number of cubic feet passing through it under the actual conditions of temperature and pressure which then exist in the meter. Gas expands with increased temperature or decreased pressure and contracts when the opposite conditions exist. If, therefore, it is metered at some pressure or temperature other than the standard, the number of heat units available for use by the consumer per cubic foot paid for may be different from the rated number.

The effect of the variation of temperature from 60° F may be considerable in individual cases; but on the average the meter temperatures are so near to 60° F that one would not know whether to raise or lower this figure if a change were to be made. The continuance of the custom of rating the gas as if always measured to consumers at 60° F is, therefore, recommended by the Bureau.

With respect to the influence of pressure [1] a somewhat different condition exists. The barometric pressure is nearly uniform throughout any one city and on the average is constant for any altitude. The day-to-day variations due to changing atmospheric conditions are of no more significance than the corresponding variations in temperature and may be disregarded in the same way. However, the average pressure will be considerably less than 30 inches of mercury at high altitudes. Thus in a city with an average barometric pressure of 27 inches (10 per cent below 30 inches) a cubic foot measured under standard conditions would actually occupy 1.11 cubic feet. However, it is impracticable at high altitudes to make a gas rich enough to have, under the conditions of measurement to a consumer, a heating value per cubic foot equal to that usually delivered at lower altitudes, where approximately standard conditions prevail. Because of this increased volume the heat received per cubic foot of gas as measured by the consumers' meters would average 10 per cent less than under standard conditions.

This does not mean that the consumer living at the lower altitude has an advantage over the consumer at a higher altitude, as under proper regulations the selling price of gas depends upon the cost, and the latter is determined by all the local conditions.

However, in those localities where the average barometric pressure is appreciably less than 30 inches of mercury, it is desirable

[1] The total gas pressure is meant here; i. e., the barometric pressure plus the pressure of the gas above the atmospheric pressure.

to include with any statement published by the regulating authorities the heating value of the gas, not only under standard conditions but also under the average total pressure of the gas in the consumers' meters in order that there shall be no misunderstanding concerning the heat per cubic foot of gas as metered to the consumer.

5. FACTORS INFLUENCING CHOICE OF HEATING-VALUE STANDARDS

(*a*) General Considerations.—Heating-value requirements are of greater importance and have a wider influence than might at first be imagined. They should not only provide for a certain quantity of heat per cubic foot, but should insure to the consumer a gas of such characteristics that its heat may be utilized conveniently and efficiently. Due consideration must be given to the types of equipment and processes of manufacture in most common use, and to the grades of gas-making materials in use or economically available. These conditions may change from time to time, and a heating value correct at the time of adoption may require change later. The gas should be free from excessive quantities of easily condensible hydrocarbon vapors since its heating value and composition can then be maintained more nearly uniform, and a more satisfactory and efficient service to the consumer will result. Ultimate cost to the consumer is of utmost importance. In fact, heating-value regulations should be so fixed as to promote efficiency and good service; or as it is often expressed in other words so that the average consumer will do his cooking, heating, and lighting at the least cost and with the least possible cause for complaint. The determination of the best heating-value standard can not, therefore, be made by the use of any empirical formula, or by averaging the results actually obtained at various places. It must rather be a matter of engineering judgment based on a knowledge of prevailing conditions.

(*b*) Relation of Heating Value and Cost of Service.—At the outset it should be understood that the higher the heating value of manufactured gas the greater will be the production cost per 1,000 cubic feet. Within reasonable limits the number of cubic feet of gas obtained in coal-gas plants from each pound of coal increases nearly proportionately as the heating value of the gas decreases. In water-gas plants high heating values can only be obtained by the use of relatively large quantities of gas oil, which is now more expensive, more difficult to obtain, and of poorer quality than formerly. The cost of producing high heat-

ing value water gas has thus become relatively greater. (See Part XI.) At the same time, with increase in heating value, there is also within certain limits an increase in the usefulness per cubic foot to the consumer, so that the two factors tend to offset each other. It is, therefore, important to determine the point at which the consumer will get the required heat at the least cost, though frequently practical difficulties of rendering good service, as, for instance, maintaining the heating value uniform, may make it desirable to adopt a somewhat lower standard.

In this connection it should be recognized that lowest net holder cost does not always mean the most economical heating value, for distribution costs and fixed charges for gases of different heating values must also be considered as well as the relative quantities which the consumer must use to do the required work.

When once correctly fixed, the standard should be altered only when economic conditions make a change desirable to conserve materials or improve the service. Decrease in heating value as a substitute for increase in rates should receive careful consideration before being made. Increasing costs of manufacture do not necessarily indicate the desirability of lowering the standard. On the other hand, present economic conditions would seem to point to lower heating values in many cases, and such lowering of standards will incidentally in most cases have the virtual effect of some increase in rates. But if the standard is properly fixed to meet the existing economic conditions, any change in it must work to the detriment of the consumer, the company, or both; and in such case it is far better to admit any necessity of increase in rates. In short, decrease in standard should not be given as merely a disguise for higher rates. The basic principle in the fixing of heating-value standards must always be kept in mind: *That heating value is best which, under the conditions which may reasonably be expected to exist in the average consumer's house, will give a uniform, reliable, and satisfactory service for the least cost consistent with providing the company a fair return on its property.*

(*c*) Practicability and Economy of the Standard.—In the fixing of a heating-value standard for gas, practical manufacturing considerations must play a very important part, for a gas which may give efficient service to the consumer may be so difficult or expensive to manufacture as to make its cost high and thus render it unsatisfactory.

In dealing with coal-gas plants in particular, practicability must be one of the chief factors to be considered in determining

the standard. With a given coal, gas of more than a given heating value can not be produced economically. The costs of operation will rapidly increase as this value is exceeded, so that the increased uesfulness per cubic foot of the gas of the higher quality will not compensate for the increase in price that would be necessary. Coals from Pennsylvania, West Virginia, and eastern Kentucky will usually give higher heating values than those of the mid-continent type, such as are found in Indiana and Illinois. But frequently the use of the poorer-grade coals is desirable from an economic point of view, since the lower price of such fuel may reduce the rates for gas sufficiently to bring about a reduction in total cost to the consumer. Thus in fixing a heating-value standard, local conditions and the possibility of using lower grade coal or more readily available fuels should be taken into account.

Not only fuels, but types of equipment should be considered. Coke ovens, for example, usually produce gas of lower heating value than do ordinary horizontal coal-gas retorts. (See Sec. XI.) The lower heating value coke-oven gas will frequently be more economical for the consumer, and any standard which might preclude its use under such conditions would be unwise. Similarly, with many of the improved types of coal-gas benches these conditions hold to greater or less extent. Labor conditions and markets for the by-products must also be considered. The standard fixed should take all of these conditions into account.

The question sometimes arises as to whether coal gas can not be enriched to some higher standard by the addition of benzol or by the gassification of oil. Such a procedure is possible, but uneconomical and in many respects very undesirable. It was done in some cases in the the early days of the industry, when these materials were cheap and when high candlepower was desired. More recently a part of the benzol removed from coke-oven gas has in some cases been returned in order to raise the heating value of the gas to the required standard and to increase the open-flame candlepower. It should be understood, however, that such enrichment as is mentioned above consists in adding hydrocarbon vapors to the gas. If chilled, and gas is always subjected to more or less variable temperature conditions, these vapors will condense and drop out of the gas. Only a portion, and at that a varying portion, will reach the consumer, so that

in addition to receiving only a part of the increase in heating value he also receives a variable heating value which tends to destroy good service. Finally, the use of such enricher will usually increase the cost of manufacture out of all proportion to the gain in heating value, so that ultimately the total cost of the service to the consumer must increase.

Heating value standards should not be fixed so high that enrichment of coal gas, or usually even of coke-oven gas from which light oil has been removed, will ever prove necessary.

On the other hand, a heating-value standard which is unnecessarily low will encourage the admixture of inert diluent gases, which destroy good service to a far greater extent than the mere decrease in the heating value of the gas would indicate (see p. 18); also the plants are more apt to be carelessly operated and apparatus may not be kept in proper repair. Experience has shown that, especially in the smaller companies, unsatisfactory and expensive service is likely to result under such circumstances.

At the time of preparation of this circular the unprecedented demand for gasoline has caused not only a very great increase in the price of gas oil, but an actual shortage of this material which is very serious. Experiments are being conducted in the use of heavier grades of oil, but the practical results of these are not yet available, and it is impossible to say what heating values may be economically obtained in water-gas plants in the future. This is particularly true since even these heavier grades of oil are in great demand for lubrication, internal-combustion engines, our merchant marine, and various industrial uses. The whole oil situation, which vitally affects water-gas production, is thus in an unsettled condition. From present indications it would appear that a considerable reduction in the standards for water gas may be desirable, and in fact necessary in the future. As has been generally recognized in the case of coke-oven gas a lower standard may frequently give a better and more economical service to the consumer than a higher one which presents practical difficulties and expense to comply with.

In the manufacture of water gas the practical limitations of the process itself do not enter as a determining factor of such great importance. Water gas can be made over quite a wide range of heating values. As explained at length in Section XI, water gas is really a mixture of two gases, the one made by passing steam over highly heated anthracite coal or coke, the other by gassifying a petroleum distillate. A decreased heating value caused by a

decreased use of oil will result in some increased use of solid fuel. At the same time, within reasonable limits, the smaller the quantity of oil used per 1,000 cubic feet of gas the greater will be the efficiency of its utilization.

Of course where it is practicable there is considerable advantage in State-wide regulations in having the same heating value for both coal and water gas, especially as very many companies distribute a mixture of these two gases in varying proportions, but it is not clear that the same standard will be practicable for both in the future.

(*d*) Importance of Uniformity in Heating Value.—Thus far the discussion of heating value has been limited to practicability in manufacture and economic advantage to the user. Other considerations, however, must be taken into account. A service which is inconvenient or unreliable is as unsatisfactory as one that is expensive.

It is a well-recognized fact that an exactly uniform heating value can not be maintained from day to day. Slight variations in the quality of the coal, temperature changes in the various parts of the apparatus, atmospheric conditions, and many other minor factors affecting operation may cause the heating value to increase or decrease temporarily. Slight variations are of no consequence, and can be detected only by the use of a gas calorimeter, but considerable departures from normal are invariably marked by serious service difficulties. Deviations above normal are as serious as those below. Any considerable decrease in heating value will cause stove burners and lights to flash back; a large increase will cause blackened mantles and "carboned" cooking utensils with consequent decrease in efficiency. In fact, within reasonable limits, the actual average fixed is often of less importance than the deviations from it. Present-day appliances can be adjusted to give satisfactory service with any average heating value between 500 and 600 Btu per cubic foot provided it is maintained uniform within proper limits. They can not, however, be adjusted to give satisfaction with *variations* of 50 Btu either above or below the average.

The necessity for uniformity has been recognized in the past by most regulatory bodies, though in many cases its importance has not been thoroughly appreciated. In all of the States which have adopted heating-value regulations for manufactured gas, except Connecticut and Massachusetts, and in many municipalities

as well, a minimum below which the heating value must not fall as well as a monthly average requirement is specified. Connecticut and Massachusetts have fixed a minimum value but make no requirement as to the average. A difference of 50 Btu between the average and minimum values has in most cases been deemed necessary; in fact this figure was mentioned in the previous edition of this circular. However, the fixing of a heating value which will result in greater uniformity than this is a distinct advantage.

A standard which is fixed too high is apt to lead to wide variations in the heating value supplied with a resulting unsatisfactory service. If the company must always be straining to comply with it, uniformity can not so readily be maintained. Minor variations in plant operating conditions or in the quality of gas-making materials can not be quickly met and compensated for; there can be, in fact, no flexibility in the process. Furthermore, as mentioned above, gas of high heating value contains larger percentages of condensible hydrocarbons, and even if produced with a fair degree of uniformity at the plant it is more easily affected by changing temperature conditions in the holders and street mains. Thus a more variable and less satisfactory service to the consumer is likely to result.

In the fixing of heating-value requirements, therefore, the Bureau of Standards recommends the adoption of *a maximum and a minimum* as well as an average value. It believes that if the average is properly fixed a company may well be expected never to allow the heating value to exceed or fall below the average actually maintained by more than 5 per cent, and some companies have found it possible to operate within 1 or 2 per cent above and below the mean. Thus in the determination of the proper average heating-value standard, uniformity should be made one of the most important matters. Lack of uniformity will cause dissatisfaction; decrease in the efficiency of gas utilization will result, and the increased demands upon the company to adjust appliances in the end will also probably be reflected in the rates, and hence further increase the cost of the service to the consumer.

(*e*) Undesirability of Very Low Heating Values.—In coal-gas manufacture the use of reasonably high heats and low pressures in the retorts is desirable. The resulting decrease in heating value is accompanied usually by a more than corresponding yield of gas, and the ratio of capital investment to output tends to decrease. Both of these factors tend to reduce the cost of the service to the consumer and have been considered in the

Bureau's recommendations; but, beyond this, reduction in heating value is usually uneconomical and undesirable.

An unnecessarily low heating-value standard for coal gas usually permits the introduction of large quantities of inert diluent gases—carbon dioxide, oxygen, and nitrogen. Small quantities of these inert gases are always present and should be considered as regular constituents, but the introduction of large quantities decreases the heating value and increases the specific gravity, thus changing the characteristics of the gas so that it entrains more air in the burner, though requiring less, while at the same time the flow through the burner orifice is decreased. As a consequence stove burners, if not properly adjusted, are apt to flash back, and other service difficulties much resembling those caused by poor pressure result. In this connection the British Fuel Research Board has recently recommended that the quantity of inert gases should not be allowed to exceed 12 per cent, and it is understood that a 15 per cent limit has been agreed to. With the standards recommended in this circular any such limit is unnecessary and extra testing work would usually be the only result, although conditions in England with the very low heating values in use probably make such a provision desirable. It should be kept clearly in mind that variations in heating value caused by inert gases are more objectionable than those caused by the slight differences in the proportions in which the combustible constituents are present. In one case the altered characteristics tend to destroy good service; in the other they tend to maintain it in spite of the changed heating value.

Water gas, unlike coal gas, can be satisfactorily produced at heating values as low as 300 Btu. However, some present-day appliances are not constructed so as to be adjustable easily for use with gas of heating value less than 500 Btu per cubic foot, and hence might not give as good efficiencies with standards lower than this.

In this country it has not thus far been generally economical or desirable to fix standards low enough to permit the heating value to fall below this point. If in the future, however, low standards are proposed, it should be remembered in considering them that a mere adjustment of present-day appliances would in some cases be insufficient to give efficient service. An alteration in the design of the burners might at times be necessary.

The subject of appliance design and inert gases need not be discussed further in this connection. It is mentioned briefly in

order to explain the necessity for care in fixing heating-value standards and the desirability of having them nearly enough alike in the different States so that appliance makers can supply satisfactory appliances without requiring special designs for particular States.

In some cases, too, plant equipment and distribution main capacity may be insufficient for the increased quantity of gas which will be required by the consumers if a very low heating-value standard is fixed. Claims that a certain heating value allows the maximum conservation of coal or oil should also be carefully scrutinized, for, while such conservation is important, it should be remembered that over-all economy is the important thing, not merely saving of one of the fuels. All of the many other factors and items of cost must be considered also.

6. RESULTS OF STATE INVESTIGATIONS

Four States (Wisconsin, New York, Massachusetts, and Indiana) have made investigations to determine a heating-value standard for their use. A brief consideration of the results obtained is of interest.

The first of these investigations was carried on by Wisconsin during 1907 and 1908, and consisted of an investigation of the quality of gas which was furnished at that time by the companies of that State and a study of conditions attending the operation of these companies. The conclusion reached was that a majority of the companies were furnishing gas of 600 Btu per cubic foot or higher, and that where this condition existed reasonably good service was to be found. A requirement of 600 Btu was therefore prescribed by the commission. Indeed, at that time no other basis than the previous practice could have been chosen, since practically no data were then available as to the relative cost or the relative usefulness of gases of different heating values.

From 1909 to 1912 a committee made up of the representatives of the gas companies and the Public Service Commission of the Second District of New York carried out an extended investigation. In this work the operation of 15 companies was studied by the committee, and information was collected as to the operating practice and probable result of changes in this practice. As a result 570 Btu was recommended as a standard; however, a monthly average heating value of 585 Btu per cubic foot was fixed by the commission, although most of the companies investigated were then producing gas of over 600 Btu. A further requirement stipulates

that no three-day average value shall be more than 5 per cent below the monthly average.

The Board of Gas and Electric Light Commissioners of Massachusetts, in cooperation with a number of the companies in that State, conducted an investigation in 1916 and 1917. The companies were allowed to maintain whatever heating value they desired and the various results were observed. In 1918 a minimum value of 528 Btu, below which the heating value should never fall, was adopted and is still in force. This standard was copied after a French standard; and the commission was further guided in the selection of this relatively low value by the belief that it would aid the companies in producing toluol during the war by allowing greater flexibility of operation. In actual practice the carefully managed companies find it necessary to maintain an average heating value of at least 535 to 540 Btu in order always to comply with the standard, while many of the smaller companies produce a very much richer gas.

An exhaustive investigation has recently been completed in the State of Indiana by a committee composed of representatives of the Public Service Commission of Indiana, the Municipal League of Indiana, the Indiana Gas Association, and the Bureau of Standards. In its report to the Public Service Commission the desirability of a uniform heating value is particularly pointed out. The recommendation is made that the average heating value be fixed at 570 Btu per cubic foot with a minimum daily average of 540 Btu. and a maximum daily average of 600 Btu. In cases of coke-oven plants and other similar processes a lowering of the average to not less than 550 Btu, with daily maximum and minimum values 5 per cent above and below the average fixed, is recommended. The commission has not yet acted on the report.

7. HEATING VALUE RECOMMENDED

(*a*) AVERAGE VALUES.—Under present economic conditions the Bureau believes that average heating value requirements in excess of 600 Btu are not justified. Above this, efficiency of manufacture will decrease. In coal gas the yield will be low; in water gas the oil requirements will be high, and the efficiency of the oil utilization will be reduced. Furthermore, the gas will be heavily laden with hydrocarbon vapors, which are easily condensed by sudden temperature changes, so that the consumer receives a gas of variable heating value.

There are, of course, cases where franchise requirements make necessary the maintenance of a heating value in excess of 600 Btu but where an equitable agreement can be reached the provisions of such a franchise may well be altered with benefit to all parties. These franchise agreements were made at a time when open-flame burners were extensively used. Since then mantle lights, which give usually at least four times the light for the same cost, have come into general use. Mantle lights do not give very satisfactory service on gas of over 600 Btu heating value, and at somewhat lower values even better service is obtained. Blackened mantles, usually the consequence of variable heating value and high hydrocarbon content of the gas, are difficult to avoid under too high standards. For these reasons heating values in excess of 600 Btu are not recommended.

Of the 18 States which have adopted heating-value regulations, 13 have fixed average values between 550 and 600 Btu, while 8 of the latter have fixed these values within the range from 565 to 585. From a consideration of the experience of these States and of the general economic conditions which have existed the Bureau of Standards believes that these values were wisely chosen. However, conditions have somewhat changed during the last few years, the grades of gas-making materials available are on the average poorer than formerly, and at the present time oil for use in manufacture of water gas is extremely difficult to obtain. The importance of uniformity in heating value, and the desirability of distributing a gas reasonably free from easily condensible hydrocarbons has also come to be recognized more and more. As a result, the tendency has been toward lower average heating values, and no State during the last five years has adopted regulations requiring an average heating value in excess of 585 Btu. In general, it is believed that the best value for adoption will be found between 525 and 585 Btu. Where it can be shown that substantial economies will result, and that the public will receive as good or better service because of greater uniformity, and suitable limits are fixed to insure this, values even lower than this may be adopted.

(*b*) Average Values Recommended for Coke-Oven Gas and for Other Special Conditions.—In many cases gas from by-product coke-oven plants has become available for distribution at a rate advantageous to the consumer. As discussed in Section XI, such plants are sometimes arranged so that the gas of high heating value produced during the early stages of carbonization may be

separated from the lower heating value gas produced later. The high-heating value gas is distributed for domestic and industrial use, the leaner gas being used in the plant. Where such an arrangement exists a heating value, the same as that fixed for coal gas, may reasonably be expected.

But such separation of rich and lean gas requires a more expensive plant and is not always practicable. When "run-of-oven" gas is produced, the maintenance of a heating value as high as that for water or coal gas is usually uneconomical. Probably 525 to 550 Btu is all that can reasonably be expected in such cases. If light oil is removed from the gas it may in some cases be uneconomical to require an average heating value even as high as 525 Btu. Special concessions are therefore recommended in the case of coke oven or other similar processes where economic advantage to the consumer can be demonstrated.

In addition to the coke-oven plants, most of which recover light oil regularly, many coal-gas and water-gas plants also did this during the war, in order to provide the Government with toluol for military purposes. In most of these latter cases the practice has been discontinued, but where continued, and where economic advantage can be shown, a reduction in the standard to permit this may prove desirable.

(*c*) Maximum and Minimum Limits.—In any case the fixing of maximum and minimum limits about 30 Btu above and below the average required is recommended; in some cases where a low monthly average is fixed a departure from it of not over 20 Btu should be allowed, and no daily average heating value should exceed this maximum nor fall below this minimum. These limits are, indeed, fully as important as the average requirement.

8. SUMMARY

The heat-producing quality of gas is one of the most important characteristics upon which its usefulness to the average present-day user depends, and therefore its heating value rather than its open-flame candlepower should be specified in the fixing of standards. This heating value is expressed in total British thermal units per cubic foot of gas as measured under standard conditions—i. e., 60° F and 30 inches of mercury pressure.

The fixing of the proper heating-value standard for any locality is a matter requiring careful investigation and expert judgment. Many different factors must be considered, involving the cost, reliability, uniformity, and general satisfaction of the

service which will result following the adoption of the standard. Matters broader in their scope than the mere furnishing of a definite quantity of heat to the consumers are thus involved. The maintenance of a uniform heating value is of especial importance; and if the standard is not properly fixed and suitable maximum and minimum limits placed, such uniformity will not be insured, or it may be even impossible to attain it and impairment of the service may result. The standard adopted must be suited to the prevailing conditions; types of processes in use and quality of gas-making materials economically available all have an important bearing on the subject. As these various factors change from time to time, changes in the heating-value requirements may also become economical and desirable.

In view of these facts the Bureau believes that in most cases a value somewhere between 525 and 585 Btu will usually prove to be the best average heating value standard. With gas produced by special processes, or where coke-oven gas is washed for the extraction of light oil, average values lower than 525 Btu may prove economical. Also, in view of the serious shortage and high price of oil for water-gas manufacture, it would appear that considerably lower standards for water gas may be necessary than have been fixed in the past. The Bureau also recommends that maximum and minimum limits be placed 20 or 30 Btu above and below the average value fixed, and that the daily average heating value be required to remain within these limits.

III. CANDLEPOWER REQUIREMENTS

Gas was originally used almost exclusively for open-flame lighting and naturally, therefore, most of the early requirements as to the quality of the gas related to the amount of light produced in such burners—i. e., to the open-flame candlepower of the gas. However, at the present time cooking, water heating, mantle lighting, and industrial applications of gas consume by far the larger percentage of the total gas made, and in these operations it is the heat given out in combustion of the gas that is of importance to the user. Only a few per cent of the gas distributed in this country is used in open flames, and in fact, probably not over 2 per cent of it should be so used, considering only economy to the consumer.

As a result of this change in conditions, heating value requirements have largely replaced candlepower requirements. In fact the situation has so changed that *there is no longer any justification for the adoption of new candlepower regulations.* In the future it

is to be expected that candlepower measurements will be utilized, not as a test of the quality of the gas, but rather as a test of the performance of gas mantles and gas-lighting appliances and installations in which the heating value of the gas is really the important factor.

Some of the old standards fixing candlepower still remain in force, but it is to be expected that within the next few years many of these will be changed to heating-value requirements. The proper points to be considered in adopting heating-value requirements are discussed in the previous section of this circular. In this connection it should be emphasized that it is very undesirable merely to supplement a candlepower standard by one fixing heating value. The heating-value standard should supersede the candlepower requirement, and the latter should be dropped.

The question is often raised, "What will be the candlepower of the gas supply when the company operates under a heating-value standard?" This question can not be answered definitely. However, with heating values generally being maintained or at present contemplated in this country, most commercial processes will give gas of sufficient open-flame candlepower for lights in cellars or other similar places where open-flame burners can properly be used instead of mantles. There are very few locations where it is not much cheaper and more satisfactory for the consumer to install one of the newer types of small mantle burners, instead of continuing to use the larger amounts of gas necessary with the open-flame lights. Small mantle units cost very little originally and are cheaply maintained; they use only one-fifth to one-fourth as much gas for the same light as does the open-flame burner; thus the saving in the gas bill much more than offsets the small cost of the installation and maintenance.

It is expected that very few candlepower requirements will be under consideration in the future, and therefore it has not been deemed necessary to include in this edition of the circular any discussion of the technical basis upon which these requirements have been fixed or the proper basis for their interpretation. Those who desire to study these phases of the subject should consult the earlier editions of this circular where these matters are discussed in detail.

IV. PURITY—CHEMICAL REQUIREMENTS

From the standpoint of the consumer it is practically immaterial what is the chemical composition of his gas supply, provided it is reasonably uniform and contains no excessive amount of inert

diluent gases and no injurious constituents. At the present time it is generally regarded impracticable to define by regulation the degree of uniformity in composition or to limit the percentage of carbon dioxide, oxygen, and nitrogen, which are the principal inert constituents; but, fortunately, limiting the variation in heating value and requiring an average heating value, which must be maintained regularly, give fairly satisfactory control of these other factors also, so that the present lack of exact requirement is not as serious as it might at first appear.

Because of the fact that carbon monoxide is the only constituent which is poisonous in the amounts ordinarily present, there has been at times some effort made by municipal authorities to limit the amount of it in the gas. However, it is not practicable, and in fact generally undesirable, to place limits on the quantity of this constituent; as a result there are now practically no regulations in regard to its presence. Coal gas contains from 5 to 10 per cent of carbon monoxide, water gas 25 to 30 per cent; limiting the amount might, therefore, limit the percentage of water gas which could be made. It is apparent that such regulation as would prevent the operation of water-gas plants would be very radical and in many cases impossible of enforcement. The fact that water gas is more toxic than coal gas is not a conclusive argument for restricting its use. Economic conditions must also be taken into account.

A large proportion of the cases of death or illness caused by gas poisoning are suicidal, or are due to irresponsible conditions, such as drunkenness, or to gross ignorance; and in the majority of these cases the character of the gas would probably have only a small influence upon the seriousness of the result. Of the remaining deaths and cases of gas poisoning a considerable number are due, not to the illuminating gas itself, but to the carbon monoxide formed by combustion of the gas with insufficient supply of air, as in a faulty appliance or in an appliance improperly set or connected with insufficient or improper flues. It is certain that the protection of the public from danger will be found to lie rather along lines of regulation of appliance form and setting, and general education of gas users as to proper precautions, than in the limitation of the carbon monoxide content of the gas itself.

The three subjects which do demand consideration in fixing gas standards in respect to purity are: Total sulphur, hydrogen sulphide, and ammonia.

1. TOTAL SULPHUR

The total amount of sulphur present in a gas is not wholly within the control of the producer, for it depends even more upon the character of the coal and oil which are employed than upon the methods of works operation. In fact, limiting the sulphur content of gas really places a limitation upon the kind of fuel which can be used. It is essential, therefore, that the limits of sulphur content be not set so stringently as unnecessarily to preclude the use of coal or oil which otherwise would be very economical for gas making. However, the users of gas have a right to expect and should be assured of the lowest quantity of sulphur in the gas which it is practicable to maintain with economy; and a restriction on the total sulphur content should always be made even if the quality of gas-making materials is thereby somewhat restricted in order to prevent the distribution of gas containing such quantities of sulphur as might prove disagreeable or injurious to health.

In general, the total quantity of sulphur in commercial gas supplies does not exceed 25 grains of sulphur per 100 cubic feet of gas. In water-gas production and in coal-gas production with the better grades of coal, this limit need not be exceeded. However, an allowance of 30 grains per 100 cubic feet of gas is desirable in order to give a wider choice in the selection of coals. Much more than this will cause a disagreeable odor when the gas is burned.

Occasionally if a supply of poor coal is received by a small company it is impossible for it to furnish gas of a normal purity until this stock is exhausted. To meet such cases reasonable tolerance in interpretation of the rules is necessary.

In the case of any gas company making as much as 100 000 000 cubic feet of gas per year, regular tests of the amount of sulphur in the supply should be made at least twice a month. Smaller companies can not afford the apparatus and the time of the necessary experienced chemists to make the tests; thus they must depend upon an occasional inspection by the State or municipal authorities, or upon the determinations of the sulphur in the coal and oil which they are using. This determination of the sulphur in the coal and oil is, of course, not an exact measure of the amount of sulphur which will appear in the gas, but it furnishes an indication of the amount to be expected.

2. HYDROGEN SULPHIDE

Any hydrogen sulphide in the gas will form on burning only the same products as the other sulphur compounds which form the

"total sulphur" present; and in the quantities ordinarily present it is no more objectionable than a corresponding amount of any other compound containing sulphur. Substantially all of the hydrogen sulphide can be removed at comparatively small expense. Therefore, to leave any appreciable quantity of this impurity in the gas is unnecessary; and since it always contributes to the objectionable products of combustion, leaving any of it in the gas is very undesirable. It is because the other sulphur compounds can not be reduced, except at prohibitive expense, below a certain figure fixed by the quality of coal or oil and the operating methods, hat it is undesirable to require their complete elimination also. One of the most important reasons for requiring the practically complete removal of hydrogen sulphide is that this necessitates careful management in the previous parts of the treatment of the gas—that is, the condensing and scrubbing—thus the absence of hydrogen sulphide is usually indicative of careful work in the removal of tar and other impurities.

The requirement proposed in this circular, limiting the amount of hydrogen sulphide in a gas to a "trace" is not unduly severe, for it will allow the presence of those amounts which are unavoidable under good commercial plant methods. It is necessary to define what is meant by a trace of hydrogen sulphide; otherwise the rule limiting it has very little significance. However, it is not desirable to set any definite numerical limit (e. g., 1 grain of hydrogen sulphide per 100 cubic feet of gas, as has sometimes been proposed), because the exact determination by quantitative methods of small amounts of hydrogen sulphide is difficult and requires a lengthy procedure in the hands of a trained chemist. The method proposed for detecting objectionable amounts is in effect quantitative and is certainly ample for all conditions of commercial control.

The limit set by the test proposed conforms closely to good commercial practice in its significance. The influence of various changes in the method of test have been carefully investigated by the Bureau in a research which is described in full in Technologic Paper No. 41, entitled "Lead Acetate Test for Hydrogen Sulphide in Gas." The test recommended can be carried out with very simple apparatus by anyone without previous experience, and it requires only a few minutes for its completion. It is entirely proper, therefore, to expect that even in the smaller gas plants a daily test will be made for hydrogen sulphide. However, it should be noted that it often requires one or two days after the detection of hydrogen

sulphide in the city supply to insure its removal from all parts of the distribution system; therefore it should not be expected that the company can immediately eliminate all of this impurity if unfortunately any appreciable quantity of it has been allowed to remain in the supply sent out from the plant.

3. AMMONIA

Although the harm which may result from the presence of considerable ammonia in the gas is sometimes disputed, it is generally believed it has an injurious effect upon the meters and upon gas fixtures, especially brass parts with which the gas comes in contact. It should, therefore, be eliminated from the gas as completely as possible. Practically no ammonia is produced in the water-gas and oil-gas processes, so that these supplies are free from this impurity. In any large coal-gas works the practically complete removal of the ammonia from the gas is effected because of its commercial value. In smaller coal-gas works a large amount of "scrubbing" water is commonly used, and in these instances the amount of ammonia passing into the gas is correspondingly small. However, some small plants with inadequate capacity for cooling and scrubbing the gas thoroughly do not remove the ammonia with sufficient care.

Most coal-gas plants need never permit more than 5 grains of ammonia per 100 cubic feet of gas. However, in a few plants where the capacity for ammonia removal is limited either through the scarcity of cold water or because of inadequate apparatus, it may be necessary to permit as much as 10 grains of ammonia per 100 cubic feet of gas. In a few cases difficulty may be met in preventing the gas once thoroughly scrubbed from being again contaminated by ammonia taken up from water in the holders or distribution system. This condition would, however, be a very exceptional one and could occur only occasionally in hot weather in a coal-gas works.

Any company making as much as 100 000 000 cubic feet of coal gas per year should be expected to provide itself with apparatus and make regular determinations at least twice a month of the quantity of ammonia in the gas supplied by it. Smaller companies must usually depend upon occasional tests by State or municipal officials, but if ammonia recovery is practiced it will often be profitable to the company to have tests made at intervals to insure the maximum recovery of this by-product.

The proposed requirement limiting ammonia is very easy to meet, being much less severe than the ordinary operating practice

of well-managed companies. However, it affords ample protection against any unreasonable amounts of this impurity.

V. GAS-PRESSURE LIMITS

The pressure at which gas is supplied to the user is, with the possible exception of heating value, the most important factor determining the quality of the service rendered. Correct and uniform pressure is of even greater importance than is usually recognized; in fact, reports of "poor gas," "low heating value," and "faulty appliances" are very often found upon investigation to be really caused by poor pressure conditions.

Poor pressure is in practice one of the most difficult conditions to guard against, even for a company which makes every effort to give good service; and although correct rules for gas pressure are not particularly difficult to fix, their intelligent enforcement probably presents greater difficulty and requires more experienced judgment than any other phase of gas-standards regulation. For ideal conditions the pressure should be exactly the same at all times; but this is, of course, impracticable, as there are always large variations in the amount of gas used, and this gives rise to variations in pressure. However, satisfactory service demands sufficient pressure at all times, an excess of pressure at no time, and the maximum uniformity of pressure which it is practicable to maintain. In order to insure this, it is necessary to set limits for the minimum pressure, the maximum pressure, and the variation of pressure on any day. While for satisfactory service proper pressure conditions must be maintained at the burner, yet a departure from these may be caused by conditions on the consumer's premises for which the company is not responsible. The pressure at the burner depends not only upon the pressure which the gas company maintains in its mains and service pipes but also upon the size and character of the house piping as related to the maximum demand of the appliances in use. The gas company should be expected to maintain proper pressure conditions at the outlet of its service pipes, provided the appliances in use do not have an unreasonably high maximum demand as compared with the average consumption. However, any conditions in the house piping, or that part of the service pipe belonging to the consumer, or any additions to the appliances in use which affect the pressure of the gas, are beyond the control of the company and should be cared for by the consumer concerned.

It might perhaps appear that the company should be required to maintain the desired pressures at the outlet of the meters. However, as a practical matter it has been found better to specify the pressure desired at the outlet of the service pipe, which is practically the inlet of the meter, for at this point the pressure is more readily measured, and any measurements generally represent conditions throughout the neighborhood rather than conditions which might be affected by a single meter. It is expected, of course, that the company will keep its meters in good order at all times, so that with satisfactory pressure at the inlet of the meter the conditions at the outlet will also be satisfactory.

There are some instances in which the gas company does not have control over the size of the service pipe connecting the main to the consumer's premises. Under such circumstances, if the size of any service pipe is inadequate for the maximum load placed upon it, it is not reasonable to demand that the company maintain proper pressures at these excessive loads. The requirements of pressure should in such cases be modified to include the phrase, "when gas is being used at not greater than the rated capacity of the service pipe."

In fixing pressure requirements it is inadvisable to make any specifications as to how the company shall meet the regulations. If reasonable time is allowed, the company should be given entire freedom to choose the best methods of accomplishing the final results. Whether it wishes to use more holders, a high-pressure belt line, a booster system, feeder mains with local or district governors, or larger low-pressure mains is immaterial, if the final requirement is met. It should be recognized also that a gas company can not always put in force at once such a system of operation as would meet the requirements which can reasonably be expected of it ultimately. If gas-distribution conditions are such as to make it impossible to distribute the necessary quantity of gas at the pressures desired, the company must be given a reasonable allowance of time in which to make the necessary alterations on its distribution system. However, it is important that the efforts of the company be promptly directed toward meeting proper pressure requirements; and in the interval before they can be fully complied with, temporary regulations, less rigid than those ultimately intended, can be enforced.

After the pressure conditions are once established in a satisfactory way throughout a city, it still means continued vigilance in order to keep them so. Growth of the city, shifting of popula-

tion from one district to another, changes of seasons, new industrial business, and many other factors must be expected and anticipated so far as possible in order that the service will not suffer. Not all of these conditions can be anticipated, but regular pressure surveys throughout the entire territory supplied by a company will do much to point out additions or changes required in the distribution system. Continuous records at a few important points on the system should also be maintained and the results from month to month and year to year carefully compared so that gradually changing conditions will be promptly noted. All these conditions are met if the proposed regulations covering regular pressure tests are complied with.

The following sections covering the important features of good pressure conditions contain recommendations quite generally applicable, but certain special conditions occasionally require their modification for some localities. However, such modifications will generally be in respect to the time which must be allowed before a company can comply with the rules, rather than any change in the rules themselves.

For a more complete understanding of the meaning and importance of pressure regulations, the discussion of gas distribution methods in use in this country, given in a later section of this circular, will be of assistance.

1. MINIMUM-PRESSURE LIMITS

A gas user may properly expect a sufficient gas pressure at the end of the company's service pipe, so that with reasonable size of house piping his appliances and burners of the ordinary forms can be operated conveniently and efficiently. To insure this, it is usually required that the pressure never falls below a minimum of 1½ or 2 inches. In general, however, reasonably satisfactory operation of domestic gas appliances can not be obtained unless the pressure is always above 2 inches [2] at the outlet of the service pipe.

As pointed out in the following section, maintenance of the necessary uniformity in pressure demands that the maximum at no time exceed twice the minimum on the same day. With a low minimum pressure this means a small permissible variation. In general, therefore, a minimum below 2 inches introduces a limit of variation that makes compliance very difficult. Furthermore,

[2] In manufactured-gas practice it is customary to express the pressure of gas in terms of inches of water column above atmospheric pressure. In natural-gas practice ounces per square inch is commonly used as the unit of pressure measurement. One ounce per square inch is equivalent to 1¾ inches of water.

a minimum of 2 inches at the service outlet is essential if the meter, house piping, or appliance connections happen to be smaller than required by the best practice. Because of these factors there is an increasing tendency to specify 2 inches rather than 1½ inches as the minimum permissible.

In the interpretation of minimum pressure regulations it should be understood that a company can not reasonably anticipate changes in the number or character of appliances used or large increases in the demand for gas, unless previously notified by consumers. The cooperation of the users of gas with the company in this particular is essential if satisfactory service is always to be had.

A sudden drop in pressure with subsequent rise to normal, such as might in rare cases extinguish lights or cause "snapping back" of stove or mantle burners, is a most serious condition to be guarded against. However, it is not intended that the minimum pressure limit shall guard adequately against these dangerously low pressures, for they constitute what are really interruptions of service. This matter is discussed further under this latter heading. (See p. 37.)

2. MAXIMUM-PRESSURE LIMITS

There has been a gradual tendency in gas distribution toward maintenance of higher pressures, first, because of the increased amount of gas which can be sent through a pipe of given size, thus continuing the use of mains otherwise insufficient in capacity; and second, because of the feeling that greater efficiency in the use of gas is possible at higher pressures. It is believed, however, that from the standpoint of the user the tendency toward higher pressure can easily be carried too far; and even considering only the resulting advantage to the company, one must set against the advantage of increased main capacity at higher pressures the increased leakage which may become serious, especially with old distribution systems. Where economy in distribution demands higher pressures, replacement of any defective portions of the systems should therefore be made. Efficiency in the use of gas can be maintained, even though high pressures are necessary in the distribution system, by use of a proper type of service regulator, which will cut down and maintain uniform the pressure of gas in the consumer's house piping. It should be understood that the limitations proposed in this circular in no case apply to

the pressure in the mains, but relate only to the pressure maintained in the consumers' premises which can by use of regulators be kept as much lower than the main pressure as is desired.

Under present conditions it is probable that pressures should not exceed 6 to 8 inches at the outlet of the service pipe to each consumer, except where appliances have been carefully adjusted for efficient work under higher pressures. In a few cases where it has been customary to supply gas at higher pressures and the consumers' equipment is suitable for this, changes in operating practice would, of course, not be essential. In this connection, however, it should be recognized that the consumer can not be trusted to regulate his appliances, especially when the pressure goes above 6 to 8 inches; and, moreover, he is generally incompetent to judge for himself whether these higher pressures are desirable for his use. For industrial applications of gas higher pressures should, of course, be permitted where desired by the user, and this condition is anticipated by the form of rule proposed.

When a particularly high area is supplied and the maximum pressure is limited, the use of pressure governors may be necessary to prevent undue increase in the pressure of gas at the higher level. The increase in pressure due to elevation above the source of supply is from one-half to 1 inch of water pressure for each 100 feet difference in level, varying with the density of the gas and being larger with coal gas than water gas. The difference also depends on the quantity of gas being used, since the friction of the flow from the lower to the higher level may at times of large use more than offset the influence of difference in level. Where intermediate or high-pressure supply lines are used to feed the distribution system through district regulators it is not usually practical to make these regulators absolutely tight, and so at times when very little gas is being used, especially between midnight and early morning, the pressure may build up beyond these governors in a way that the company can not altogether control. Thus high altitudes or slight difficulties with regulators frequently introduce excessive pressures during hours when little gas is used, but such conditions are not serious and should not be regarded as violations of the pressure regulations. Pressures up to 12 or 15 inches at these times of the night will not be dangerous and the slight inconvenience to the few persons using gas at such hours is not serious.

3. ALLOWABLE PRESSURE VARIATION

The maximum and minimum pressure limits discussed in the preceding sections refer to the entire distribution system. They must be supplemented by a requirement limiting the variation in pressure at any single customer's premises; in fact, variation between these extremes would not be permissible at any one point, since an appliance which is adjusted to suit any particular pressure does not render best service at any pressure differing greatly from this. A limitation which has commonly been set upon the variation of pressure has been that the maximum at any consumer's service outlet on any day shall not be greater than twice the minimum on that same day at that same service outlet; or, expressed in other words, that the variation shall not be greater than 100 per cent of the minimum pressure. Ordinarily this is a satisfactory regulation, but when the minimum is more than 3 inches the variation allowed by it is greater than is necessary with good gas-distribution practice. It seems better, therefore, to limit the variation permissible in terms of the number of inches of pressure difference allowed between the maximum and the minimum at any single point in the distribution system. For this purpose the following schedule showing the maximum variation permissible for different minimum pressures is suggested:

Minimum	Greatest variation permissible
2 to 3 inches	2 inches.
3 to 4 inches	2½ inches.
Over 4 inches	3 inches.

It might seem that this more stringent system of limiting the pressure variation would be unnecessary, for an equal percentage change in pressure produces about the same effect upon the gas consumption at one pressure as at another. For example, doubling the pressure by an increase from 2 to 4 inches produces practically the same effect on the amount of gas consumed as does doubling the pressure by changing from 6 to 12 inches. However, with a minimum pressure of 4 inches or more, if the maximum is twice the minimum, a greater variation is permitted than is usually essential under careful and economical operation; and where the cost of distributing the gas is not thereby seriously increased it is better to limit the variation more strictly, although, of course, in any case too stringent regulations may necessitate

unduly large investment in the distribution system and, therefore, an unnecessarily large cost of distribution. It is believed, however, that such regulations as are proposed in the preceding paragraph will usually improve service sufficiently to justify the expense incurred in meeting them. Where this is not the case less stringent requirements should be fixed.

These regulations as to variations in pressure may well be waived during the hours from 10 p. m. to 5 a. m., when there is very little gas being used. It is evident that were this provision not made, a company, finding it necessary to maintain 7 inches pressure near the plant at times of maximum demand in order to give 2 inches pressure in the outlying districts, would be forced to keep up 4 inches pressure throughout its distribution system during the night. But the leakage which inevitably occurs in all such systems will be approximately 40 per cent greater at 4 inches than at 2 inches pressure. A change in pressure beyond the usually allowable limits of variation is therefore frequently desirable during periods of very light demand. Economies will be effected which will eventually be reflected in the cost of the service to the consumer, while the decrease in the quality of the service in a part of the system during the night will be unimportant, because of the very small quantity of gas being used. However, under no circumstances should the pressure fall below 2 inches in any part of the system, nor should it exceed 8 inches except where differences in elevation or medium-pressure systems feeding through district regulators make compliance with this maximum impracticable during the night, as previously discussed under "Maximum pressure limits."

In view of these facts the Bureau recommends the above form of regulation, of course with the understanding that it may require some time before full compliance can be expected from any gas company, if its distribution system is initially not wholly adequate.

It is customary for the pressure variation to be limited on the basis of the pressures at any service outlet on a single day. This has usually been deemed sufficient, because the greatest variation which will ordinarily occur during a considerable period of time is no greater than the variation during the worst day of that period. In other words, it is usually the condition of the system on days of peak load which determines the severity of the limitations imposed. However, it is not permissible that the average pressure maintained in any district be changed from season to season or year to year without affording the consumers the pro-

tection against poorly adjusted appliances under the new conditions of pressure. The rules proposed, therefore, include the requirement that the company must provide for the readjustment of appliances whenever it desires to modify the pressure conditions so radically as to make this necessary.

In order to give somewhat greater freedom of choice to the companies, the Bureau in a former edition of this circular suggested that the company determine the normal pressure which it desired to maintain in different districts of a city and then be expected to supply gas always at pressures closely approximating the normal chosen. This regulation has been followed in a few cases, but with the latest available information—namely, that pressures above 6 to 8 inches are usually undesirable, there seems little need for this form of regulation. The Bureau is, therefore, now of the opinion that the older, simpler form of regulation is at least as good, if not better, for most circumstances. Where regulations allowing the company to choose the normal are in force, it is only necessary for the company to fix 4 inches as a normal for its entire system and the regulation then is in effect identical with one placing the limits at 2 inches minimum, 6 inches maximum, and a variation not greater than 100 per cent of the minimum.

4. MOMENTARY AND PULSATING VARIATIONS OF PRESSURE

A momentary variation of pressure is a change of pressure of short duration, usually almost instantaneous, which does not recur periodically. A pulsation in pressure is a regular recurrence of changes in pressure either above or below the normal, each change being of short duration, usually almost instantaneous, and of approximately the average amplitude. Such conditions are decidedly detrimental to the business of the gas company and it may be counted upon to take prompt action in every case without official requirement that it do so. In fact, with one exception, no attempt has been made to restrict these momentary or pulsating pressures by official regulations. In the report by William A. Baehr to the Commission of the First District of New York State this question has been carefully considered, and the gas companies in the boroughs of New York City are now operating under regulations on this subject. The following rules which are now in force there seem to be met and to be giving satisfaction:

5. On and after January 1, 1913, the maximum momentary pressure variation (defined as a sudden increase or decrease of pressure, practically instantaneous, and not recurring with regular periodicity or frequency, nor necessarily with the same amplitude) at the consumer's end of the company's service pipe to any consumer shall

not exceed a total range of eight-tenths ($\frac{8}{10}$) inch water column on two consecutive days.

6. On and after July 1, 1913, the maximum pulsating pressure variation (defined as a sudden increase or decrease of pressure of short duration, practically instantaneous, and recurring with regular periodicity or frequency, and usually with approximately the same amplitude) at the consumer's end of the company's service pipe to any consumer shall not exceed a total range of eight-tenths ($\frac{8}{10}$) inch water column on two consecutive days. On and after January 1, 1914, said maximum pulsating pressure variation shall not exceed a total range of five-tenths ($\frac{5}{10}$) inch water column on two consecutive days.

5. PRESSURES FOR NATURAL-GAS SERVICE

In natural-gas service for equally satisfactory appliance operation, higher pressure is necessary than is required for manufactured gas. This is because of the somewhat different characteristics of the gas. The previous discussion relating to minimum and maximum pressure is, in general, equally applicable to natural-gas service if ounces per square inch are substituted for inches of water pressure and the same numerical limits utilized. For natural-gas service the same limits of pressure variation—that is, the maximum not to exceed twice the minimum on the same day at the same service outlet—is essential for thoroughly satisfactory service; but the much greater fluctuation in demand upon natural-gas systems between winter and summer seasons often makes a limit as close as this impractical. Because of this difficulty it is dangerous to make any generalization as to how closely the variation in pressure of natural-gas supplies can be limited. The same principles hold as for manufactured gas, but the lower cost per 1000 feet, introducing much greater demands for gas in heating and industrial work, must always be considered as also introducing new factors which demand consideration in the fixing of requirements for such localities.

VI. METERS AND METER TESTING

Since the record given by a meter of the amount of gas passed is the basis of settlement between the company and the consumer, the importance of correct meter registration is evident. The consumer is justified in expecting that his meter will be correct when installed, and also that it will be retested at sufficiently frequent intervals so that any discrepancies which develop subsequently will probably be detected promptly in a routine way. In addition, arrangement must be made for special tests when there is any reason to suspect a particular meter of error; and a basis for adjustment of such errors when detected should, of course, be provided. The rules proposed covering meter accuracy and test-

ing provide for all of these contingencies. The fact that some meters may become "fast" and thus result in bills too large, and others "slow" or "D. R." (don't register), making other bills correspondingly too small, does not make frequent meter testing of less consequence to a gas company. For to neglect meters and permit them to become inaccurate with the complaints which inevitably result is a condition not desired by any company. And the gas-using public can well afford a reasonable expenditure for meter testing in order that each user may be protected from possible excessive charge. With careful planning and proper management this supervision of meter accuracy is worth all that it costs as an insurance and the cost is distributed, as it should be, over all gas users. In some cases the testing work desired is carried out by State or municipal officials, who actually check every meter before it is installed for use on a consumer's premises and check them again when removed. In general, however, this is not necessary, as a gas company can do this work accurately and more economically than is usually possible in municipal and State laboratories. Moreover, even with State or city inspection practically all of the necessary testing work must be duplicated by the gas company as a part of the routine meter repair shop practice. In this way State or city inspection of every meter is likely to result merely in duplication that creates an unnecessary expense. The work done by the company can readily be supervised as to apparatus, methods, and records; and in this way at very little expense the public official having local jurisdiction over matters of gas service can insure accurate and regular work in the company shops, without the necessity of any duplication. The extent to which these details of the company's work need be prescribed in advance is clear from the proposed rules.

In any city where the gas company has as many as 500 meters in service it should certainly be required to purchase and use a standard meter prover to test its meters regularly, as provided in the rule. Where fewer meters are in use it may often be more economical to arrange with a larger company in a near-by city to do the necessary testing work, but under any circumstances regular testing should be maintained and the facilities for this work be readily available.

1. ACCURACY REQUIRED

The custom sometimes followed in the past, of putting a meter back into service without adjusting it, if it is found to be less than

2 per cent in error, is not satisfactory. It is recommended that meters be adjusted with the highest accuracy commercially practicable before installation. A tolerance of 1 per cent fast or slow is sufficient for any company which carefully supervises its meter shop. With such tolerance meters will start in service as nearly correct as it is practicable to have them. It is possible to set all but a very few old-style meters correct within one-half per cent on every adjustment, and these older styles can be set correct within 1 per cent. In all but the smallest companies it is proper, therefore, to require that every meter be set within 1 per cent of correct before it is put into use. Of course it is understood that the allowance of this variation from correctness does not mean that the meters will be set in error by this amount; the tolerance allows only for the unavoidable irregularity of the work on a commercial scale, and the average of the errors will be practically zero, substantially as many being slightly slow as are slightly fast.

In a company which has less than 1,000 consumers and which does not have facilities for opening meter cases and adjusting the mechanism, it is probably wise to allow a somewhat greater tolerance than that above mentioned. In such cases the company should be allowed to put a meter back into service without readjustment, if it is not in error by more than 1½ per cent and appears otherwise in good order, rather than to incur the expense of shipping the meter away to a meter shop.

While a meter should be set to be correct within close limits before being installed, it can not be expected to retain this very high degree of accuracy throughout the period of its use. In fact, it should not be classed as a fast or slow meter unless it is found to be in error by more than 3 per cent. Up to and including this amount neither the consumer nor the company, as the the case may be, will have suffered any appreciable injustice.

2. FREQUENCY OF ROUTINE TESTS

As indicated above, it should be required that all meters be tested before installation for use on the consumer's premises. This would apply not only to old meters which have been repaired or removed from service for any cause, but also to new meters. The testing of a meter which is purchased from a manufacturer may seem unreasonable, for these meters are supposed to be very carefully adjusted. However, the gas company is responsible for the condition of the meters and the manufacturer's adjustment should not be depended upon.

Since a large part of the expense in routine testing of meters is the result of the time required to remove a meter and replace it by a new one, it works no hardship to require that every meter be tested before installation, even though it has been tested only a short time previously. Most companies, because of this fact, never reset a meter without retesting it, even though it may have been out in service only a few months.

The experience of many companies and State and city officials would seem to indicate that once in five years is approximately the right interval to specify for this periodic testing. If too frequent tests are required, the expense is excessive; on the other hand, if too long an interval is allowed the number of meters in error by appreciable percentages becomes too great.

The purity and character of the gas will influence the length of time meters will retain their accuracy. Gas containing excessive quantities of sulphur, ammonia, tar, or oxygen will cause a rapid deterioration of the meter diaphragms, with the result that the meter will soon be in error; also the dry gases of low heating value which are coming to be distributed more and more have the tendency to dry out the diaphragms more rapidly than those of higher heating value. This whole subject is being investigated by a committee of the American Gas Association, and it seems likely that means for preserving meter diaphragms from the drying action of low heating value gases may be found which will result in substantial increase in the time meters may properly remain in service without retest, provided the gas is free from impurities. In the adoption of rules such further information as may become available subsequent to the publication of this circular should be given due consideration.

Under present conditions five years is probably about the right period to fix for routine testing. This will require that about 30 per cent of the total number of meters installed be tested each year, including not only the routine tests, but also those removed from service through the change of consumer, complaints, and special work of various sorts. The reason that a shorter period might work a hardship is evident when one realizes that a four-year removal rule means that 35 per cent be tested each year; a three-year removal rule, that about 45 per cent be tested each year, etc.

Because of their greater importance, meters larger than 10-light size will usually be tested more often than the smaller meters.

However, this can be left to the judgment of the company, as it must watch these larger meters closely for its own protection.

When a new meter rule goes into effect the initial testing of old meters then in service is an important consideration. As soon as the work can be undertaken, those longest in use should be first tested; and within a reasonable period all of the old meters should be brought in, tested, and if necessary adjusted, as the initial series of periodic inspections. After this all meters should be tested at regular intervals.

3. TESTS ON REQUEST OF CONSUMER

Although tested at regular intervals a meter may, because of any one of numerous factors, become somewhat in error, and this through no fault or carelessness of the company owning it. In order that whenever such a condition is suspected the consumer can be assured as to the accuracy of the meter in use on his premises, there should be a provision that the gas company will, under reasonable conditions, test his meter on request. The proposed regulations incorporate this idea. Although it might be feared that a large number of complaints would be lodged under this rule, and thus a great expense incurred for meter testing, actual experience in States where similar rules are in force shows that only a small number of tests have to be made under such a requirement as this. Complaints which are well founded are met by observing such a rule, and the company gains more than enough to compensate for the expense incurred. It is generally admitted that no fee should be charged for tests made of a gas meter upon the request of the consumer unless such test is requested with undue frequency.

It is generally better that the gas company should have the opportunity to make tests upon request of the consumers, and thus adjust its accounts like any other business organization, rather than that all complaints of suspected meter error should go at once to the city or State inspectors. There is no reason to believe that a gas company will take any advantage of the consumer in the sense of improperly testing or incorrectly adjusting meters. When the work of the company is properly supervised by State or city authorities, persistent errors of this sort could not escape detection, and the consumer need not anticipate any deliberate overcharges of this sort.

However, a test to determine the accuracy of the meter should be made by the company only if the consumer is satisfied in ad-

vance to accept the results of such test as the basis for adjustment of the accounts which are suspected of being in error. This is an essential condition on the score of justice to the gas company. Moreover, if a meter has been tested by the company usually it will avail nothing if it is again tested by the city or State officials, even though the consumer does not feel satisfied with the result of the company's test; because during the first test there may be a change in the meter diaphrams, and then a second test is not of any significance as to the condition of the meter before removal from the consumer's premises. Unless the consumer is willing to accept the results of the company's work it is better, therefore, that he should secure a test by the city or State officials in the first place.

If a consumer desires a test by a city or State representative he should be expected to pay the expense of this test unless the meter is actually found in error to his disadvantage, in which case the gas company can properly be charged the expense of the test. The basis upon which these tests by city or State authorities can properly be made and the fees adjusted is indicated in the proposed set of rules. The amount of the fee should be made as nearly as practicable equal to the total cost of the test, not only the cost to the city or State, but also that cost incurred by the company in removing the meter for test and replacing it with a new one. If the fees are not made adequate to cover the expense, the condition may arise that a company will ask the officials to do the testing work on large meters at nominal fees, and thus the city or State will be incurring some expense that should be borne in the meter-testing department of the company. In one or two instances this has actually been the experience of officials working under a fee system not adequate to provide for the actual expenses incurred in the work.

Whenever a test is made by either company or public official at the request of a consumer, the consumer should be encouraged to be present personally or by representative at the time the test is made so that he can satisfy himself that the work is fairly and carefully done. The actual supervision of the work which the consumer can exercise is of course small, but the psychological advantage of thus handling the case openly and frankly is considerable.

4. ADJUSTMENT OF BILLS FOR METER ERRORS

In case meters are found to be fast by more than 3 per cent as a result of tests made upon the request of the consumer either to

the company or to the public officials, the probable excess in charges during the previous period of use of this meter should be refunded to the consumer and any fee deposited for the test returned. However, it is usually impracticable to determine just when a meter began to be in error, and *it should not be assumed that the meter has been coming to the error found at the time of test gradually and uniformly during the entire period of its use.* In general, therefore, the best results are obtained if the refund be made on the basis of the six months immediately preceding the time of its removal from service. Thus uniformity of refunds is accomplished and much quibbling between company and complainant is saved, to the advantage of both.

Likewise if a meter, on such test made at the request of a consumer, is found to be more than 3 per cent slow, the company should be entitled to make proper additional charge for gas probably consumed but not registered for a past period not to exceed six months.

In routine testing where a meter is found to be fast some companies make it a practice to refund to the consumer any excess estimated to have been charged. On the other hand, as a practical matter it is usually very difficult to collect from consumers any deficiency where meters are found to have been slow. In this connection it should be noted that a meter which is in proper adjustment when installed may run any amount slow and even fail to register gas at all, but it is exceedingly rare to find one as much as 8 per cent fast. Thus, except in the case of large consumers, the refund will be very small and hardly worth the additional cost of the bookkeeping, etc., necessary if such refund were made, all of which costs will eventually be reflected in the rates for gas. However, some companies make such refunds as a matter of public policy. In any event a statement of the practice of the company regarding refunds to consumers on meters found fast upon routine test should be filed with the commission as part of the company's rate schedule.

VII. GENERAL SERVICE REQUIREMENTS

1. PLANT AND OPERATION

(*a*) PLANT INSPECTION AND MAINTENANCE.—In the operation of any public utility it is important that the plant and facilities be maintained in as high a state of efficiency as practicable. This makes it possible to render safe, adequate, and continuous service.

In gas utilities regular inspection of the plant and equipment is essential in order to accomplish this. Public-service commissions have come to recognize this fact and requirements as to inspections are now quite general.

(*b*) Operating Records.—All well-managed utility companies keep more or less complete operating records for their own information, even though there are no municipal or State regulations on the subject. It is, however, none the less desirable for a regulatory body to require that certain records be kept, and even in some cases to specify the form in which they shall be kept. Information which it may from time to time require is thus readily available. If such records are kept it is unlikely that inefficient operation or undesirable practice will continue long before it is brought to the attention of the management. For this reason, if for no other, the requirement that certain records be kept is desirable. The important records which should be required are suggested by the rules recommended in Section IX.

(*c*) Interruptions of Service.—One of the first principles of gas-utility operation is that under no circumstances should gas service be interrupted. Cases where the gas supply fails throughout the entire system are not common, and among the larger companies are exceedingly rare. However, even with the most skillful and best-intentioned management interruptions in the service may occur from time to time. Since such interruptions afford a basis for complaint and may give rise to accidents, a record of all such interruptions should be kept.

(*d*) Accident Records and Reports.—In some States the public-service commission which has charge of standards for service is also responsible for the supervision of safety precautions; the accident records of the utility companies therefore come within its jurisdiction. Even where a State industrial commission is responsible for this work, it is desirable that the public-service commission also receive reports on all accidents that involve the utility and the public or may directly or indirectly affect either the quality or continuity of service rendered. Where no other agency is charged with the duty of investigating the cause and means of preventing recurrence of accidents, it would be well for the public-service commission to give such attention to this subject as is feasible under the local circumstances, since interest in the subject is thereby increased and exchange of experience between companies is facilitated, to the advantage of all concerned.

2. TESTING AND REPORTS

(*a*) TESTING METHODS AND FACILITIES.—The rules recommended for State regulation and the ordinance form proposed for municipal use both indicate the extent to which the gas companies or the municipal inspector should make tests. The methods to be used and the equipment or facilities required in this work are described in full in Bureau of Standards Circular No. 48, "Standard Methods of Gas Testing." In a number of cases it has proven desirable to indicate that the work done under such regulations must be conducted in accordance with the recommendations of that circular. In any event it should be prescribed that the apparatus and equipment provided should be complete and of a form acceptable to the supervising authorities. It is especially desirable that the commission be advised regarding the location of testing stations which are being established by companies under their jurisdiction so that the results obtained may be representative of the conditions specified in the rules. Apparatus which requires inspection or calibration before use would, of course, be subject to such examination by the supervising authorities.

(*b*) RECORDS OF TESTS.—The records of tests of gas quality or service should be preserved in a complete form in order that the nature of the test and its significance may be clearly evident upon the test record itself. It is very undesirable to trust to the memory of the inspector or assistant making tests for any important conditions or details pertinent to the inspection; and of course it is expected that all such records will be preserved for an adequate length of time, usually two to five years, in order that the service at any particular previous period may be a matter of record. It is desirable that summarized results of all tests be made available to properly authorized local officials, as well as State representatives, so that the actual conditions existing in a locality may be determined by anyone having a reasonable ground for interest in them. Proper publicity will go far toward eliminating a feeling of suspicion regarding the quality of service rendered.

(*c*) RECORDS OF METERS AND METER TESTS.—In the rules suggested by the Bureau there have been indicated the important records as to meters and meter inspections which should be kept. Careful attention to these records by the supervising officials of the gas company, as well as by the representatives of the State commission technical staff, will usually reveal promptly any condition which demands special attention. For example, an unusual number of meters found defective or out of adjustment for

any particular cause would be quickly revealed if it were the practice regularly to go over the records of meter tests and note unusual results. Means for the correction of such faulty conditions could promptly be taken before serious consequences became general throughout a certain class of meters or even throughout the entire territory served. This point is especially emphasized, as too often these records are assumed only to be of interest as setting down past history, and are only seldom given the attention which they merit as an aid in anticipating trouble or correcting faulty conditions.

(*d*) Reports to Commission.—When requested, the companies should transmit to the commission reports of the quality of service rendered, heating value, pressure conditions, etc., but the company should not be put to the expense of compiling such reports unless real use is to be made of them. If such reports are regularly examined by the engineering staff of the commission, helpful suggestions to the companies as to improvement of service and efficiency will often result, and at the same time a more intimate knowldege of conditions throughout the State will be possible by the commission.

Publication by the commission of reports as to service conditions will also often dispel unwarranted suspicion on the part of the public. A frank presentation of facts is frequently a most effective method of encouraging good relations between a company, its consumers, and the public officials charged with the supervision of relations between these two interests.

3. RELATION OF COMPANY AND CONSUMERS

(*a*) Complaints.—Frequently consumers' appliances get out of adjustment or unforeseen service conditions arise which give the consumers real cause for complaint; but also, because of their unfamiliarity with meters and with the difficulties of gas manufacture or distribution, they sometimes complain without reason. However, the public pays both for the gas which it uses and the cost for inspection and supervision of service; it is therefore entitled to courteous and patient treatment when complaints are made either to the company or to the public officials. There is no question but that most gas managements recognize these principles and do their best to satisfy the public, as well as to serve it fairly.

It is highly desirable that where complaints of service are received by the State commissions or city authorities they coop-

erate with the company in the investigation of the trouble, rather than merely order the company to remove the cause of the difficulty. On the other hand, these officials should encourage the public to go directly to the gas company with its difficulties and complaints, in the confidence that the company will treat these fairly and thoroughly, so that to the maximum possible extent the relations between company and consumer may be adjusted by the parties themselves. Of course, records of all formal complaints should be made and such records should be examined by company officials from time to time, as the information in them should serve as a guide for improvement both of service and of public relations.

(*b*) INFORMATION FOR CONSUMERS.—It is generally required that each utility shall preserve for the information of its consumers a record of the rate schedules, the rules or standards in force through the local and State authorities, and similar information. It is also desirable that a company provide means for assisting its consumers upon request to secure more efficient service, to learn how to read the service meters, and in every other way to make clear any matters connected with that part of the business with which the customer comes in contact. A requirement to this effect is therefore recommended in the proposed rules.

(*c*) METER READINGS AND BILL FORMS.—It is highly desirable that a consumer be able to determine from an examination of his monthly statement alone the basis upon which charge is rendered. The requirement that the bill show meter readings and the pertinent portion of the rate schedule is therefore desirable.

(*d*) DEPOSITS FROM CONSUMERS, METER RENTALS, AND SPECIAL CHARGES.—Charges such as these are really part of the business arrangement between the utility and its consumers, and as such many commissions consider them to be outside the scope of service rules. It is, of course, fair that deposits be required of consumers unknown to the utility to guarantee payment of bills, and that it be definitely understood that the utility is justified in charging for certain work. It is important, however, that deposits should not be excessive and the consumer be assured of the return of his deposit when he ceases to use the service; that charges for work done be reasonable; and that there be no unjust discrimination between consumers or classes of consumers. Therefore, those commissions which do not include in their service rules provisions covering these matters usually require the various utilities themselves to prepare such regulations and file them with the commis-

sion for approval as a part of their rate schedules. This general method has the advantage of allowing considerable flexibility to meet local conditions, and where in use has been successful.

Since matters of deposits and special charges do affect the public relations of utility companies, about one-half of the commissions which have adopted state-wide regulations have considered it proper to cover one or more of these subjects in them. For those who share in this view, and also as a guide to utility companies as to the subjects which it may be desirable to cover in preparing such regulations, matters of deposits from consumers and other special charges have been included among the "Proposed Forms of Regulations," (Sec. IX).

(*e*) DISCONTINUANCE OF SERVICE.—In the same way that certain charges are referred to in these rules, although not strictly matters of service, some commissions have considered it desirable to include a limited statement of when service should be cut off from any consumer or class of consumers. It is, of course, a fundamental principle that service should be cut off whenever considerations of safety to life or property make it necessary. Reasonable notice of discontinuance of service should be given in all cases where practicable. Where not covered in State-wide regulations, rules regarding discontinuance of service for failure to settle accounts should be adopted by each company, subject to the approval of the commission, and then be made a part of the rate schedule of the company.

VIII. ENFORCEMENT OF TECHNICAL REGULATIONS

For the full enforcement of the technical regulations, such as are discussed in previous chapters of this circular, there are three distinct lines of work necessary, viz: First, regular inspection to determine whether or not there is full compliance on the part of the company with the regulations; second, investigation of each case where noncompliance is found, to determine the cause and, if possible, the remedy for the deficiency; and, third, action to induce compliance or to bring redress for any inexcusable noncompliance which may be found. It is important that careful investigation of each case be made, for any action which may be taken to enforce compliance with a regulation without preliminary consideration of all the facts involved, frequently results in needless friction, or possibly even in expensive litigation to no useful purpose. Indeed, noncompliance is often the unavoidable result

of conditions beyond the control of the gas company, and in such cases cooperation, rather than criticism, should be given.

The service rendered by gas companies in the United States has been supervised and regulated by both State and municipal authorities. The results sought are the same under either jurisdiction, but the methods vary somewhat according to the extent and character of the territory affected.

1. SERVICE INSPECTION UNDER STATE RULES

The systematic testing of gas under State rules may be done by State inspectors or by the companies under the direction and supervision of the State officers. For all except possibly very thickly populated States, where the distance between cities is very small, the plan of requiring that the companies do the routine testing seems to be preferable. This plan is recommended by the Bureau because of the success with which it has been followed first in Wisconsin and more recently also in other States. The performance of all official tests by State inspectors, rather than by the companies under the supervision of the State officials, requires a very fully organized inspection service. In one State, for example, five gas inspectors and seven gas-meter inspectors are required to make the regular tests, and even with this large force the companies are, on the average, visited for a gas inspection only about once each month. It does not appear that this plan would be a desirable one to apply in general, particularly in the States having only a few gas companies.

(*a*) Regular Testing by Companies.—The rules proposed by this circular for State regulation indicate the testing work which it is believed should be done by the companies. Under this scheme each gas company will test all meters regularly, will take regular pressure records, and will daily test the gas supplied for hydrogen sulphide; further determinations of purity and heating value would be made by the larger companies, as indicated in the proposed rules. The number of records and frequency of tests to be made by the companies can usually be left to the companies themselves. If any company does not make as many or as frequent tests as may seem to the commission to be desirable, an informal request by the latter that the frequency or number be increased would usually be sufficient to bring satisfactory results.

The records of these tests and the complaint files would be open to the State inspectors at all times, and by visits at irregular intervals the tests of the company could be supervised, so that,

even were there a desire to make inaccurate or misleading records of this sort, it could not be done without danger of detection by the inspectors calling at unexpected times. This point is emphasized here to meet the possible objection that the companies' tests would not be of real value for inspection work. The Bureau does not believe that this objection is valid for two reasons: First, the average company desires for its own protection to give satisfactory service and it has little incentive to make false reports; second, the probability of false reports passing unobserved, even if the company attempted to make them, is small with careful supervision by State officials. Most excellent results can be had by cooperation of the companies and the State inspectors, and the results will be sufficiently accurate and will be economically obtained.

The proposed requirement of tests of heating value is very similar to that made in a number of States. Even companies making less than 10 000 000 cubic feet of gas annually can well afford to purchase and use a calorimeter, since the expense of such purchase and use would rarely be regarded as excessive. The saving accomplished by the closer works control, which is possible when making regular calorimetric tests, makes a good calorimeter a profitable investment even in the case of small companies.

The plan followed by a number of States of requiring regular and full surveys of gas-pressure conditions to be made by the companies is an excellent one. It is impossible for most State commissions to take these records by their own inspectors, and the records taken by the companies are usually a satisfactory substitute if the work is properly supervised. Occasional records taken by the State officials are, of course, desirable to check up the work of the companies.

(*b*) Supervision of Companies' Testing.—When the routine tests are made by the companies, it is desirable that State inspectors make frequent visits to check the work. In the arrangement of this part of the testing work the first question is as to the frequency of tests required. Although the answer to this question would be largely affected by local conditions, the experience of the Wisconsin commission has led to a conclusion of perhaps general applicability, expressed by their chief gas inspector as follows:

> In the regulation of gas service throughout an entire State it is believed that the work of the State should be largely supervisory, and that the responsibility in all cases should be left with the company so far as this is possible. Small plants can not make all of the technical tests required, but the larger plants should be required to

make these tests and the State inspectors need only make such visits as will insure compliance with the law. If the companies are required to keep accurate records, it is believed that more visits should be made to small companies than to large ones. Since these smaller plants can do very little themselves in the way of testing, these inspections could be made monthly, at least, to advantage. Plants a little larger, however, which are equipped for testing the quality of the gas would need to be visited less frequently than monthly. Bimonthly or quarterly inspections should give very good control. The companies should be visited frequently enough to keep track of what they are doing, and occasionally without warning an exhaustive investigation should be made. It is believed that more is accomplished by "follow-up" inspections where companies have failed to comply with the rules than by very frequent inspections of all plants. Two plants of the same size do not require, of necessity, the same number of inspections.

The frequency of inspections may be subject to modification by the commission, since it is obviously unnecessary to visit a progressive company which makes all reasonable effort to comply with the rules, as often as another of the same size which, because of poor management, continually fails to conform to the regulations.

Testing would generally be done at the office of the gas company, in some cases with the apparatus of the company itself. If the apparatus is set up and tests of heating value made as soon as practicable after the arrival of the inspector, the readings would be uninfluenced by the company's knowledge of his presence. After these readings were taken the pressure gages can be set and the company's records of gas quality, meter tests, and complaints examined. As all but the smallest companies would have testing apparatus for the use of the inspectors the instruments which need be carried would be very few in number.

One other necessary portion of the traveling inspection work is the calibration or standardization of the companies' testing apparatus and instruments which are used for all of the company tests and for many of those by the inspectors. Such calibrations could be made by the regular inspector once or twice a year, as seemed necessary. The methods to be employed for routine and for special testing, the character of stations needed, as well as the methods for adapting the ordinary apparatus to traveling inspection, form a part of Bureau Circular No. 48, "Standard Methods of Gas Testing."

In the examination and testing of meters the commission need not undertake the testing and sealing of many meters. The aim should be to supervise the testing performed by the companies themselves in such a manner as to insure the regularity of the periodical testing, the use of suitable equipment and methods, and the keeping of full records of such tests. The inspectors should examine these records whenever a regular inspection is

made; and summaries of meter tests may be collected and filed with the commission.

The proposed rules provide that a consumer may have his meter tested by the company at any time he may desire (provided this is not oftener than once a year), and it is believed that, under the conditions existing, most of the disputes regarding the accuracy of meters can be settled in this way without appeal to the commission. The rules also provide for the test of service meters by inspectors of the commission on formal complaint of consumer, and a few meters will be tested under this provision.

In addition to prescribing methods and checking prover equipment, it is well to send inspectors to the various cities occasionally, and to choose at random and remove from service a number of meters for test. It is believed in this manner the State sufficiently insures the accuracy of service meters at comparatively slight expense.

(*c*) Regular Testing Work by State Inspectors.—In some States it has been thought best to have official tests made regularly in all cities, rather than only to supervise the routine work as done by the companies. It is assumed that under such system each inspection made by a traveling inspector would include determination of sulphur, ammonia, and heating value, and the taking of one or more records of the pressure of the gas. The frequency of visits for such purpose may be determined by the size of the company concerned. The practice in New York State provided six tests per year for each company and one extra test for each 10 000 000 cubic feet of gas produced after the first 10 000 000, but with a maximum of 26 tests per year. In Massachusetts the law requires at least two tests per year for each company, but the board makes an average of 12 to 15 tests per year per company, the range being from 2 to 49.

Having determined the frequency of test necessary in each city, the division of the work into inspection districts is a very simple matter. From the amount of work required in certain of the largest cities, it would probably be necessary to have an inspector permanently located in each of these places. If such inspector also had charge of the meter work of this city, then conditions governing the work would be very similar to those in any municipal inspection office. For the smaller places the visits should be arranged from one week to another.

Meter testing, if done by State officials, would in no case be subject to such definite preliminary arrangement as the traveling

gas inspection, since work of this character would be determined by the needs of the various companies for meters which must be tested before installation. The work could, however, be planned by the chief inspector from week to week, according to the requests received from the companies for meter inspection. This plan has met with some success in the New York inspection work.

If we assume that because of complaints, repairs, purchase of new meters, etc., the equivalent of 30 per cent of all the meters in use would require test each year, a basis of calculation is furnished for determining the number of meter testers required in any State. The number of meters which one inspector could test during a year would vary so widely, due to difference of distance between meter shops, length of stay at any one place, and the character of the conveniences which could be provided by the various companies, that no exact estimate can be made as to the time required. The First District Commission of New York estimated that for the routine meter inspection a single meter tester could prove and seal 75 meters per day, but in working through a State no such speed could be maintained. An allowance of 25 meters per man per working day would be a conservative estimate and on this basis one inspector would test about 7000 meters per year. The meter inspectors could readily be aided by the gas inspectors when their time was not wholly occupied with the routine gas tests. This combination of duties would be especially desirable when a long side trip was necessary to reach a single city, since then one trip could answer for both gas and meter testing.

(*d*) Settlement of Disputes and Complaints.—Two classes of disputes will demand consideration by the commission: First, complaints of consumers; and, second, differences arising between the companies under supervision and the commission itself.

The complaints of consumers as to the service rendered them by the company should, if possible, be first referred to the company itself for consideration, since the commission need take action only in case of a serious difference which can not be adjusted by such procedure.

Settling of the more important disputed cases by public hearing and subsequent ruling of the commission should be an expeditious and satisfactory method, since matters with which the commission should be very familiar are usually in question. The immediate reference of all such disputes to a court of law would make their

settlement unnecessarily complex and expensive; resort may be had to legal procedure later if desired.

Whenever it appears that a company can not, with its current methods of operation, comply with the provisions made by the State, it becomes necessary to investigate the reasons therefor. Such investigations may suggest certain practicable changes in operating methods which will make the gas service conform to the regulations; the commission should have authority to order reasonable changes if the company is unwilling to comply with the suggestions of the commission. If, however, it is not practicable to comply with the general rules, the commission should have authority to amend its rules to provide for each special case.

2. CITY INSPECTION SERVICE

Where a regulatory gas ordinance is adopted by a city it is customary to provide for municipal gas inspection service at the same time. However, it is fully as important to make provision, both for the investigation of special cases of noncompliance with the ordinance on the part of the gas company, and for the procedure in case of dispute. The necessity of making full regulations to care for all such situations is the real source of difficulty in the municipal enforcement of gas regulations which is so well eliminated by the flexibility of the State rules under the administration of a commission with its technical staff.

It is not possible to outline here the practice of various cities in gas-ordinance enforcement, but the best points in each particular which have come to the attention of the Bureau are given in the following general plan.

In so far as is known by the Bureau, there is no city in this country which requires that the tests for determination of compliance with the law be made by the company; and although this scheme has been found to operate very well under State supervision, it is not so clear that it is suitable for adoption under municipal control. Whenever the city wishes to enforce regulations as to gas quality, it will usually be best to provide a city official to make regular tests of the qualities specified, rather than to require the company to make such tests subject to the supervision of some city official. This does not apply, however, to the testing of gas meters—a point which is discussed in a later section.

(*a*) Appointment of Inspectors.—The advantage derived from examining the inspector before appointment leaves no doubt as to its advisability. (See p. 78.) Where a city has an estab-

lished municipal civil-service system, the form proposed can be eliminated or incorporated into the existing plan of appointments. The necessary restrictions as to who is eligible have such obvious purpose that comment seems scarcely needed. The gas company should welcome all precautions that will protect it from the charge of undue influence over the inspector or the inspection work. However, it should not be supposed that a man formerly in the employ of a gas company is disqualified for the position of inspector, as has been contended in some cases. Such experience would be a valuable preparation for this position, if the circumstances of his leaving the company's employ were not such as to preclude fair dealing.

The members of the examining board should be selected for their ability and willingness to judge the qualifications of the applicants for the position of inspector. They should be fitted to examine the chemical, engineering, and executive business ability of the candidates, and hence the board may well consist of a chemist, an engineer, and a business man. The members of such board should, if possible, be persons not connected either with the political offices of the city or the city council. The choice of men to compose the board who are well known in their professions and whose integrity is above question will be a long step toward securing an inspector who will be fair and satisfactory to all concerned. Where a suitable board of three is not available a smaller number may be used. Care should be exercised when there is a single examiner that personal interest or prejudice can not be charged against such person. The city chemist or city engineer may at times serve to advantage on such board; but usually the further removed from city officials' influence the examining board is, the better.

The best results will usually be gained, not only for the city, but also for the gas company, if the latter takes no part in the matter of the appointment of inspectors. It is, however, fair to receive suggestions from the gas company as to the character of the examination. It must not be forgotten that the applicants expect to test the gas, not to make it, and their knowledge of testing methods is more essential than their familiarity with works management, even though the latter be not wholly neglected. The character of the examination will be determined by the duties prescribed by the city for the office in question. The information and directions given in the circular of this Bureau on testing methods will offer a basis for the questioning of candidates.

In many cities the inspector holds office for the same period as the other city officials; but too frequent appointment of new men increases the chance of inexperience and its attendant inefficiency. The first appointment should be made as soon as possible after the passage of an ordinance to fill out the partial term remaining till the next regular time for such appointments. After that, appointments for four or five year periods will be best; but service for a probationary period is desirable in many cases. Under civil-service rules the term can conform to the general rules.

The salary of an inspector is determined by the local conditions and by the number and frequency of tests required of him. In any event, a competent, well-paid inspector is the most economical in the long run. An inefficient inspector may cause trouble between city and company, and will often cause more expense through legal difficulties than is saved by the lower salary. In many cases the city gas inspection will require much less than the whole of a man's time; in such cases an efficient worker who is at the same time employed elsewhere can often be procured to direct the work or even to carry it out himself. In some small cities the gas-inspection work might be done by the city chemist, city engineer, city electrician, or other official with some technical training.

(*b*) Regular Inspection Required.—The regular gas-inspection work of a city would fall under four heads, viz: Heating-value determinations, tests of purity, pressure record taking, and tests of meters.

Regardless of the number of tests made by the company, the inspector could well make two or more determinations per day of the heating value. If several stations are operated, at least one test a day at each should be made, but with a single station at least two tests per day would be desirable. The provisions of the proposed ordinance indicate the requirements on this subject which will probably be best for general use.

The frequency and methods of testing for the purity of the gas are indicated in the ordinance proposed. From the discussion of the requirements themselves, the methods of enforcement are clear. Details of these testing methods are, of course, included in the general circular on gas-testing methods.

In the municipal control of gas-service conditions, a satisfactory plan is to provide for a few pressure records to be taken by the city inspector. These records do not serve as a guide in the planning or maintenance of proper distribution conditions, but they are a check upon the companies' efforts in this work. The company

whose work is thus inspected will, of course, find it necessary to take its own records of pressure conditions in order to determine the modifications necessary to give such service as may be required by the city. Indeed, it is urged by some that a minimum number of pressure records to be taken by the company should be fixed by ordinance; for example, in New York City, where the number of the company's records is specified, gages must be so located that no consumer will be more than 3800 feet from the gage station. For many cities such concentration will not be needed; but it is important that all parts of the district supplied with gas be carefully watched, as changes from year to year may develop serious deficiences in one part or another. It is not practicable to give any general rule as determining the number of gages for use in a city.

In addition to the gages used for regular tests, one or more for use in investigation of complaints of service are needed. The requirement of "additional gages" may not apply to many very small cities where the variation of pressure over the area supplied does not warrant the extra expense involved. Under these circumstances, one or more simple portable U-shaped water gages should be used to check up outside conditions when this is required.

Two methods of checking the meters are available—one in which every meter is tested by the inspector, the other by which the company is required to make these tests. The Bureau recommends that the routine testing of meters be done in all cases by the company, but that authority for inspection of this work be given to the inspector. For State work this plan is unquestionably the better; for cities it seems also preferable. Some city or State official would be expected to make the complaint meter tests, when the company did the routine work. Although some of the meter inspection work which appears to representatives of this Bureau to be most efficiently done has been found in the shops of the companies themselves, yet, where it is desired, an official inspection of the company's meter-testing work is reasonable and proper. Indeed, such inspection even if not strictly necessary is such a valuable protection to the company against unfair public criticism, that the slight inconvenience to the company would be more than compensated thereby. For small cities, where there is neither city nor State gas-inspection service, the complaint tests may be made by the city engineer or some other official.

(*c*) Special Inspection Work.—The proposed ordinance form defining the duties of the inspector is drawn to cover the needs of the largest cities, and may frequently be shortened or modified. However, there are very few subjects that can be entirely omitted even for smaller cities, since the duties defined are, in general, only such as would naturally accompany the office of inspector, whether this officer be specially appointed for this work or one of the other regular city officials to whom the gas testing has been assigned.

The fair and cordial cooperation of the gas company and the inspector in the investigation of complaints and irregularities of service is of utmost importance, although unfortunately such cooperation is not general. The Bureau believes that, generally speaking, the inspector can best serve the public by the fullest cooperation with the company in the examination of the quality of the gas and the character of the service rendered. The plan of cooperation of public officials with the company in the removal of causes of deficiency in service, which has been applied in some States, should, where possible, be followed in the municipal enforcement of similar regulations.

3. TESTING STATIONS AND METHODS

The location of the testing station at the proper point has a bearing upon the efficiency of the testing done, for if the gas tested does not truly represent the gas distributed throughout the given district, the results are misleading and unfair either to the company or to the public. Definite requirements as to location of the station are sometimes made in the ordinance in the effort to insure that these essential conditions are met.

Tests on the gas should be representative of that delivered in the district in which such tests are made. Heating-value determinations made at the manufacturing works would frequently be in error, for an improperly condensed gas might give substantially higher values at the works than when delivered to the consumers. Tests after exposure to the ground temperatures for a half mile or more will usually eliminate nearly all of this effect. However, it should be noted that the loss in heating value during distribution is very much less than the loss in candlepower. Furthermore, the loss in heating value with dry gases of lower heating value, such as are coming more and more to be distributed, is less than with those of high heating value. Thus the location of the testing

station is not of such great importance as formerly when candle-power regulations were generally in force.

In small cities the location of the testing equipment in the office of the gas company or of some city official can advantageously be made. It is usually best, especially under State rules, to allow the company to choose the location of the testing station or stations, subject to the approval of the proper regulating authorities. In some cases it may even be proper to locate the testing station at the works.

Local conditions should to a great extent determine the number of testing stations, since when one station can test the gas supplied to a whole district there is no need for a second station, even though the consumption may be four or five million cubic feet daily. Again, a station may be required at some points where only half a million cubic feet is the daily output, since the tests at no other station would be affected by the gas going to such district. This latter case is particularly true where the company has several manufacturing plants in operation and the gas may not be thoroughly mixed before being delivered. In general, there should be at least one station for each manufacturing plant. Geographical considerations are also very important, since in a closely settled city as New York, with a high consumption of gas per mile of main, the stations need not be so numerous in proportion to consumption as otherwise. In any city where two companies distribute gas over the same district a single station may easily be equipped for testing the gas from both.

After a laboratory is properly located, the use of an improper service-pipe connection to it may render good results difficult. Such trouble is met with when the service pipe is too small or too long, or when it passes through a long air shaft, or through a cold basement or hot furnace room, or has many side connections. The service pipe should be as short as possible, with few or no turns and the least possible change of temperature from the main to the laboratory. No testing station should be chosen where the conditions do not permit approximate compliance with the above requirements of service connections. The inspector, if properly qualified for his position, should be fitted to superintend the purchase and installation of the necessary equipment. Therefore, his recommendations as to the laboratory, the office, and their equipment should be given due weight. The details of station equipment have been investigated by this Bureau and a discussion of

certain phases of this question is included in the circular on methods of testing.

One of the most frequent sources of trouble between the gas inspectors and the gas companies has been the selection of testing methods and the interpretation of inspection results. In order to eliminate such difficulty as far as possible, it has proven desirable for a city to adopt rather detailed provisions in its gas-testing ordinance, and such provisions have been embodied in the ordinance proposed. However, it is clearly impossible to provide for all details in the ordinance itself, and some means of settlement of differences is desirable. A few American and a large number of English cities have for this purpose made reference to the reports of the London gas referees, and thus made them the basis for settlement; but because of the different conditions in the manufacturing and testing methods of the two countries the American cities have found this reference to English practice somewhat unsatisfactory.

In order to furnish to the American gas inspectors a source of information on standard testing methods, the Bureau of Standards has issued a circular on this subject (Circular No. 48, "Standard Methods of Gas Testing"), which represents not only a summary of work done at the Bureau, but also a review of the experience of some of the well-known gas chemists and municipal inspectors. This circular will be revised from time to time in order to have it contain the latest information available. It is believed that the recommendations of this circular can be used as a basis for settlement of differences with the assurance that the result of such reference will be fair to both parties. The effect of any change in such circular upon the methods or apparatus used in testing would be limited by the definite provisions of the ordinance itself, and so could not work serious injury either to the gas company or to the public.

Since cases not covered by any other sections or provisions can readily be imagined, and may on rare occasions occur, they should be provided for. It is desirable that this be done by the arbitration board, as suggested in proposed section 15, rather than by the courts, which in most cases are not familiar with the technical points involved. Resort to this board would be only of rare occurrence.

4. PENALTIES

The failure to observe regulations regarding gas quality or service may be due to accident, carelessness, or neglect on the part

of the company; but in any case the public by their representatives, either city inspector or State official, is entitled to an explanation of the circumstances which caused the deficiency. In the case of accidental and unpreventable violation, the company has nothing to fear from such full understanding of the facts, for in such case no unfavorable criticism or penalty should result. Under other circumstances a reasonable publicity, or in extreme cases a fine or penalty of some form, is not unjust to the company for violation of a reasonable requirement.

It will be observed that no penalties are proposed in this circular for failure to meet the requirements. Specific penalties have generally been found unnecessary under State commission regulation, and it is believed that in most cases this will also prove true where the city undertakes the enforcement of an ordinance. The influence of public opinion is powerful, and this, combined with the knowledge that penalties commensurate with the impairment of the service or for violation of the reasonable orders of the proper authorities may be exacted, have in the past always proven sufficient to insure good results. It is to the interest of the gas company to furnish good service, and violations of regulations will usually be found to be the result of accident or unforeseen circumstances. Where a definite penalty is specified for such violation, its exaction in compliance with the law in such cases comes at a time when the company requires assistance and cooperation in removing the difficulty rather than fine and criticism, and thus is apt to produce ill-feeling and aggravate the difficulty. The Bureau of Standards therefore recommends that no definite penalties be fixed for violation of regulations, but that the power be given the proper authorities, upon noncompliance due to inexcusable neglect, to proceed after notification to collect from the gas company such amount as may be commensurate with the impairment of the service.

Provision is made in section 4, paragraph (*d*), that the monthly report of the inspector shall be open to the public. This should offer an incentive to the company to furnish gas always within the specified limits. A public advertisement of a slight deficiency in a way to subject the company to unfair criticism is, of course, to be condemned; however, a simple public statement that the quality of the gas was found to be above standard or deficient to a certain degree may sometimes be desirable. This illustrates the need for good judgment on the part of the inspector, and shows the importance of careful selection of the man to fill this office.

IX. PROPOSED FORMS FOR REGULATIONS

In order to give in convenient form a summary of the recommendations of the Bureau of Standards on State and municipal gas regulations, a set of rules suitable for enforcement by a State commission and an ordinance suitable for adoption by a city have been prepared. These proposed forms may not be adopted as a whole, as local conditions may make alterations desirable; but in general they can be closely followed, for it is believed that the requirements will be found to be applicable in the great majority of cases. The importance of the many details in the regulations proposed is greater than it may appear at first sight, and it is recommended that any modifications of the general form be made only after careful consideration. Every effort has been made to make the suggested regulations comprehensive; abbreviation may in some cases be possible, but care should be taken that no essential part is omitted. The numerical values specified must, of course, be modified to meet local needs, and the ordinance and rules proposed must be considered in the light of the discussion of the preceding sections of this circular, any necessary changes being made to meet special conditions.

The intention of the Bureau in recommending the following rules should be borne in mind both in the consideration of them at the time of adoption and during enforcement of similar requirements. The following principles apply:

1. These rules define good practice which can normally be expected. They should not be rigidly enforced under any conditions that introduce unusual difficulty of compliance, but should be waived temporarily to meet such conditions. Especially should rules be set aside if compliance with them costs more than the results of compliance are worth to the public and gas consumers.

2. The regulatory authorities in charge of such matters should make every effort to cooperate with the gas companies in furnishing good service, and in return can expect frank, fair dealing from the companies.

3. Penalties to enforce compliance with rules are not recommended; a penalty may be required as a last resort to insure obedience to formal orders of a commission, but its use should be restricted to this function alone.

4. It is as much the function of the commission and its rules to protect a company from unreasonable demands as it is to prevent inadequate service or unfair charges to the public.

1. RULES PROPOSED FOR THE USE OF STATE COMMISSIONS

In a number of States the regulations for gas service are combined with similar regulations for electric, water, and other utility service. In such cases it is, of course, desirable to make the form and general provisions of the corresponding regulations the same for all utilities, and the form proposed herein should be modified so far as may be necessary to accomplish this. State laws and local practice may also make necessary modifications of the proposed rules. For example, these rules are applicable to municipally owned plants, but in certain States municipal utilities are not subject to regulation by the commission Thus, while as little departure from them as is necessary is advised, yet before adopting any provision it should be carefully scrutinized in the light of local conditions.

Rules and Regulations Prescribing Standards for Gas Service, Providing for the Testing of Gas Meters, and Otherwise Regulating the Service of Gas Utilities

GENERAL PROVISIONS

RULE 1. AUTHORIZATION OF RULES.[3]—(*a*) The Public Utilities Law of the State of ———— provides that the Public Service Commission shall be empowered to establish rules and fix standards for gas service as follows:

[Extract from law granting this authority.]

In accordance with the above provisions the Public Service Commission has adopted the following rules and fixed the following standards for manufactured-gas service, to become effective the ———— day of ————, 19—. All previous rules or standards conflicting with those contained herein are hereby superseded.

(*b*) The adoption of these rules shall in no way preclude the Public Service Commission from altering or amending them in whole or in part, or from requiring any other or additional service, equipment, facility, or standard, either upon complaint or upon its own motion, or upon the application of any utility. Furthermore, these rules shall not in any way relieve any utility from any of its duties under the laws of this State.

RULE 2. APPLICATION OF RULES.[3]—(*a*) These rules shall apply to any person, firm, or corporation which is now or may hereafter become engaged as a public utility in the business of furnishing gas to domestic or commercial consumers within the State of ————.

[3] Rules 1, 2, and 3 would of course be changed to suit the loca lState laws and regulations. The definitions of rule 3 should correspond with any similar definitions occurring in the public service commission law under which such rules as these may be adopted.

(*b*) The rules are intended to define good practice which can normally be expected. They are intended to insure adequate service and prevent unfair charges to the public, and to protect the utilities from unreasonable demands. The cooperation of the utilities with the commission is presupposed.

(*c*) In any case where compliance with any of these rules introduces unusual difficulty, such rule may be temporarily waived by the commission upon application of the utility. If in such case compliance with the rule would cost more than the results of such compliance are worth to the public and gas consumers, it may be permanently set aside by the commission.

RULE 3. DEFINITIONS.[3]—In the interpretation of these rules the word "commission" shall be taken to mean the Public Service Commission of the State of ———; the word "utility" shall be taken to mean any person, firm, corporation, or municipality engaged in the business of supplying manufactured gas to domestic, commercial, or industrial users within this State; and the word "consumer" shall be taken to mean any person, firm, corporation, municipality, or other political subdivision of the State supplied by any such utility.

RECORDS AND REPORTS

RULE 4. RECORDS.—(*a*) A complete record shall be kept of all tests and inspections made under these rules as to the quality or condition of service which it renders.

(*b*) All records of tests shall contain complete information concerning the test, including the date, hour, and place where the test was made, the name of the person making the test, and the result.

All records required by these rules shall be preserved by the utility for at least two years after they are made. Such records shall be kept within the State at the office or offices of the utility and shall be open for examination by the commission or its representatives at all reasonable hours.

RULE 5. REPORTS TO COMMISSION.—Each utility shall, at such times and in such form as the commission may prescribe, report to the commission the results of any test or tests required to be made or the information contained in any records required to be kept by the utility.

GENERAL SERVICE PROVISIONS.

RULE 6. INSPECTION OF PLANT AND EQUIPMENT.—(*a*) Each utility shall inspect its plant, distribution system, and facilities in

[3] Rules 1, 2, and 3 would of course be changed to suit the local State laws and regulations. The definitions of rule 3 should correspond with any similar definitions occurring in the public service commission law under which such rules as these may be adopted.

such manner and with such frequency as may be necessary to maintain them in proper condition for use in rendering safe, adequate, and continuous service. Such record shall be kept of the conditions found as the utility itself shall consider necessary for the proper maintenance of its system, unless in special cases a more complete record be specified by the commission.

(*b*) Each utility shall, upon request of the commission, file with the commission a statement regarding the condition and adequacy of its plant, equipment, facilities, and service in such form as the commission may require.

RULE 7. INTERRUPTIONS OF SERVICE.—Each utility shall keep a record of any condition resulting in an interruption of service affecting its entire system or major division thereof, including a statement of the time, duration, and cause of any such interruption.

RULE 8. ACCIDENTS.—Each utility shall, as soon as possible, report to the commission each accident happening in connection with the operation of its property, facilities, or service, wherein any person shall have been killed or seriously injured or whereby any serious property damage shall have been caused.[4] Such first report shall later be supplemented by as full a statement as is posble of the cause and details of the accident and the precautions, if any, which have been taken to prevent similar accidents.

RULE 9. COMPLAINTS.—Each utility shall make a full and prompt investigation of all service complaints made to it by its consumers, either directly or through the commission. It shall keep a record of all such complaints received, which record shall show the name and address of the complainant, the date and character of the complaint, and the adjustment or disposal made thereof.

RULE 10. INFORMATION FOR CONSUMERS.—(*a*) Each utility shall, upon request, give its consumers such information and assistance as is reasonable, in order that consumers may secure safe and efficient service; and upon request it shall render every reasonable assistance in securing appliances properly adapted and adjusted to the service furnished.

(*b*) Each utility shall adopt some means of informing its consumers as to the method of reading meters, either by printing on its bills a description of the method of reading meters, or by a

[4] Where a State industrial commission receives accident reports, it should be unnecessary for the utility to report accidents to the Public Service Commission also. However, in the case of any accidents or damage caused by interruptions of service, poor quality of service, or involving in any way the relations of the utility and the public, it is assumed that the industrial commission would transmit a report of such accident to the Public Service Commission in order that the latter might also be enabled to make an investigation to determine whether its rules had been violated or were in any way inadequate.

notice to the effect that the method will be explained at the office of the utility upon application. It is recommended that an exhibition meter be kept on display in each office maintained by a utility.

Rule 11. Meter Readings and Bill Forms.—(*a*) Each service meter shall indicate clearly the cubic feet of gas registered by such meter. Where gas is metered under high pressure or where the quantity is determined by calculation from recording devices, the utility shall supply the consumer with such information as will make clear the method by which the quantity is determined.

(*b*) Bills shall be rendered periodically, and they shall show the readings of the meter at the beginning and end of the period for which the bill is rendered, the date of the meter readings, the number of cubic feet of gas supplied, and the unit price. On all bills which include any other items than a definite unit price for gas, the other factors used in computing the bill shall be clearly stated, so that the amount may be readily recomputed from the information appearing upon the bill.

Each bill shall bear upon its face the date when the bill was mailed or left at the premises of the consumer or the latest date on which it may be paid without loss of discount or incurring of penalty.

Rule 12. Change in Character of Service.—In case any substantial change is made by the utility in the gas pressure or other service conditions which would affect efficiency of operation or adjustment of appliances, the appliances of all consumers in the district affected shall be readjusted by the utility for the new conditions without charge.

TESTING

Rule 13. Definition of a Cubic Foot of Gas.—When the gas itself is to be tested under these rules, a cubic foot of gas shall be taken to be that amount of gas which occupies the volume of 1 cubic foot when saturated with water vapor and at 60° F and under a pressure of 30 inches of mercury. For purpose of measurement of gas to a consumer a cubic foot of gas shall be taken to be the amount of gas which occupies a volume of 1 cubic foot under the conditions existing in such consumer's meter as and where installed.

Rule 14. Testing Facilities.—(*a*) Each utility shall, unless specifically excused by the commission, provide such laboratory meter-testing equipment and other equipment and facilities as may be necessary to make the tests required of it by these rules or

other orders of the commission. The apparatus and equipment so provided shall be subject to the approval of the commission, and it shall be available at all times for the inspection or use of any member or authorized representative of the commission.

(*b*) Each utility shall make such tests as are prescribed under these rules with such frequency and in such manner and at such places as is herein provided or as may be approved or ordered by the commission. Unless otherwise directed by the commission, the methods and apparatus recommended by the National Bureau of Standards in the latest addition of its Circular No. 48, "Standard Methods of Gas Testing," may be used.

METER ACCURACY AND TESTING

RULE 15. METER PROVER.—(*a*) Each utility furnishing metered gas service shall own an approved type of meter prover, preferably of not less than 5 cubic feet capacity, equipped with suitable thermometers and other necessary accessories, and it shall maintain such equipment in proper adjustment so that it shall be capable of determining the accuracy of any service meter to within one-half of 1 per cent. Each such meter prover shall be so placed that it will not be subjected to drafts or excessive temperature variations.

(*b*) The accuracy of all provers and methods of operating them will be established from time to time by a representative of the commission. All alterations, accidents, or repairs which might affect the accuracy of any meter prover or the method of operating it shall be promptly reported in writing to the commission.

RULE 16. GAS-METER ACCURACY. (*a*) *Installation Test.*—Every gas-service meter, whether new, repaired, or removed from the service for any cause, shall be in good order and shall be adjusted to be correct to within 1 per cent when passing gas at 6 cubic feet per hour per rated light capacity before being installed for the use of any consumer: *Provided, however,* That a utility which has less than 1,000 consumers, and which has no facilities for opening meter cases and adjusting the mechanism, may put a meter back into service if it is not found to be in error by more than 1½ per cent and appears otherwise to be in good order.

(*b*) *Method of Testing.*—All tests to determine the accuracy of registration of any gas-service meter shall be made with a suitable meter prover. Each meter shall be marked with the date of the last test made on that meter.

(*c*) *Special Meters.*—Any meter, the readings or record of which is based on the differential pressure in such meter or upon the measurement of any portion of the total gas delivered to a consumer, shall be tested for accuracy before installation in a manner satisfactory to the commission.

RULE 17. RECORD OF METERS AND METER TESTS.—(*a*) Whenever any gas service meter is tested, the orginal test record shall be preserved, including the information necessary for identifying the meter, the reason for making the test, the reading of the meter upon removal from service, and the result of the test, together with all data taken at the time of the test in sufficiently complete form to permit the convenient checking of the methods employed and the calculations.

(*b*) A record shall also be kept, numerically arranged, indicating for each meter owned or used by any utility the date of purchase, its identification, a record of the use, repairs, and tests to which it has been subjected, and its present location.

RULE 18. PREPAYMENT METERS.—No utility shall use prepayment meters geared or set so as to cause a rate or amount higher than would be paid if a standard-type meter were used, except under such special rate schedule as may be approved by the commission for this class of service.

RULE 19. LOCATION OF METERS.—No consumer's meter shall be installed in any location where it may be unreasonably exposed to heat, cold, dampness, or other cause of damage or in any unduly dirty or inaccessible location.

RULE 20. PERIODIC TESTING OF METERS.—(*a*) No gas-service meter hereafter installed shall be allowed to remain in service more than five years from the time when last tested.[5]

(*b*) During each period of 12 months after these rules take effect, until all meters now in service shall have been tested, each utility shall remove approximately 20 per cent of all meters now in service, those longest in service being removed first. Such meters shall not be replaced in service until tested and made to comply with the other provisions of these rules.

RULE 21. METER TESTING ON REQUEST OF CONSUMERS.—(*a*) Each utility shall, at any time when requested in writing by a consumer upon reasonable notice, test the accuracy of the meter in

[5] The matter of proper treatment of meter diaphragms, as well as the length of time during which a meter may be expected to remain in proper condition of accuracy, is at present being carefully studied by a committee of the American Gas Association. Any rule regarding the periodic testing of meters should be formulated in the light of any further information which may become available subsequent to the publication of this circular.

use by him; provided the consumer will agree to accept the result of the test made by the utility as determining the basis for settling the difference claimed.

No deposit or payment shall be required from the consumer for such meter test except when a consumer, whose average monthly bill for gas service is less than $25, requests a meter test within six months after date of the installation or of the last previous test of this meter, in which case he shall be required by the utility to deposit with it, to cover the reasonable cost of such test, an amount not to exceed the following:[6]

For each standard type gas service meter—
Not exceeding 10 lights capacity..... $
Exceeding 10 lights, but not exceeding 45 lights capacity.....
Exceeding 45 lights capacity.....
For any meter rated other than by lights capacity, including increased capacity meters commonly called A and B meters, the deposit shall be the same amount as is required for a meter of corresponding size rated by its lights capacity.

The amount so deposited with the utility shall be refunded or credited to the consumer, as a part of the settlement of the disputed account, if the meter is found when tested to register more than 3 per cent fast; otherwise the deposit shall be retained by the utility.

(*b*) A consumer may be present when the utility conducts the test on his meter, or, if he desires, may send an expert or other representative appointed by him.

(*c*) A report giving the name of the consumer requesting the test, the date of the request, the location of the premises where the meter has been installed, the type, make, size, and serial number of the meter, the date of removal, the date tested, and the result of the test shall be supplied to such consumer within a reasonable time after the completion of the test.

Rule 22. Referee Meter Tests by Commission.—(*a*) Upon written application to the commission by a consumer a test will be made of the consumer's meter as soon as practicable by a representative of the commission. The application for such test shall be accompanied by a remittance of the amount fixed below as the fee for such test. This fee shall be retained by the commission. However, if the meter is found to be more than 3 per cent fast the utility shall repay to the consumer the amount of the fee paid by the consumer to the commission for such meter test.

[6] These amounts should be filled in by commissions and should be based on the actual cost of doing the work.

(*b*) The amount of the fee to be paid for a meter test made by the commission shall be as follows:[7]

For each gas-service meter –
Not exceeding 10 lights capacity..... $
Exceeding 10 lights, but not exceeding 45 lights capacity.....
Exceeding 45 lights capacity.....

For any meter rated other than by lights capacity (including increased capacity meters commonly called A and B meters), the fee shall be the same amount as is required for a meter of corresponding size rated by its lights capacity.

(*c*) This rule shall not interfere with the practice of a utility with reference to its tests of gas-service meters, except that in the event of an application by a consumer to the commission for a referee test as herein provided, the utility shall not knowingly remove, interfere with, or adjust the meter to be tested without the written consent of the consumer, approved by the commission.

RULE 23. ADJUSTMENT OF BILLS FOR METER ERROR. (*a*) *Fast Meters.*—If on test of any gas-service meter made by the commission or the utility at the request of a consumer it be found more than 3 per cent fast, the utility shall refund to the consumer such percentage of the amount of his bills for the period of six months just previous to the removal of such meter from service—or for the time the meter was in service, not exceeding six months—as the meter shall have been shown to be in error by such test: *Provided, however*, That if the error was due to some cause, the date of which can be fixed, the overcharge shall be computed back to, but not beyond, such time. No part of any minimum-service charge shall be refunded.

(*b*) *Slow Meters.*—If on test of any gas-service meter made by the commission or the utility at the request of a consumer it be found more than 3 per cent slow, the utility may collect from the consumer the amount estimated to be due from the consumer for gas used but not charged for in bills rendered for not to exceed the six months previous to removal of the meter.

(*c*) Each utility shall file with the commission a statement setting forth its practice with respect to refunds and collections from consumers when upon test other than at the request of the consumer the meter is found to be fast or slow in excess of 3 per cent.

HEATING-VALUE REQUIREMENTS AND TESTS

RULE 24. CALORIMETER EQUIPMENT AND LABORATORY.—(*a*) Each utility selling more than 10 000 000 cubic feet of manu-

[7] These amounts should be filled in by commissions and should be based on the actual cost of doing the work.

factured gas per year shall provide and maintain a calorimeter of a type approved by the commission and all necessary accessories therefor.[8]

(*b*) The calorimeter equipment shall be installed in a suitably located testing station, which station shall preferably be not less than 1 mile from any gas manufacturing plant, except in the smaller municipalities where a lesser distance may be desirable. The location of such testing station shall be selected by the utility and approved by the commission.[9]

(*c*) The accuracy of all calorimeters, as well as the method of making heating-value tests, shall be subject to the determination and approval of a representative of the commission.

RULE 25. HEATING-VALUE TESTS.—(*a*) Each utility maintaining a calorimeter testing station shall there determine the heating value of the gas supplied to its consumers at least once each day (Sundays and holidays excepted), unless the sales of that utility in the community or communities for which this station is to serve are less than 50 000 000 cubic feet of gas per year, in which case the heating value of the gas shall be determined on not less than three days each week.

(*b*) Each utility making heating-value determinations shall adopt, subject to the approval of the commission, a standard form for recording the results of each such test. Each determination of heating value shall be recorded originally upon the form adopted for that purpose and such forms shall be retained as a permanent record.

RULE 26. HEATING-VALUE REQUIREMENTS. (*a*) *Average Requirement.*—Each utility supplying manufactured gas shall maintain the monthly average total heating value of such gas at any point within 1 mile of the manufacturing plant at not less than ——— Btu per cubic foot: *Provided, however,* That in the case of gas produced by the by-product coke-oven process, or in case of other good and sufficient reason any utility finds it impracticable or uneconomical to manufacture gas of the heating value aforesaid, it shall file a statement with the commission clearly setting forth all pertinent facts, and the commission, after investigation, may by special order fix such lower average heating-value standard as may by them be deemed proper for said utility.

[8] Utilities not required to purchase calorimeters are nevertheless advised to do so, as the improved operating efficiencies obtainable will usually more than pay for the cost of the apparatus.

[9] Among the smaller companies, the commercial office will usually be found the best location for the testing station.

To obtain the monthly average total heating value of a gas, the results of all tests of heating value made on any day during the calendar month shall be averaged, and the average of all such daily averages shall be taken as the monthly average.

(*b*) *Maximum and Minimum Limits.*—The heating value of the gas shall be maintained with as little deviation as practicable; and to this end the average total heating value on any one day should not exceed or fall below by more than 30 Btu, the monthly average standard herein fixed, or otherwise fixed by special order of the commission for a particular utility.

(*c*) Where manufactured gas is delivered to the mains under a pressure in excess of 5 pounds per square inch, the heating value may be determined before compression.

NOTE.—Any statement published by the utility as to the average heating value of the gas supplied should indicate that it was measured under standard conditions—i. e., at 60° F and under a pressure of 30 inches of mercury.

PURITY REQUIREMENTS AND TESTS

RULE 27. PURITY REQUIREMENTS. (*a*) *Hydrogen Sulphide.*—All manufactured gas distributed in this State shall not contain more than a trace of hydrogen sulphide. The gas shall be considered to contain not more than a trace of hydrogen sulphide if a strip of white filter paper, moistened with a solution containing 5 per cent by weight of lead acetate, is not distinctly darker than a second paper freshly moistened with the same solution after the first paper has been exposed to the gas for one minute in an apparatus of approved form, through which the gas is flowing at the rate of approximately 5 cubic feet per hour, the gas not impinging directly from a jet upon the test paper.[10]

(*b*) *Total Sulphur.*—All manufactured gas distributed in this State shall contain in each 100 cubic feet not more than 30 grains of total sulphur.

(*c*) *Ammonia.*—All manufactured gas distributed in this State shall contain in each 100 cubic feet not more than 5 grains of ammonia.

RULE 28. TESTS OF PURITY.[11]—Each utility supplying manufactured gas shall daily test the gas leaving its holders for the presence of hydrogen sulphide in the manner above specified.

Each utility selling more than 100 000 000 cubic feet of manufactured gas per year shall provide and maintain such apparatus

[10] Such test papers gradually become discolored by exposure to the air and it is not common practice to preserve them. It is, however, possible to preserve the color by applying a thin white-shellac varnish to the paper after it has become entirely dry.

[11] For apparatus required and methods of testing see Bureau of Standards Circular No. 48, "Standard Methods of Gas Testing."

and facilities as are necessary for the determination of total sulphur and ammonia in the gas; and each such utility shall periodically (preferably semimonthly) determine the amount of total sulphur and ammonia in the gas distributed by it, and shall keep a record of the results of all such tests, as provided for in rule 4: *Provided, however,* That any such utility supplying only water gas or oil gas, or mixtures of these, shall not be required to provide apparatus for or make determinations of the amount of ammonia in the gas.

GAS-PRESSURE REQUIREMENTS

RULE 29. GAS PRESSURE LIMITS AND ALLOWABLE VARIATION.[12] (*a*) *Maximum and Minimum Limits.*—The pressure of manufactured gas supplied by any utility, as measured at the outlet of the utilities service pipe to any consumer, or in the case of high-pressure systems at the outlet of the house governor, should be maintained as uniform as practicable, and it should never be less than 2 inches nor more than 8 inches of water pressure, except as the consumer may request in writing the maintenance of some higher pressure.

(*b*) *Allowable Variation.*—Between the hours of 5 a. m. and 10 p. m.[13] the pressure of the gas at the outlet of the utility's service pipe, or house governor, to any consumer shall never vary by more than the following amounts:

Minimum pressure maintained	Maximum pressure variation permissible
2 to 3 inches	2 inches
3 to 4 inches	2½ inches
Over 4 inches	3 inches

(*c*) No utility shall be deemed to have violated the preceding paragraph of this rule if it can be shown to the satisfaction of the commission that the variations occurring in gas pressure were due to unforeseen demand or to temporary conditions beyond the control of the utility.

RULE 30. PRESSURE-TESTING EQUIPMENT.—(*a*) Each utility shall maintain on its distribution system in each city in which it supplies gas at least one recording gas-pressure gage for each 50 miles of mains, or fraction thereof, and no utility shall maintain

[12] Suggested pressure regulations for natural-gas service are contained in Section V, paragraph 5, page 38.

[13] Change in these hours may be necessary in some localities to conform to the habits of the people in the use of gas.

less than two such recording-pressure gages, of which one should be portable.

(*b*) Each utility shall regularly make records with such recording gages of the pressures in various parts of its distribution system. The charts or records thus obtained shall bear the date and place where the pressure was taken and shall be filed as a permanent record.

PUBLIC RELATIONS

NOTE.—Many commissions make no attempt to regulate the more strictly business arrangements between the utility and its consumers, considering such arrangements to be outside the scope of service rules. Nevertheless, in such cases the utility is usually required to provide the commission with full information regarding such arrangements and some provisions, such as are contained in rule 37, should probably be included. Under such circumstances rules 31 to 36, inclusilve, may be omitted.

Some of the commissions, however, have considered these business arrangements a proper part of service rules, and in about one-half of the cases where State-wide requirements have been adopted one or more such provisions have been included. For those who share in this view the following forms are given:

RULE 31. DEPOSITS FROM CONSUMERS TO GUARANTEE PAYMENT OF BILLS.—(*a*) Each utility may require from any consumer or prospective consumer a deposit intended to guarantee payment of current bills. Such required deposit shall not exceed the amount of an estimated 90 days' bill of such consumer; *Provided, however,* That a minimum deposit of $5 may be required. Interest shall be paid by the utility upon such deposits at the rate of — per cent per annum, payable upon the return of the deposit for the time such deposit was held by the utility and the consumer was served by the utility, provided such period was not less than six months.

(*b*) Each utility having on hand deposits from consumers or hereafter receiving deposits from them, shall keep records to show: (1) The name of each consumer making such deposit, (2) the premises occupied by the consumer when the deposit was made, (3) the amount and date of making the deposit, and (4) a record of each transaction concerning such deposit, such as payment of interest, interest credited, etc.

(*c*) Each utility shall issue to every consumer from whom a deposit is received a nonassignable receipt.

(*d*) Each utility shall provide reasonable ways and means whereby a depositor who makes application for the return of his deposit, or any balance to which he is entitled, but is unable to produce the original certificate of deposit or receipt, may not be deprived of his deposit or balance.

RULE 32. DISCONTINUANCE OF SERVICE FOR VIOLATION OF RULES OR NONPAYMENT OF BILLS.—(*a*) No utility shall discontinue the service to any consumer for violation of its rules or regulations, or for nonpayment of bills, without first having

diligently tried to induce the consumer to comply with its rules and regulations or to pay his bills. Service shall actually be discontinued only after at least 24 hours' written notice of such intention shall have been given to the consumer by the utility. *Provided, however,* That where fraudulent use of gas is detected, or where a dangerous condition is found to exist on the consumer's premises, the gas may be shut off without notice in advance.

(*b*) Whenever the supply of gas is turned off for violation of rules or regulations, nonpayment of bill, or fraudulent use of gas, the utility may make a reasonable charge for the cost to it of turning the gas on again.

RULE 33. REPLACEMENT OF METERS AND CHANGES IN LOCATION OF SERVICE.—(*a*) Whenever a consumer requests the replacement of the service meter on his premises, such request shall be treated as a request for the test of such meter, and as such shall fall under the provisions of rule 20.

(*b*) Whenever a consumer moves from the location where gas is used by him and thereby requires the disconnecting and connecting at a new location of the gas supply, and the same work has been done for him within one year preceding, the utility may make a reasonable charge for the work.

RULE 34. EXTENT OF SYSTEM IN WHICH UTILITY MUST MAINTAIN SERVICE.—Each gas utility, unless specifically relieved in any case by the commission from such obligation, shall operate and maintain in safe, efficient, and proper condition all of the facilities and instrumentalities used in connection with the regulation, measurement, and delivery of gas to any consumer up to and including the point of delivery into the piping owned by the consumer.

RULE 35. MAPS.—Suitable maps or records shall be kept on file showing the size, character, and location of each street main, district regulator, street valve, and drip.

RULE 36. STREET MAIN EXTENSIONS.—Each utility shall adopt rules, subject to the approval of the commission, under which it will, upon written request for service by a prospective consumer or a group of prospective consumers located in the same neighborhood, make the street main extension necessary to give service and furnish service-pipe connection or connections.

RULE 37. RATE SCHEDULES, RULES and REGULATIONS.—Copies of all schedules of rates for service, forms of contracts, charges for service connections and extensions of mains, and of all rules and regulations covering the relations of consumer and

utility shall be filed by each utility in the office of the commission. Complete schedules, contract forms, rules and regulations, etc., as filed with the commission, shall also be on file in the local offices of the utility, and shall be open to the inspection of the public.

This order shall become effective on ———.

2. PROPOSED CITY ORDINANCE

In some cases where there is no public service commission, or where the commission has no authority over gas service, the cities frequently regulate such service by ordinance.

After an examination of a large number of existing gas ordinances, the Bureau has attempted to embody in the following model the best features of these existing ordinances and such additional matter as has seemed necessary, and to arrange the several sections in logical and convenient form. The proposed ordinance will be found adequate for most situations, but should of course be modified where necessary to meet any unusual local conditions, as is indicated in the preceding discussion. The regulations herein suggested are sufficiently comprehensive to insure to the consumers ample protection and good service under the conditions which are likely to be encountered. They should, however, be considered in connection with the discussion contained in the earlier part of this circular, particularly the general considerations set forth on page 44.

In the adoption of regulations for gas service by a city, it will usually be found wiser to include them in a regulatory ordinance rather than in the gas company franchise. New processes, methods of operation, and types of appliances, or changes in economic conditions may make a revision of the regulations for service desirable from time to time, while changing prices of material and labor may also make necessary a change in the rates for gas. It is therefore believed wiser to include in the franchise, which is usually in the nature of a formal contract, and as such difficult to change, only a provision that the city may from time to time establish by ordinance reasonable regulations, standards, and rates for gas service. It is a suggested form for such a regulatory ordinance that is given below.

The suggested form of ordinance is intended to meet normal conditions in a city of 25 000 or more population. For smaller cities the ordinance should be simplified, since the advantages to be gained by the enforcement of such regulations in very small cities may be overbalanced by the extra cost of such enforcement.

AN ORDINANCE Providing for the appointment of a gas inspector and defining the duties of such officer; providing for the inspection of gas and gas meters; prescribing rules and regulations for the quality, pressure, and measurement of gas supplied to consumers, and for the enforcement thereof.

The mayor and city council of ——— do ordain as follows:

SECTION 1. *Definitions.*—In this ordinance the words "city" and "company" shall be construed to refer, respectively, to the city of ——— and the ——— company; the word "gas" shall include any and all gas made by said company and distributed for the use of either public or private consumer in said city; the word "consumer" shall include any person, company, or corporation to whom the company shall furnish gas for use within said city; and the words "mayor," "city clerk," "city treasurer," "inspector," and "city council" shall be understood to refer, respectively, to the mayor, the city clerk, the city treasurer, the gas inspector, and the city council of said city of ———.

SEC. 2 *Appointment of Inspector.*—The mayor, subject to the approval of the city council, shall appoint as inspector a suitable person who is qualified and recommended to the mayor and the city council, as follows:

——A——— and ———B——— and ———C——— shall constitute a board for the examination of all persons who shall apply for the position of inspector or deputy inspector. Said board shall give public notice of the time and place of such examination at least one month before the same is to be held, and the notice shall be published in the official papers of the city at least twice each week during said month. At the time and place so fixed the board shall examine all applicants, in such a manner as it shall deem necessary, to determine their technical knowledge and competency to perform all duties of inspector or deputy inspector, as called for in this ordinance. After such examination said board shall certify to the mayor and the city council the names of such persons as said board shall deem fully competent to perform such duties. Only persons whose names are so certified shall be eligible to be appointed inspector: *Provided, however,* That any person who shall previously have held the office of inspector under the provisions of this ordinance may be reappointed to said office without such certificate from the board; *Provided, also,* That a person who has once been certified as competent by said board shall be subsequently eligible for appointment without again being examined, during a period of five years from such first examination.

The inspector, his deputies or his assistants, shall not be pecuniarily interested, either directly or indirectly, in the manufacture or sale of gas, gas meters, or any article or commodity used by gaslight companies, or used for any purpose connected with the consumption of gas. The inspector, his deputies, or his assistants shall not give certificates or written opinion to a maker or vender of such article or commodity.

The inspector, appointed as hereinabove provided, shall take an oath of office such as is required of other city officials, and he shall serve for a term of four years, or until his successor shall be properly appointed.

The mayor may remove the inspector at any time for sufficient cause, but notice shall first be given to the inspector of the charges against him and he shall be given a period of 10 days in which to answer such charges. All such charges and the inspector's defense against them shall be made a matter of record: *Provided, however*, That at the time when first appointed the inspector shall serve for a probationary period of 6 months; and he may be removed by the mayor during said 6 months without the notice of charges against him as is required above.

The salary of the inspector shall be ——— per annum.

SEC. 3. *Deputies and Assistants.*—The inspector, with the consent and approval of the city council, may appoint one or more deputy inspectors. Only those persons who shall have been certified by the board of examiners provided for in section 2 as competent to become deputy inspectors shall be eligible to be appointed as deputy inspectors. Said deputies so appointed shall have the power, under the direction of the inspector, to perform any duty which may be required of the inspector under the provision of this ordinance.

The inspector, with the consent and approval of the city council, may appoint one or more assistants or clerks (who need not necessarily be competent to make the tests herein provided for), who shall, under his direction, aid in the performance of the duties of this office.

Each of said deputies and assistants shall take an oath of office such as is regularly required of other city officers.

SEC. 4. *Duties of the Inspector.*—The inspector in person or by deputy or properly qualified assistant, shall perform the following duties:

(*a*) He shall test or determine, as hereinafter prescribed, the quality, purity, and pressure of the gas and, upon request by consumers as hereinafter provided, the accuracy of gas meters.

He shall have full charge of all testing stations, laboratories, and offices provided for his use for such testing and for the keeping of records.

(*b*) He shall receive and investigate complaints regarding the quality of the gas or gas service furnished by the company.

(*c*) He shall keep a record of all regular tests and calibrations made by him or his assistants and of all formal complaints made to him or to other city officials, all of which records shall be preserved complete and correct. Upon request he shall open said records to the company, and, in his discretion, to any person who wishes to examine them.

(*d*) He shall make a monthly report containing the results of all tests, made by him or his assistants, of the heating value, impurities, and pressure of the gas, as well as the results of such tests as may have been made on consumers' meters. One copy of said report shall be sent to the company, one to the city council, and one to the city clerk, who shall keep it available for examination by the public.

(*e*) He shall make a special report to the city clerk whenever the quality or pressure of the gas shall be shown by test not to conform to the requirements of this ordinance. The substance of said special report shall be communicated to the company by telephone or by special messenger from the inspector immediately upon completion of the test which showed such condition to exist. A confirmation of any such telephone message shall be delivered to the company in writing not later than the next working day following that on which the test is completed, and the company shall acknowledge in writing the receipt of the report when so requested.

(*f*) He shall perform any and all other duties naturally connected with this office as required or implied by any part of this ordinance, or as specially assigned to him at any time by the city council.

SEC. 5. *Testing Stations.*—As soon as practicable after the passage of this act the city shall provide the necessary testing stations, and it shall equip and maintain the same with such apparatus and supplies as may be needed for carrying out the provisions of this ordinance. Each of said stations shall be located at or near a center of gas consumption, and, if possible, shall be not less than one mile nor more than two miles, measured in a direct line, from any manufacturing plant of the company.[14]

[14] When the gas sold in any city is made in another city, the testing station should be located at or near the center of gas consumption in the city where the gas is sold.

The company shall run a special service pipe into each of said testing stations, the same to be of such size and installed in such manner as may be directed by the inspector: *Provided*, That the company shall be allowed so to protect this service as to prevent its exposure to temperatures lower than those of the gas-supplying main.

SEC. 6. *Methods of Testing—General Provisions.*—All tests of the heating value of the gas used to determine compliance with the provisions of this ordinance shall be made at the regular testing stations by the inspector or his authorized assistant; and the company may, if it so desires, have a representative present at any of said tests.

The character of the apparatus and supplies used in all testing, the calibration of apparatus, the testing of supplies, and the methods of making official tests shall be substantially as determined by the provisions of the current issue of the National Bureau of Standards' Circular No. 48, "Standard Methods of Gas Testing."

When the gas itself is to be tested, a cubic foot of gas shall be taken to be that amount of gas which occupies the volume of 1 cubic foot when saturated with water vapor and at 60° F, and under a pressure of 30 inches of mercury. For purpose of measurement of gas to a consumer a cubic foot of gas shall be taken to be the amount of gas which occupies a volume of 1 cubic foot under the conditions existing in such consumer's meter as and where installed.

SEC. 7. *Heating Value.*—The company shall maintain the monthly average total heating value of the gas, when tested as herein provided, at not less than — Btu per cubic foot; and no daily average total heating value of the gas shall be less than — Btu per cubic foot of gas or more than — Btu per cubic foot.

The heating value of the gas shall, if possible, be determined by the inspector at least once each working day at each of the testing stations provided for in section 5 of this ordinance. The average of all of the results thus obtained on any one day at various testing stations shall be considered the daily average total heating value of the gas for that day: *Provided, however*, That not less than two single determinations shall be used to determine such daily average. The average of all the daily averages obtained thus during any one calendar month shall be considered the monthly average total heating value of the gas for that month: *Provided, however*, That not less than 20 daily averages shall be

used to determine a monthly average heating value upon which compliance with the provisions of this ordinance shall be determined.

SEC. 8. *Impurities.*—The gas supplied by the company when tested as prescribed herein shall not show the presence of more than a trace of hydrogen sulphide, and shall contain in 100 cubic feet of gas not more than 30 grains of sulphur in any and all forms known as total sulphur, and not more than 5 grains of ammonia.

Once each working day at each testing station the gas shall be tested for hydrogen sulphide by exposing to the gas for 1 minute in a standard apparatus a strip of white filter paper freshly moistened with a solution containing 5 per cent by weight of lead acetate, the gas flowing at the rate of approximately 5 cubic feet per hour and not impinging directly from a jet upon the test paper. The gas shall be judged free from more than a trace of hydrogen sulphide if the paper thus exposed is not distinctly darker than another similar strip of paper which is wet with the same solution but has not been exposed to the gas.[15]

The determination of total sulphur and ammonia shall be made once every two weeks: *Provided, however,* That if the gas shows on such first determination either total sulphur or ammonia in excess of that allowed under the first paragraph of this section, a second determination of that impurity appearing by the first determination to be in excess of the allowable amount shall be made, beginning on the same or the next working day following that day on which said first determination is completed; and the average of the two determinations thus made during any week shall be considered as representing the quantity of total sulphur or ammonia in the gas for that week.

SEC. 9. *Pressure of Gas.*—The pressure of the gas, as measured at the outlet of the company's service pipe to any consumer,[16] shall never be less than 2 inches nor more than 8 inches of water pressure without the written permission of the inspector.

Between the hours of 5 a. m. and 10 p. m. the pressure of the gas at the outlet of the company's service pipe to any consumer shall never vary by more than the following amounts, viz:

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[15] With reference to preservation of such test papers see footnotes *d*, *e*, *g*, in Table 3.

[16] In the case of high-pressure systems where individual house governors are used, this phrase should read "at the outlet of the house governor."

Minimum pressure maintained	Maximum pressure variation permissible
2 to 3 inches	2 inches
3 to 4 inches	2½ inches
Over 4 inches	3 inches

Each testing station shall be equipped with a continuously recording pressure gage by means of which a record shall be made of the gas pressure at said station. Additional gages shall be employed regularly to determine the pressure of the gas at other places throughout the city.

In case that the gas pressure in any district shall be found to be less than 2 inches of water pressure, then the company shall, if possible, permanently correct this deficiency within three months of the time when it is first reported to the company: *Provided, however*, That if this deficiency of pressure be first reported to the company between November 1 and April 1, then the company shall be allowed until the 1st of the following July to make such correction;[17] but if at any time a pressure shall be discovered by or reported to the company as less than 1½ inches, then correction of this deficiency shall be made as speedily as practicable.[18]

The company may change the normal pressure in any district provided it shall give written notice to the gas inspector of such change and shall without charge to the consumers readjust all appliances in use in the district for the new normal pressure.

SEC. 10. *Meters and Meter Testing.*—Every gas-service meter, whether new, repaired, or removed from service for any cause, shall be in good order and shall be adjusted to be correct to within 1 per cent [19] when passing gas at 6 cubic feet per hour per rated light capacity before being installed for the use of any consumer. Each meter shall be marked with the date of the last test made on that meter. Meters shall be tested as follows:

(*a*) During each period of one year after the passage of this ordinance, until all meters now in service have been tested, the company shall remove approximately 20 per cent of the meters now in service, those longest in service being removed first. Said

[17] In cities where the ground does not freeze enough to interfere seriously with street operations, the correction of conditions causing low pressure can be made within three months; under such circumstances there is no need to make the exception for the winter months.

[18] If a permit is required to open the streets, then the company shall not be held responsible for any delay in the granting of the necessary permit or permits.

[19] In the smaller companies which have no facilities for opening meter cases and adjusting the mechanism an accuracy of 1½ per cent is all that should be required. See p. 40.

meters shall be tested by the company and proper adjustments and repairs made where necessary.

(*b*) No meter shall be allowed to remain in service more than five years after being once tested before being again tested. (See footnote p. 69.)

(*c*) Any consumer's meter shall be tested free of charge by the company, upon application of said consumer, unless in special cases the company is given permission by the inspector to make a charge for such tests in an amount not to exceed the actual cost to the company: *Provided*, First, that said meter has not previously been tested by the company or by the inspector within six months of said application; and, second, that the consumer shall agree to accept the result of such test by the company as a basis for settlement of the difference claimed.

(*d*) Upon application of any consumer and after deposit with the inspector by said consumer of the sum of $1, the inspector shall test said consumer's meter. If the meter proves to be slow or correct within 3 per cent, one-half of said deposit shall be paid to the company and one-half of the deposit shall be paid into the city treasury by the inspector as a fee for said test. If the meter proves more than 3 per cent fast, the company shall pay into the city treasury 50 cents as the fee for said test, and the deposit of $1 shall be returned to said consumer by the inspector; and, further, the company shall refund to the complaining consumer such a percentage of the amount of the bills for the six months just previous to said complaint, or for the time said meter was in use, not exceeding six months, as the meter shall have been shown to be in error by such test. If the meter proves more than 3 per cent slow, the company may charge to the complaining consumer such percentage of the amount of the bills for the six months just previous to said complaint, or for the period during which said meter was in use by said consumer, not exceeding six months, as the meter shall have been shown to be in error by such test: *Provided, however*, That if the inaccuracy of the meter was due to some cause, the date of which can be fixed, the overcharge or undercharge shall be computed back to, but not beyond, such time.

The company shall own an approved type of meter prover, preferably of not less than 5 cubic feet capacity, equipped with suitable thermometers and other necessary accessories, and it shall maintain such equipment in proper adjustment so that it shall be capable of determining the accuracy of any service meter

to within one-half of 1 per cent. The prover shall be so placed that it is not subjected to drafts or excessive temperature variations.

The removal and transportation of all meters shall be done by the company at its own expense, except as provided in the preceding paragraph.

For purposes of inspecting the testing of meters, the inspector shall have access at all reasonable hours to the shops of the company where such tests are made and to the records of all such tests as are performed under the provisions of this ordinance. He shall be allowed at any time to examine the provers used for the testing of meters and to check the results of tests on any number of meters which he may wish to examine. This inspection shall be such as not to interrupt the regular testing work of the company more than is necessary to insure careful and accurate tests of all meters, and the company shall in no case be relieved of the responsibility for the accuracy of its meters.

SEC. 11. *Company Records.*—The company shall maintain the records described hereinafter, and shall allow free access to said records at all reasonable hours to the inspector or other city official who may be authorized by the city council to have such privilege.

The records shall include the following:

First. A record of all consumers purchasing gas from the company and the number of the meter or meters in use by each.

Second. A record of all meters owned by the company, with the date of their purchase, and a record of the use, repairs, and tests to which each has been subjected, with the result of each test and the location of each meter.

Third. A record of all complaints made to the company regarding the quality of the gas or gas service and of the method of disposal of each of said complaints.

Fourth. A record of any condition resulting in an interruption of service affecting its entire system or major division thereof, including a statement of the time, duration, and the cause of such interruption.

SEC. 12. *Complaints.*—The company shall make a reasonable investigation of all complaints made to it by the inspector or by any consumer and shall promptly take such steps as may be necessary to remedy the difficulty.

SEC. 13. *Penalties.*—In any case where the company has failed to comply with the provisions of this ordinance, and upon investi-

gation such noncompliance has been due to carelessness or inexcusable neglect, the city council may, at its discretion, impose such penalty as is commensurate with the impairment of the service, but in no case in excess of $—— in any one month. If the company shall fail to pay said amount as herein required within 30 days, then the city, by its proper officials, shall take action as provided in section 14 hereof, or, if necessary, in some court of competent jurisdiction.

SEC. 14. *Disputed Cases.*—In case of any dispute between the city or the inspector and the company as to the carrying out of any provision of this ordinance which is not provided for elsewhere in this ordinance, then said dispute or difference shall be settled as follows: An arbitration board, as between the city and the company, shall be appointed—one member by the city, one member by the company, and a third member by agreement between said first two members. The decision of these three, or a majority of them, shall be binding upon all concerned. The expenses of said arbitration board shall be borne equally by the city and the company.

SEC. 15. *Repeal.*—All ordinances of the city and parts thereof controvening or inconsistent with the terms of this ordinance are hereby repealed.

SEC. 16. *Time of Becoming Effective.*—This ordinance shall take effect and be in force from and after ———.

X. STATE AND MUNICIPAL STANDARDS NOW IN FORCE

The Bureau of Standards has attempted to make a complete compilation of all legislation and administrative regulations as apply to heating value, candlepower, purity and pressure of gas, gas-meter testing, and other phases of gas-company operations discussed in this circular. This information is summarized in this section in a form practically complete to May 1, 1920. The data for States are believed to be complete in every particular, but the municipal requirements have not been available in every case. The effort has been made to have substantially a complete report for all cities of 8000 or more in population or where 50 000 000 cubic feet or more of manufactured gas is used per year.

The following 20 States and the District of Columbia have rules for regulating gas service:

Arizona.	Kansas.	New Jersey.
California.[20]	Maryland.	New York.
Colorado.	Massachusetts.	Oregon.
Connecticut.	Missouri.	Pennsylvania.
District of Columbia.	Montana.	Washington.
Illinois.	Nevada.	West Virginia.
Indiana.	New Hampshire.	Wisconsin.

The following 11 States have commissions with authority for regulating gas service, but no rules have as yet been prescribed:

Alabama.	Ohio.	Vermont.
Georgia.	Oklahoma.	Virginia.
Idaho.	Rhode Island.	Wyoming.
Maine.	Utah.	

In the following 17 States the commissions have no clearly defined authority to issue rules for the regulation of gas service:

Arkansas.	Michigan.	North Dakota.
Delaware.	Minnesota.	South Carolina.
Florida.	Mississippi.	South Dakota.
Iowa.	Nebraska.	Tennessee.
Kentucky.	New Mexico.	Texas.
Louisana.	North Carolina.	

In order to make clear in convenient form the status of the regulations of gas service in each municipality, the following tabulation has been prepared. These cities may be grouped according to the rules in force as follows:

State rules in force	228
State commission has authority (unexercised)	51
City ordinances in force	76
No rules in force and no State commission in authority	24
Municipal operation	2
Total, less duplicates	369

CHARACTER OF STANDARDS FOR GAS SERVICE IN CITIES

NOTE.—"State" indicates that a State commission has authority to supervise gas-company operations; where marked thus (*) the commission has rules for service actually in force for the State as a whole. "None" indicates that no State commission has authority and that no State or city rules are operative. Where the city owns and operates the gas plant, this fact is shown. The numbers opposite the city names relate to the tables following this list: 1 refers to heating value; 2, candlepower; 3, purity; 4, gas pressure; 5, meter accuracy; 6, inspection provided.

Adrian, Mich. . . . . 1, 2, 4.	Altoona, Pa. . . . . State.*
Akron, Ohio. . . . . State.	Amsterdam, N. Y. . . . . State.*
Alameda, Calif. . . . . State.*	Ann Arbor, Mich. . . . . 1, 6.
Albany, N. Y. . . . . State.*	Anniston, Ala. . . . . State.
Albion, Mich. . . . . None.	Ansonia, Conn. . . . . State.*
Allentown, Pa. . . . . State.*	Appleton, Wis. . . . . State.*

[20] Rules in California not applicable in some large cities.

Arlington, Mass. . . . . State.*
Atlanta, Ga. . . . . State, 1, 6.
Atlantic City, N. J. . . . . State.*
Attleboro, Mass. . . . . State.*
Auburn, N. Y. . . . . State.*
Augusta, Ga. . . . . State, 1.
Aurora, Ill. . . . . State.*
Austin, Tex. . . . . None.
Baltimore, Md. . . . . State.*
Bangor, Me. . . . . State, 1, 5.
Battle Creek, Mich. . . . 1, 2, 3, 4, 5, 6.
Bay City, Mich. . . . . 2, 4, 5, 6.
Bayonne, N. J. . . . . State.*
Beaumont, Tex. . . . . 5, 6.
Bellefontaine, Ohio. . . . State municipal plant.
Belleville, Ill. . . . . State.*
Bellingham, Wash. . . . . State.*
Beloit, Wis. . . . . State.*
Benton Harbor, Mich. . None.
Berkeley, Calif. . . . . State.*
Bethlehem, Pa. . . . . State.*
Beverly, Mass. . . . . State.*
Binghamton, N. Y. . . . . State.*
Birmingham, Ala. . . . . State, 1, 2, 3, 4.
Bloomington, Ill. . . . . State.*
Blue Island, Ill. . . . . State.*
Boise, Idaho. . . . . State.
Boston, Mass. . . . . State.*
Boulder, Colo. . . . . State.*
Bridgeport, Conn. . . . . State.*
Bridgeton, N. J. . . . . State.*
Bristol, Conn. . . . . State.*
Brockton, Mass. . . . . State.*
Brookline, Mass. . . . . State.*
Buffalo, N. Y. . . . . State.*
Burlington, Iowa. . . . . 5, 6.
Burlington, Vt. . . . . State.
Butler, Pa. . . . . State.*
Butte, Mont. . . . . State.*
Cambridge, Mass. . . . . State.*
Camden, N. J. . . . . State.*
Canton, Ohio. . . . . State.
Cedar Rapids, Iowa. . . . 1, 3, 4, 5, 6.
Central Falls, R. I. . . . . State.
Champaign, Ill. . . . . State.*
Charleston, S. C. . . . . 1, 2, 3, 4, 5, 6.
Charleston, W. Va. . . . . State.*
Charlotte, N. C. . . . . 6.
Chattanooga, Tenn. . . . 1, 2, 3, 4.
Chelsea, Mass. . . . . State.*
Chester, Pa. . . . . State.*
Chicago, Ill. . . . . State.*
Chicago Heights, Ill. . . State.*
Chicopee, Mass. . . . . State.*
Cincinnati, Ohio. . . . . State, 4, 5, 6.
Cleveland, Ohio. . . . . State, 1, 2, 3, 4, 6.
Clinton, Iowa. . . . . 1, 2.
Cohoes, N. Y. . . . . State.*
Columbia, S. C. . . . . None.
Columbus, Ga. . . . . State.
Columbus, Ohio. . . . . State.
Colorado Springs, Colo. State.*
Concord, N. H. . . . . State.*
Council Bluffs, Iowa. . . 2, 5.
Covington, Ky. . . . . None.
Cranston, R. I. . . . . State.
Cumberland, Md. . . . . State.*
Dallas, Tex. . . . . 1, 4, 5, 6.
Danbury, Conn. . . . . State.*
Danville, Ill. . . . . State.*
Danville, Va. . . . . State, municipal plant.
Davenport, Iowa. . . . . 2, 3, 4, 6.
Dayton, Ohio. . . . . State, 5.
Decatur, Ill. . . . . State.*
Denver, Colo. . . . . State.*
Derby, Conn. . . . . State.*
Des Moines, Iowa. . . . . 1, 3, 4, 5, 6.
Detroit, Mich. . . . . 1, 2, 3, 4, 5, 6.
Dubuque, Iowa. . . . . None.
Duluth, Minn. . . . . 1.
Durham, N. C. . . . . None.
Easton, Pa. . . . . State.*
East Chicago, Ind. . . . . State.*
East Orange, N. J. . . . . State.*
East St. Louis, Ill. . . . . State.*
Eau Claire, Wis. . . . . State.*
Elgin, Ill. . . . . State.*
Elizabeth, N. J. . . . . State.*
Elkhart, Ind. . . . . State.*
Elmira, N. Y. . . . . State.*
El Paso, Tex. . . . . 6.
Erie, Pa. . . . . State.*
Evanston, Ill. . . . . State.*
Evansville, Ind. . . . . State.*
Everett, Mass. . . . . State.*
Everett, Wash. . . . . State.*
Fall River, Mass. . . . . State.*
Fargo, N. Dak. . . . . 1, 2, 5, 6.
Fitchburg, Mass. . . . . State.*
Flint, Mich. . . . . 1, 3, 4, 5, 6.
Fond du Lac, Wis. . . . . State.*
Fort Dodge, Iowa. . . . . None.
Fort Smith, Ark. . . . . None.
Fort Wayne, Ind. . . . . State.*
Fort Worth, Tex. . . . . 6.
Framingham, Mass. . . . . State.*

Freeport, Ill. . . . . State.*
Fresno, Calif. . . . . State.*
Galesburg, Ill. . . . . State.*
Galveston, Tex. . . . . None.
Gary, Ind. . . . . State.*
Glens Falls, N. Y. . . . . State.*
Gloucester, Mass. . . . . State.*
Gloversville, N. Y. . . . . State.*
Grand Rapids, Mich. . . . 1, 2, 3, 4, 5, 6.
Granite City, Ill. . . . . State.*
Green Bay, Wis. . . . . State.*
Greensboro, N. C. . . . . 5, 6.
Hackensack, N. J. . . . . State.*
Hagerstown, Md. . . . . State.*
Hamilton, Ohio. . . . . State, 1.
Hammond, Ind. . . . . State.*
Harrisburg, Pa. . . . . State.*
Hartford, Conn. . . . . State.*
Haverhill, Mass. . . . . State.*
Hazelton, Pa. . . . . State.*
Hoboken, N. J. . . . . State.*
Holyoke, Mass. . . . . State.*
Houston, Tex. . . . . 2, 5, 6.
Huntington, Ind. . . . . State.*
Huntington, W. Va. . . . . State.*
Indianapolis, Ind. . . . . State.*
Iowa City, Iowa. . . . . None.
Ithaca, N. Y. . . . . State.*
Jackson, Mich. . . . . 1, 2, 4, 5, 6.
Jackson, Miss. . . . . 1, 2, 4.
Jacksonville, Fla. . . . . None.
Jamaica, N. Y. . . . . State.*
Jamestown, N. Y. . . . . State.*
Janesville, Wis. . . . . State.*
Jersey City, N. J. . . . . State.*
Johnstown, Pa. . . . . State.*
Joliet, Ill. . . . . State,* 1, 2.
Kalamazoo, Mich. . . . . 1, 2, 3, 4, 5, 6.
Kankakee, Ill. . . . . State.*
Kansas City, Kans. . . . . State,* for natural gas.
Kansas City, Mo. . . . . State, 2, 4, 5, 6.
Kenosha, Wis. . . . . State.*
Kewanee, Ill. . . . . State.*
Key West, Fla. . . . . None.
Kingston, N. Y. . . . . State.*
Knoxville, Tenn. . . . . 5, 6.
La Crosse, Wis. . . . . State.*
Lafayette, Ind. . . . . State.*
Lancaster, Pa. . . . . State.*
Lansing, Mich. . . . . 1, 2, 4, 5, 6.
La Porte, Ind. . . . . State.*
Lawrence, Mass. . . . . State.*
Lewiston, Me. . . . . State.

Lexington, Ky. . . . . 6.
Lima, Ohio. . . . . State.
Lincoln, Nebr. . . . . 1, 2, 3, 4, 5, 6.
Little Rock, Ark. . . . . None.
Lockport, N. Y. . . . . State.*
Logansport, Ind. . . . . State.*
Long Beach, Calif. . . . . State.*
Long Branch, N. J. . . . . State.*
Lorain, Ohio. . . . . State.
Los Angeles, Calif. . . . . State,* 1, 2, 3, 4, 5, 6.
Louisville, Ky. . . . . 1, 3, 4, 5, 6.
Lowell, Mass. . . . . State.*
Lynchburg, Va. . . . . State.
Lynn, Mass. . . . . State.*
McKeesport, Pa. . . . . State.*
Macon, Ga. . . . . State.
Madison, Wis. . . . . State.*
Malden, Mass. . . . . State.*
Manchester, N. H. . . . . State.*
Marshalltown, Iowa. . . . . None.
Mason City, Iowa. . . . . 1, 3, 4, 5, 6.
Medford, Mass. . . . . State.*
Memphis, Tenn. . . . . 2, 5, 6.
Meriden, Conn. . . . . State.*
Middletown, Conn. . . . . State.*
Millville, N. J. . . . . State.*
Milwaukee, Wis. . . . . State.*
Minneapolis, Minn. . . . . 1, 2, 3, 4, 5, 6.
Mobile, Ala. . . . . State.
Moline, Ill. . . . . State.*
Montclair, N. J. . . . . State.*
Montgomery, Ala. . . . . State.
Mount Vernon, N. Y. . . . State.*
Muncie, Ind. . . . . State.*
Muskegon, Mich. . . . . None.
Muskogee, Okla. . . . . State.
Nashua, N. H. . . . . State.*
Nashville, Tenn. . . . . 2, 6.
Newark, N. J. . . . . State.*
Newark, Ohio. . . . . State.
New Bedford, Mass. . . . . State.*
New Britain, Conn. . . . . State.*
New Brunswick, N. J. . . State.*
Newburgh, N. Y. . . . . State.*
New Castle, Pa. . . . . State.*
New Haven, Conn. . . . . State.*
New London, Conn. . . . . State.*
New Orleans, La. . . . . 1, 3, 4, 5, 6.
Newport, Ky. . . . . 6.
Newport, R. I. . . . . State.
Newport News, Va. . . . . State.
New Rochelle, N. Y. . . . State.*
Newton, Mass. . . . . State.*

New York, N. Y.....State.*
Niagara Falls, N. Y.....State.*
Norfolk, Va.....State, 5, 6.
Norristown, Pa.....State.*
North Adams, Mass.....State.*
Northampton, Mass.....State.*
Norwalk, Conn.....State.*
Norwich, Conn.....State.*
Oakland, Calif.....State,* 6.
Oak Park, Ill.....State.*
Ogden, Utah.....State, 1.
Oklahoma City, Okla...State.
Omaha, Nebr.....1, 2, 3, 5, 6.
Orange, N. J.....State.*
Oshkosh, Wis.....State.*
Ottawa, Ill.....State.*
Ottumwa, Iowa.....None.
Pasadena, Calif.....State,* 1, 3,4, 5,6.
Passaic, N. J.....State.*
Paterson, N. J.....State.*
Pawtucket, R. I.....State, 2, 3.
Pensacola, Fla.....None.
Peoria, Ill.....State.*
Perth Amboy, N. J.....State.*
Petersburgh, Va.....State.
Peru, Ind.....State.*
Philadelphia, Pa.....State,* 2, 5, 6.
Phoenix, Ariz.....State.*
Pittsburgh, Pa.....State.*
Pittsfield, Mass.....State.*
Pomona, Calif.....State.*
Port Arthur Tex.....2.
Port Huron, Mich.....1, 2, 3, 4, 5, 6.
Portland, Me.....State.
Portland, Oreg.....State.*
Portsmouth, Ohio.....State.
Portsmouth, Va.....State.
Poughkeepsie, N. Y.....State.*
Providence, R. I.....State, 1, 6.
Pueblo, Colo.....State.*
Quincy, Ill.....State.*
Quincy, Mass.....State.*
Racine, Wis.....State.*
Raleigh, N. C.....None.
Reading, Pa.....State.*
Revere, Mass.....State.*
Richmond, Va.....State.
Roanoke, Va.....State, 1, 2, 3, 4, 5, 6.
Rochester, N. Y.....State.*
Rockford, Ill.....State.*
Rock Island, Ill.....State.*
Rome, N. Y.....State.*
Sacramento, Calif.....State.*
Saginaw, Mich.....1, 2, 3, 4, 5, 6.
St. Joseph, Mo.....State.*
St. Louis, Mo.....State,* 1.
St. Paul, Minn.....1, 2, 4, 5, 6.
Salem, Mass.....State.*
Salt Lake City, Utah...State.
San Antonio, Tex.....None.
San Diego, Calif .....State,* 1, 3,4, 5, 6.
San Francisco, Calif....State,* 1, 2,4, 5, 6.
San Jose, Calif.....State.*
Santa Barbara, Calif...State,* 5, 6.
Saratoga Springs, N. Y..State.*
Savannah, Ga.....State, 1, 5, 6.
Schenectady, N. Y.....State.*
Scranton, Pa.....State.*
Seattle, Wash.....State.*
Sheboygan, Wis.....State.*
Shenandoah, Pa.....State.*
Shreveport, La.....5, 6.
Sioux City, Iowa.....1, 2, 3, 4, 5, 6.
Sioux Falls, S. Dak.....1, 3, 4, 5, 6.
Somerville, Mass.....State.*
South Bend, Ind.....State.*
Spokane, Wash.....State.*
Springfield, Ill.....State.*
Springfield, Mass.....State.*
Springfield, Mo.....State,* 2.
Springfield, Ohio.....State, 2.
Stamford, Conn.....State.*
Steubenville, Ohio.....State.
Stockton, Calif.....State.*
Superior, Wis.....State.*
Syracuse, N. Y.....State.*
Tacoma, Wash.....State.*
Tampa, Fla.....None.
Taunton, Mass.....State.*
Terre Haute, Ind.....State.*
Toledo, Ohio.....State, 2, 5, 6.
Tonowanda, N. Y.....State.*
Topeka, Kans.....State,* for natural gas.
Torrington, Conn.....State.*
Trenton, N. J.....State.*
Troy, N. Y.....State.*
Tulsa, Okla.....State.
Utica, N. Y.....State.*
Vallejo, Calif.....State.*
Vincennes, Ind.....State.*
Wabash, Ind.....State.*
Waco, Tex.....5, 6.
Walla Walla, Wash.....State.*
Waltham, Mass.....State.*
Warwick, R. I.....State.
Washington, D. C.....State.*
Waterbury, Conn.....State.*
Waterloo, Iowa.....1, 2, 5, 6.

Watertown, N. Y.....State.*
Waukegan, Ill.....State.*
Waukesha, Wis.....State.*
West Hoboken, N. J....State.*
Westchester, N. Y.....State.*
Wheeling, W. Va.....State.*
Wichita, Kans.....State,* for natural gas.
Wilkes-Barre, Pa.....State.*
Williamsport, Pa.....State.*
Wilmington, Del.....5, 6.
Wilmington, N. C.....None.
Winona, Minn.....None.
Winston-Salem, N. C...None.
Woodhaven, N. Y.....State.*
Woonsocket, R. I.....State.
Worcester, Mass.....State.*
Yonkers, N. Y.....State.*
York, Pa.....State.*
Youngstown, Ohio.....State.
Zanesville, Ohio.....State.

TABLE 1.—Heating Value

A. STATE RULES OR LAWS

[Applicable primarily to manufactured gas; to natural gas only as noted]

State	Total heating value required		Minimum volume of sales above which calorimeter is required	Specified frequency of test	Specified place of test	Records
	Monthly average [a]	Minimum				
	Btu/ft.³	Btu/ft.³	Millions of ft.³			
Arizona	600	550			Within 1 mile radius from distribution center.	
California	570	540	20	Daily if annual sales exceed 50 000 M; at least 3 days a week if less.	1 mile from distribution center	To be kept permanently.
Colorado	575	525	20	At least 4 days a week	Within 1 mile of manufacturing plant.	To be kept at least 2 years.
Connecticut		[b] 528	20	At least 3 days a week	Within 1½ miles of manufacturing plant.	To be accessible to commission and kept at least 3 years. Monthly report to commission.
District of Columbia	600	550 daily average.		Daily	Commission testing stations	To be accessible to commission and kept at least 3 years.
Illinois	[c] 565	530	20	At least 3 days a week [d]	Within 1 mile of plant and at a point of consumption.	Do.
Indiana	570	540	All companies.	Periodic	Within 1 mile radius from distribution center.	To be open to public.
Kansas (natural gas)		800	20	At least twice a week by utility or pipe-line or producing company.		
Maryland	600	550	15	If annual sales are 15 000 M to 30 000 M, at least 3 days a week; if sales exceed 30 000 M, each working day.	Within 1 mile of manufacturing plant.	To be kept.
Massachusetts		[e] 528	15	At least twice a year and as much oftener as board requires.	Not less than ¼ mile from manufacturing plant.	

Missouri	[f] 570	520	20	At least 3 days a year [d]	Within 1 mile of manufacturing plant.	To be available to commission and preserved at least 2 years.
Montana	[g] 475	450	10	Periodic	Within 1 mile radius from distribution center.	To be open to public.
Nevada	550	500	5	do	do	Do.
New Hampshire	[h] 565	550	20	At least 3 days a week	Within 1 mile radius from manufacturing plant.	Do.
New Jersey		525	20	Periodic	Within 1 mile radius from distribution center.	To be kept on file in office of company.
New York, first district.	[i] 650	615 (3-day average).	All companies.	Daily	Not less than ½ mile in air line from manufacturing or distributing station.	To be open to public.
New York, first district (Coney Island).		525				

[a] The following States define "monthly average": California, Colorado, Connecticut, District of Columbia, Illinois, Maryland, Missouri, New York (first district), and Oregon.

[b] Gas delivered to mains at above 2 pounds pressure to be tested before compression. The minimum total heating value of 528 Btu was fixed as "a war emergency measure," modifying a requirement of 575 Btu monthly average total heating value and minimum of 530 Btu.

[c] For gas carried at 5 pounds pressure or higher the values specified are: Monthly average, 530 Btu; minimum value, 520 Btu. "Present heating value standard" (September, 1914, the date of adoption of rules) must not be lowered without permission of commission. This affects only a few small cities where candlepower rules have been in force.

[d] The heating value of natural gas is to be tested at least three times a year.

[e] A penalty of $100 attaches where gas falls below standard on three consecutive inspections, or on three inspections made within a period of 30 consecutive days. No other State provides such specific penalty.

[f] No utility shall lower its "present" (October, 1915) standard heating value without permission of commission.

[g] Basis of rating not stated, but intended to be the cubic foot measured at local barometric pressure. These Montana requirements are, therefore, equivalent to 600 Btu and 70 Btu under "standard" (sea level) conditions.

[h] The former average total heating value of 600 Btu was changed to 565 Btu "as an emergency measure," effective Apr. 1, 1917.

[i] This heating-value standard (650 Btu) is only an alternative to candlepower requirement (*q. v.*) and is optional with company with consent of commission. If adopted it will be effective not more than three months after termination of the war. With permission of commission a company may, during this period, reduce its heating-value standard below 650 if it proportionately reduces its rates.

TABLE 1.—Heating Value—Continued

A. STATE RULES OR LAWS—Continued

[Applicable primarily to manufactured gas; to natural gas only as noted]

State	Total heating value required		Minimum volume of sales above which calorimeter is required	Specified frequency of test	Specified place of test	Records
	Monthly average	Minimum				
	Btu/ft.^{3}	Btu/ft.^{3}	Millions of ft.^{3}			
New York, second District.	[a] 585	5 per cent below 585 for 3-day average.	20	Daily	Within 2 mile radius from manufacturing plant.	To be kept permanently and to be open to public.
Oregon	570 oil gas; 600 other gas.	550	10	At least 3 days a week.	Within a mile radius from manufacturing plant, or, if made out of city, at or near center of consumption or at a regular laboratory of commission.	To be open to public.
Pennsylvania	[b] 550 coke-oven gas; 570 other gas.	500 coke-oven gas; 520 other manufactured gas; 800 natural gas.	20	At least 3 days a week [c]	Within 1 mile radius from manufacturing plant.	To be kept.
Washington	600	550	10	A least weekly		To be open to public.
Wisconsin	520	Max. variation 4 1/2%.	20	At least 3 days a week.	Within 1 mile radius from distribution center.	Do.

[a] These requirements apply only to companies supplying 20 000 M or more cubic feet per year; companies supplying less than this amount may, however, exercise the option to adopt the same standard to be under the same general requirements. By special ruling the Niagara Light, Heat & Power Co. is allowed to supply coke-oven gas of 550 Btu monthly average and 525 Btu minimum 3-day average and 500 Btu absolute minimum. Manufactured gas delivered to mains at a pressure above 5 pounds per square inch shall be tested for heating value before compression.

[b] Manufactured gas delivered to mains at a pressure above 5 pounds per square inch shall be tested for heating value before compression.

[c] See foot note [d], p. 93.

TABLE 1.—Heating Value—Continued

B. MUNICIPAL REQUIREMENTS

City	Heating value required	Specified frequency of test	By whom test is to be made	Remarks
	Btu/ft.^{3}			
Adrian, Mich	Minimum, 600			
Ann Arbor, Mich	Monthly average, 575; minimum, 525			
Atlanta, Ga	Monthly average, 575; minimum, 550			
Augusta, Ga	Monthly average, 575; minimum, 550			
Baltimore, Md	Monthly average, 500; maximum, 520; minimum, 490.	Daily		
Bangor, Me	600			
Battle Creek, Mich	Monthly average, 600	Twice a day	Company	
Birmingham, Ala	575 gross			
Cedar Rapids, Iowa	600 gross	Daily		
Charleston, S. C	600 gross	Twice a month		
Chattanooga, Tenn	Minimum, 600			
Cincinnati, Ohio	Minimum, 800			Natural gas.
Cleveland, Ohio	Monthly average, 600 gross; daily average, 550 gross.			Natural gas; minimum, 800 Btu.
Clinton, Iowa	Minimum, 600			
Dallas, Tex	633			Natural gas.
Des Moines, Iowa	560 total	Daily	City	
Detroit, Mich	600 gross			
Duluth, Minn	Monthly average, 585; yearly average, 600; daily minimum, 500.	Daily		In accordance with Wisconsin standards.
Flint, Mich	Monthly average, 590 gross; minimum, 550			Within 1 mile from holder.
Grand Rapids, Mich	600 gross	Periodic and at request of common council.		
Hamilton, Ohio	Minimum 800			Natural gas.
Iowa City, Iowa	Daily average, 600 gross	Twice a day on at least 20 days a month.	City	Pro rata discount if heating value below 600 for month.
Jackson, Mich	Minimum daily, 540; average of 3 tests at least 1 hour apart within 24 hours must be at least 565.			

TABLE 1.—Heating Value—Continued

B. MUNICIPAL REQUIREMENTS—Continued

City	Heating value required	Specified frequency of test	By whom test is to be made	Remarks
	Btu/ft.^{3}			
Jackson, Miss	Average, 570; minimum, 550			
Joliet, Ill	600			
Kalamazoo, Mich	Monthly average, 600; minimum daily average, 550.	Daily	Gas inspector	If below standard must make two tests that day.
Lansing, Mich	Minimum average, 600			
Lincoln, Nebr	625	Daily; 15 tests per month sufficient for monthly average.	Gas inspector	Discount of 5 cents per M per 10 Btu below average of 625.
Los Angeles, Calif	600 gross	Daily, with 2 extra not less than 3 hours apart if less than standard.	Board of Public Utilities	Conditions of test defined.
Louisville, Ky	Minimum, 700			Natural gas; pro rata discount if heating value is below 700 for any month.
Mason City, Iowa	600 gross			
Minneapolis, Minn	Monthly average, 600 gross; minimum, 550	Twice daily on 20 days a month.	City	Discount on bills if less than 600 average.
New Orleans, La	Monthly average minimum, 600; daily average minimum, 575.	At least 3 days a week	Company	
Ogden, Utah	Minimum, 500	Daily	do	
Omaha, Nebr	600 net	Weekly or oftener		Within 1½ miles from holder.
Pasadena, Calif	Minimum, 600 gross	Twice daily with 6-hour interval.	City chemist	Conditions of test defined.
Philadelphia, Pa	Minimum, 530 gross			
Port Huron, Mich	600			
Providence, R. I	Average, 510			
Roanoke, Va	Monthly average, 600 gross; daily average minimum, 550.	Twice each day	Gas inspector	
Saginaw, Mich	570	Periodic	Company	Checked by city engineer.

St. Louis, Mo	600			
St. Paul, Minn	Monthly average, 600; minimum, 550	Daily	City	Junkers calorimeter used 1 mile from works.
Salt Lake City, Utah	525			
San Diego, Calif	550 gross	If below standard, 2 extra tests not less than 3 hours apart.	Gas inspector	Conditions of test defined.
San Francisco, Calif	Minimum, 600			
Savannah, Ga	Monthly average minimum, 575; minimum, 550		Company	
Sioux Falls, S. Dak	Monthly average, 575 total; daily average, 550 total.	Daily	City	
Waterloo, Iowa	Equal to cities of like size in Iowa			

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TABLE 2.—Candlepower

A. STATE RULES OR LAWS

[The only State rules or laws fixing candlepower of gas are those established for single communities. However, the Public Service Commission of the First District of New York under such requirement is charged with the enforcement in this entire district (Greater New York City) of a 22-candlepower requirement. Numerous municipal candlepower requirements remain, but a number of these are not actively enforced.]

B. MUNICIPAL REQUIREMENTS

City	Candlepower required	Standard specified	Test burner specified	Specified frequency of test	By whom test to be made	Kind of gas now supplied
	Candles					
Adrian, Mich	16					Coal gas.
Battle Creek, Mich	15½					Mixed gas.
Bay City, Mich	18	Standard sperm candles.	Lava-tipped Bunsen-argand	Daily	Company	
Birmingham, Ala	15					Coal gas.
Charleston, S. C	20 (average)			Twice a month	City chemist	Water gas.
Chattanooga, Tenn	16					Mixed gas.
Cleveland, Ohio	16	Standard sperm candles.	Bunsen-argand			Do.
Clinton, Iowa	16					Do.
Council Bluffs, Iowa	22					Water gas.
Davenport, Iowa	20					Mixed gas.
Detroit, Mich	18	Standard sperm candles.	Lava-tipped Bunsen-argand.	Daily	City	Do.
Fargo, N. Dak	15					Coal gas.
Grand Rapids, Mich	16			Periodic and at request of common council.		Mixed gas.
Houston, Tex	18					Water gas.
Jackson, Mich	16					Mixed gas.
Jackson, Miss	16					Coal gas.
Joliet, Ill	15					Coke-oven gas.
Kalamazoo, Mich	16	Standard sperm candles.	Bunsen-argand	3 times per week		Mixed gas.

Kansas City, Mo	22	do		Daily		Do.
Lansing, Mich	18					Do.
Lincoln, Nebr	18	English sperm candles	Sugg's London argand No. 1.	Daily	Gas inspector	Water gas.
Los Angeles, Calif	18	Standard sperm candles.	Self-luminous, one best adapted.	do	Board of Public Utilities.	Oil gas.
Memphis, Tenn	20					Water gas.
Minneapolis, Minn	15	Bureau of Standards pentane lamp.	Lava-tipped or open-flame.	Twice daily on 20 days during month.	City	Mixed gas.
Nashville, Tenn	16; never less than 15	Standard sperm candles.			City, cost by company if below standard.	Do.
Omaha, Nebr	23 at holders; 21.2 at test room; 18 for coal gas.	do	Lava-tipped, fish-tailed	Weekly or oftener		Water gas.
Pawtucket, R. I	16					Mixed gas.
Port Arthur, Tex	20					Oil gas.
Port Huron, Mich	16		Bray special low pressure slit-union.			Mixed gas.
Roanoke, Va	16					Do.
Saginaw, Mich	16 coal gas; 20 water gas; 16 mixed gas; 1 mile from holder.				Company, checked by city engineer.	Do.
St. Paul, Minn	14, 1½ miles from holder					Do.
San Francisco, Calif	19					Oil gas.
Sioux City, Iowa	21 at City Hall station; 18 beyond radius of 2 miles.	Standard sperm candles.	Lava-tipped or open-flame.	At least 20 separate days per month.	City engineer	Water gas.
Springfield, Mo	18					Do.
Springfield, Ohio	16	Sperm candles	Fish-tail			Natural gas.
Toledo, Ohio	16	Standard sperm candles.		3 days per week		Mixed gas.
Waterloo, Iowa	Equal to that furnished any city in Iowa and not less than 16.	Sperm candles			Expert, cost paid by loser.	Water gas.

TABLE 3.—Purity—Chemical Requirements

A. STATE RULES OR LAWS

[Abbreviations: S=sulphur; NH_3=ammonia; H_2S=hydrogen sulphide or "sulphuretted hydrogen"]

State	Hydrogen sulphide		Maximum sulphur allowed	Maximum ammonia allowed	Tests for S and NH_3 required of company	
	Limit	Required frequency of test			Minimum volume of sales above which test is required [a]	Specified frequency of test
			Grains/100 ft.^{3}	Grains/100 ft.^{3}		
Arizona	Trace		30			
California	do	Daily	30	5	100	Regularly.
Colorado	Trace (B. of S.)[b]	do	30	5	75	Do.
Connecticut	Trace (B. of S.)	do	30	5	100	At least monthly.
District of Columbia	Not show presence (B. of S.)		[c] 30	[c] 5		
Illinois	1 grain per 100 cu. ft.[d]	Daily	30		50	At least weekly.[e]
Indiana	Trace		30			
Maryland	Trace (B. of S.)	Daily	30	10	100	Regularly.
Massachusetts [f]	Must be absent	Twice a year or oftener, as board determines.	30			Twice a year or oftener, as board determines.
Missouri [g]	Trace (B. of S.)	Daily	30	5	50	Regularly.
Montana	Trace		30			
Nevada	do		30			
New Hampshire	Trace (B. of S.)	Daily	30	10		
New Jersey	Trace		30			
New York, Second District.	Must be absent [h]		30	10		
Oregon	Must be absent (B. of S.)	Daily	25	5		
Pennsylvania			30			
Washington	Trace		30	5		
Wisconsin	do		30			

[a] Requirements as to apparatus and tests for determination of ammonia do not apply in any State to companies making only water gas or oil gas or a mixture of these; in Illinois it does not apply to any gas companies.

[b] The expression (B. of S.) is used to indicate that the manner of testing for hydrogen sulphide which is specified in the rules follows closely the standard method recommended by the Bureau of Standards in this circular, page 27.

[c] As tested at any of the commission's testing stations.

[d] Test for hydrogen sulphide in Illinois is to be by method recommended, which is somewhat more severe than Bureau of Standards method (see p. 27 of this circular), or by any other method approved by the commission. Hydrogen sulphide test papers are to be kept one year, available to the commission.

[e] No tests for ammonia required; records of sulphur tests to be kept.

[f] In Massachusetts a company whose gas on three consecutive inspections or on three inspections made within a period of 30 consecutive days is found to be below the standard purity requirements is liable to a forfeiture of $100, unless excused by board.

[g] In Missouri records of all tests for impurities are to be kept at least two years, available for inspection.

[h] Hydrogen sulphide test specified for New York State, Second District, is less severe than Bureau of Standard method (see p. 27 of this circular).

TABLE 3.—Purity—Chemical Requirements—Continued

B. MUNICIPAL REQUIREMENTS

City	Hydrogen sulphide limit	Maximum allowance			Other specifications
		Sulphur	Ammonia	Carbon monoxide	
		Grains/100 ft.^{3}	Grains/100 ft.^{3}	Per cent.	
Battle Creek, Mich	Trace	30			
Birmingham, Ala	Absent	25	5	25	
Cedar Rapids, Iowa	do	30	4		Test daily.
Charleston, S. C	do	20	5		
Chattanooga, Tenn	do	20	10		
Cleveland, Ohio	do	30	10		
Davenport, Iowa					As good quality as furnished consumers in other cities of same population in Iowa and Illinois.
Des Moines, Iowa	Absent	20	4		Weekly test for NH_3 and S; daily test for H_2S by method specified.
Detroit, Mich	do	30	10		Weekly test for H_2S.
Flint, Mich	Trace	30	5		Test by company daily for H_2S and NH_3, monthly for S.
Grand Rapids, Mich	Absent	30	10		
Kalamazoo, Mich	Trace	30	5		Tests weekly by city inspector. If excess appears to be present another test to be made on same or next day and average taken.
Lincoln, Nebr	Absent	20	10		Sufficient odor to be readily detected by smell.
Los Angeles, Calif	do	25	5	25	Free from all other noxious impurities. Daily test by Board of Public Utilities, with 2 extra tests not less than 3 hours apart if excess appears to be present.
Louisville, Ky					The gas supplied by company shall be "straight" natural gas without admixture of air or artificial gas.
Mason City, Iowa	Absent	30	4		
Minneapolis, Minn	do	20 Apr. 1 to Oct. 1; 30 rest of year.	4		Weekly tests for S and NH_3; tests on at least 20 days a month for H_2S by specified method. If excess of impurities are present tests must be made daily until requirements are complied with.
New Orleans, La	do	30	5		Test daily by company.
Omaha, Nebr	do	15	5		Test daily.

Pasadena, Calif.	do	25	5	25	Free from all other noxious impurities. Monthly test. Conditions of test defined.
Pawtucket, R. I.	do	20	10		
Port Huron, Mich.	do	30	10		
Roanoke, Va.	do	30	5		Daily test for H_2S; weekly for S and NH_3.
Saginaw, Mich.	do	30	10		Tests made by company, checked by city engineer.
San Diego, Calif.	do	25	5	25	Free from all other noxious impurities. If excess appears to be present 2 extra tests to be made not less than 3 hours apart.
Sioux City, Iowa	Trace	20 Apr. 1 to Oct. 1; 30 other times.	4		Weekly test for S and NH_3; H_2S at least 20 days a month.
Sioux Falls, S. Dak.	do	30	5		Method of test for H_2S specified.

TABLE 4.—Gas Pressure Requirements

A. STATE RULES AND LAWS

[Applicable primarily to manufactured gas; to natural gas only as noted]

State	Pressure allowed					Testing requirements			Records
	Maximum of water	Minimum of water	Daily variation allowed at any point			Place of test	Tests required	Gages required	
			Percentage of minimum pressure	Inches of water	Ounces per square inch				
	Inches	Inches							
Arizona		1½				Meter inlet	Frequent and regular.		Open to public.
California	12	2		In low-pressure mains not more than 4.		Meter outlet	Weekly	1 for each 100 miles; at least 12 altogether.	Do.
Colorado [a]	[b] 8	2	100			Service outlet	Continuous, if city of 2500.	1 in cities 2500 to 5000; 2 or more in cities over 5000.	To be kept 2 years.
Connecticut [a]	[c] 8	[d] 2		2 (from district normal).		Meter inlet	Continuous	1 per district; at least 2 altogether.	
District of Columbia	6	2	100			Service outlet			
Illinois	[b] 8	2	[e] 100			Meter outlet	Frequent	1 or more	
Indiana	6	1½	100			Meter inlet	do		Open to public.
Kansas, natural gas [f]	[b] 8	2	100			Meter outlet	do	1 or more	To be kept 3 years.
Maryland [g]	[b] 6	2	100			Service outlet		1 per district; at least 2 altogether.	
Missouri	[b] 8	2	100			do	Continuous in cities 2500 to 5000; frequent in cities over 5000.	1 in cities 2500 to 5000; 2 or more in cities over 5000.	To be kept 2 years.

Montana	[c] 5	1½	100			Meter inlet	Frequent		Open to public.
Nevada	6	1½	100			do	do		Do.
New Hampshire	8	2		3		Service outlet	Regular, and as frequent as commission directs.	1 or more	Do.
New Jersey	6	1½	100			Meter inlet	Frequent		Do.
New York, First District [h]	6, on 2 consecutive days.[b]	2, on 2 consecutive days.		2, on 2 consecutive days.		Service outlet	Continuous	1 per square mile; no consumer to be more than 3800 feet in air line from a gage.	To be kept 3 years.
New York, Second District.[i]	[c j] 3¾	1½				Service main			
Oregon [a]	[b] 6	2		2		Service outlet	Continuous	1 per district; at least 2 altogether.	
Pennsylvania, manufactured gas.[k]	8	1½	100			Meter outlet	Frequent	1 or more	To be kept 2 years.

[a] Subject to approval of the commission in Colorado, Connecticut, Oregon, and West Virginia, each "gas utility may divide its distributing systems into as many districts as it shall consider desirable, and it shall fix for each such district or for its distributing system as a whole the normal pressure of gas which it proposes to maintain."

[b] A higher service pressure may be maintained if consent of commission is obtained in Colorado, Maryland, and Missouri; or if consumer consents to it in writing, in New York (First District) and Oregon; or in Illinois, Kansas, or Pennsylvania (natural gas only) if provided for in contract with consumer and no discrimination is shown.

[c] Allowance is made for altitude, an increased elevation of 125 feet at point of consumption from that at center of consumption in Connecticut, or that of holder in Montana and Washington, or 100 feet above the holder in New York (Second District), being considered as being accompanied by an increase of gas pressure equivalent to 1 inch of water.

[d] * * * "When meter is passing gas at not more than 6 cubic feet per hour per rated light capacity * * *."

[e] Illinois provides, however, that "variations in pressure entirely beyond the control of the utility shall not be considered as a violation of this rule."

[f] Kansas excuses utility for noncompliance with pressure requirements where "unusual operating conditions" render compliance impossible. The burden is placed on pipe line or producing utilities to supply gas under conditions which will make compliance possible.

[g] Maryland and West Virginia excuse utility for noncompliance with pressure requirements where "extraordinary demand in extreme weather" or "inadequacy of supply which is clearly beyond the control of the utility" renders compliance impossible.

[h] These requirements apply to the Borough of Manhattan, but are taken to be typical of the First District's requirements. There is also the requirement that the maximum momentary pressure variation shall not exceed a total range of 0.8 inch on two consecutive days; and that the maximum pulsating pressure variation shall not exceed a total range of 0.5 inch on two consecutive days.

[i] An old State law applicable only to cities of second class.

[j] No maximum pressure shall be prescribed in service mains the pressure of gas from which is regulated by service governors supplied and maintained without charge to consumers; but in practice the 3¾ inches maximum allowance is not enforced, even where no regulators are in use.

[k] Commission excuses company of violations of rules if due to fault of consumer or to "causes entirely beyond its control."

TABLE 4.—Gas Pressure Requirements—Continued

A. STATE RULES AND LAWS—Continued

State	Pressure allowed					Testing requirements			Records
			Daily variation allowed at any point						
	Maximum of water	Minimum of water	Percentage of minimum pressure	Inches of water	Ounces per square inch	Place of test	Test required	Gages required	
	Inches	Inches							
Pennsylvania, natural gas.[a]	[b] 14	1½		4 (from normal).		Meter outlet	Frequent	1 or more	To be kept 2 years.
Washington	5, for more than 1 hour.[c]	2, for more than 1 hour.				Meter inlet	Daily	2 or more if output exceeds 10 000 M per year.	Open to public.
West Virginia, natural gas.[d e]			700		6 (from normal).	Service outlet	At least one continuous record; other tests as needed.	1 per district, if 50 consumers.	Do.
Wisconsin	6	2	[f] 100			do	Frequent	1 or more	Do.

[a] Pennsylvania excuses utility where noncompliance is due to "extraordinary demand in extreme weather."

[b] A higher surface pressure may be maintained if consent of commission is obtained in Colorado, Maryland, and Missouri; or if consumer consents to it in writing, in New York (First District) and Oregon; or in Illinois, Kansas, or Pennsylvania (natural gas only) if provided for in contract with consumer and due discrimination is shown.

[c] Allowance is made for altitude, an increased elevation of 125 feet at point of consumption from that at center of consumption in Connecticut, or that of holder in Montana and Washington, or 100 feet above the holder in New York (Second District), being considered as being accompanied by an increase of gas pressure equivalent to 1 inch of water.

[d] Subject to approval of the commission in Colorado, Connecticut, Oregon, and West Virginia, each "gas utility may divide its distributing systems into as many districts as it shall consider desirable, and it shall fix for each such district or for its distributing system as a whole the normal pressure of gas which it proposes to maintain."

[e] Maryland and West Virginia excuse utility for noncompliance with pressure requirements where "extraordinary demand in extreme weather" or "inadequacy of supply which is clearly beyond the control of the utility" renders compliance impossible.

[f] This is not a daily variation allowance. The rule is that "the maximum pressure at such outlet * * * shall never be greater than double the minimum pressure at that outlet."

TABLE 4.—Gas Pressure Requirements—Continued

B. MUNICIPAL REQUIREMENTS

City	Pressure allowed			Place of test	Tests required	Remarks
	Maximum of water	Minimum of water	Daily variation of minimum			
	Inches	Inches	Per cent			
Adrian, Mich		3				
Battle Creek, Mich		2				
Bay City, Mich						Pressure shall be proper and reasonable and at all times subject to inspection and approval of board.
Birmingham, Ala	9	2		In each of 6 districts		City divided into 6 districts.
Cedar Rapids, Iowa	6	2 or 3	100	Meter inlet		Minimum 3 inches within 1 mile of works; elsewhere 2 inches.
Charleston, S. C	4	1½		City Hall	Twice a month	
Chattanooga, Tenn	5	1½				
	Ounces	Ounces				
Cincinnati, Ohio	4	12				Natural gas.
	Inches	Inches				
Cleveland, Ohio	6	1½	100	Consumer's burner		
	Ounces					
Dallas, Tex	8					Do.
	Inches					
Des Moines, Iowa	6	2	100	Outlet of service pipes	Continuous	Same pressure as supplied to cities of same population in Iowa and Illinois.
Detroit, Mich	4½	1½		Meter inlet	Daily	
Flint, Mich	8	2		do		
Grand Rapids, Mich	4.5	1.8		do	Periodic and at request of common council.	
Jackson, Mich	8	2				
Jackson, Miss	6	2				
Kalamazoo, Mich	6	2	100	Meter inlet	Continuous	

TABLE 4.—Gas Pressure Requirements—Continued

B. MUNICIPAL REQUIREMENTS—Continued

City	Pressure allowed			Place of Test	Tests required	Remarks
	Maximum of water	Minimum of water	Daily variation of minimum			
	Inches	Inches	Per cent			
Kansas City, Mo	13	5				Natural gas.
Do	4	1½		At 5 places in city		Manufactured gas.
Lansing, Mich	4½	1½				
Lincoln, Nebr	5	1½			Daily	
Los Angeles, Calif	9	2				Continuous in each district.
	Ounces	Ounces	Ounces			
Louisville, Ky	5	3	1½	Outlet of service pipes	Continuous	Natural gas.
	Inches	Inches	Inches			
Mason City, Iowa	6	2	100	Meter inlet		
Minneapolis, Minn	4	2		Entrance of service pipe to building.		
New Orleans, La			2 inches from normal.	Outlet of service pipe		Company may divide distribution system into districts and fix normal pressure for each or all districts.
Pasadena, Calif		3				Natural gas; not more than is required to give safe and adequate service.
Port Huron, Mich	4½	1½				
Roanoke, Va	6	2		Outlet of service pipe		
Saginaw, Mich	4.5	1.8	100	At meter	Periodic by company	Checked by city engineer.
San Diego, Calif	9	2			Continuous	
San Francisco, Calif	9	2				
Sioux City, Iowa	6	2	100	Meter inlet	Continuous	Record taken at not less than 3 points.
Sioux Falls, S. Dak	3½	1¾	2 inches from normal.	Company's outlet		Company may divide city into districts and shall fix for each a normal pressure.
St. Paul, Minn		2		Service outlet		

TABLE 5.—Gas Meter Regulations

A. STATE RULES AND LAWS *f*

State	Routine meter tests		Complaint meter tests [a]		Meter accuracy		Companies required to have prover [d]	Test rate specified	Adjustment of bills prescribed		
	Made by—	Frequency	Time limit for free test by company	Fee for test by commission [c]	At installation	Required to avoid bill adjustments			Refunds	Additional charge allowed	Period for which adjustment is made
		Years	Months		Per cent						Months
Arizona *g*	Company	3	12	$1	±3	±3	All	Yes			
California	do	6	6	$2 to $8	±1	±2	do		Yes	Yes	6, or definite defective period.
Colorado	do	5	12 *b*	do	±1	±2	All having over 200 meters.	Yes	do	do *h*	6
Connecticut	do	5	12	$1 *i f*	*j* +1 −2	+2	All	do	do	No	6, or definite defective period.

[a] Arizona, Colorado, Connecticut, District of Columbia, Illinois, Indiana, Kansas, Maryland, Missouri, Montana, Nevada, New Hampshire, New Jersey, Pennsylvania, West Virginia, and Wisconsin require that utility furnish customer with report of test; West Virginia also requires this report to be rendered to commission; Arizona, Colorado, Maryland, Nevada, Montana, New Jersey, Pennsylvania, West Virginia, and Wisconsin require record of test to be kept by utility; Nevada requires this record to be filed with commission; Colorado, Connecticut, Illinois, Kansas, and Indiana require customer to abide by results of such test as basis of adjusting differences.

[b] Colorado allows a special charge with commission's consent. Pennsylvania and West Virginia provide fees for test if meter is correct within established tolerance.

[c] This fee is paid by consumer if meter is slow or within the tolerance limits; by utility if meter is fast beyond the tolerance limit.

[d] Connecticut, District of Columbia, Illinois, Kansas, Maryland, Massachusetts, Missouri, Oregon, Pennsylvania, and Wisconsin require an accuracy in meter provers within one-half of 1 per cent. Most of these States, and in addition Colorado, New Hampshire, New Jersey, and New York (First District), require certain conditions as to temperature, spacing, etc., of the room in which prover is kept.

[e] The following States specify that two test runs shall be made on each meter, the results of which shall agree with each other within one-half per cent: Illinois, Kansas, Maryland, Missouri. New York (First District) requires that a second test shall be made of meters giving proof on first test less than 99 per cent or more than 100 per cent registration.

[f] Records, sealing, prepayment meters, and other meter requirements:

(*a*) *Records.*—All of the commissions have established certain requirements as to the keeping of meter records. Many States (Colorado, Connecticut, District of Columbia, Illinois, Kansas, Maryland, Missouri, New Hampshire, Oregon, Pennsylvania, West Virginia, and Wisconsin) require that a history of each meter be kept. These same States and Arizona, Indiana, Montana, Nevada, New Jersey, New York (First District), and Washington require utility to keep record of all meter tests. This requirement may be said to be practically general. Illinois requires a monthly and annual tabulation of the results of meter tests, arranged according to types of meter and interval of test; New Jersey requires a monthly or quarterly summary of tests, according to size of company. West Virginia requires special test reports. Where the regular inspecting is done by the commission the records are kept by the commission (New York (Second District) and Massachusetts), as well as records of referee tests.

(*b*) *Sealing.*—There is generally a requirement that all meters shall be sealed after being tested. The commission's seal is usually attached by an employee of the commission or by an authorized agent (West Virginia). Kansas allows the sealing to be done by the company. Illinois, Oregon, and Washington, while not requiring sealing, do cause the meters to be tagged in such manner as to serve some of the purposes which are accomplished by sealing.

(*c*) *Prepayment Meters.*—Before installing prepayment meters "adjusted to vend the service at a rate in excess of that charged to customers served through ordinary integrating meters," the consent of the customer (Connecticut) or of the commission (Illinois and Kansas) must be obtained. Connecticut and Maryland require company to leave with the

(Footnote *f* continued on page 111.)

TABLE 5.—Gas Meter Regulations—Continued

A. STATE RULES AND LAWS—Continued

State	Routine meter tests		Complaint meter tests		Meter accuracy		Companies required to have prover	Test rate specified	Adjustment of bills prescribed		
	Made by—	Frequency	Time limit for free test by company	Fee for test by commission	At installation	Required to avoid bill adjustments			Refunds	Additional charge allowed	Period for which adjustment is made
		Years	Months		Per cent						Months
District of Columbia	Company under supervision of commission.	5	12	$0.50 to $1	±2		do	do			
Illinois	Company	5	6	$2 to $8	±1	±2	do	do [e]	Yes	Yes [h]	6
Indiana	do	3	6	$2	±2		do	do			
Kansas, natural gas	do	5	12	$2 to $8 and up.	±1	+2	All but smallest	do [e]	Yes	No	6, or definite defective period.
Maryland	do		12	$1 to $2 or expense.	[k] ±1		All	do [e]			
Massachusetts	Board [l]		1	Cost of moving and $0.25 or more fee.	±2		Large, and others as required by board.	No			
Missouri	Company	5	12	$2 and up	[m] ±2		If over 200 meters	Yes [e]			
Montana	do	5	12	do	±2	±2	All	do	Yes	No	Half period since last test or some definite period.
Nevada	do	3	6	$1.50	±2		do	do			
New Hampshire	do	5	12	$1 or estimated cost.	±2	±3	do	do	Yes	Yes [h]	6
New Jersey	do	6	6	$1	±2		do	do			
New York, First District.	Commission	6 or 7	No limit.	$0.50 to $2	±2		do	No [e]			

New York, Second District.	....do....	.....	...do....	Expense.....	±2	.....	.....	...do....	.....	.....	
Oregon.....	Company.....	5.....	12.....	$2 to $8.....	±1	+3 −5	All.....	Yes.....	Yes.....	Yes [h]...	3
Pennsylvania.....	....do.....	5 [n].....	No limit [b]	.....	±2	+2	.....do.....	...do.....	...do.....	No.....	Current bill or definite defective period.
Washington.....	....do.....	5.....	12.....	$3.....	±2	.....	If annual sales exceed 15 000 M.	...do....	.....	.....	
West Virginia, natural gas.	....do [o].....	5, for domestic meters. [p]	12 [b].....	$1.50 to $12 and up.	±2	±2	All except those excused by commission.	...do.....	Yes.....	Yes [h]...	3, for domestic meters.
Wisconsin.....	....do.....	4.....	6.....	$2 to $8.....	±2	.....	All.....	...do.....	.....	.....	

Footnote *f* continued from page 109.

customer a slip, showing meter readings and money taken from meter. Massachusetts holds that the company is responsible for loss of money by fire. In Maryland the commission prescribes the rules as to meter readings in the case of proportional meters to suit the specific conditions of each case.

(*d*) *Miscellaneous Meter Requirements.*—Missouri requires each service meter to be suited to the particular needs of the installation. Pennsylvania does not allow a meter to be installed which has not been tested within a year, and requires an inspection of fittings, connections, etc., 60 days after installation. West Virginia recommends keeping meters in a dry, protected place and tagging each of several meters placed close together to identify houses respectively served by them. Arizona's weights and measures law attaches a penalty for noncompliance with meter requirements. The District of Columbia and Massachusetts specifically mention that only authorized employees of the company shall have access to customers' property and remove or set meters. New Jersey allows no charge for changing or removing meter, except in case the type of meter is changed within a year of previous installation. A charge of $1 is allowed for this change.

g In Arizona the State inspector and city sealers of weights and measures are under the direction and control of the Corporation Commission.

h Illinois and New Hampshire provide that in cases of substantial importance and where the utility is not at fault the company, if a meter is found slow in excess of tolerance, may render bill for gas not previously billed for period during which error existed, but not to exceed six months. West Virginia has a similar provision, but the period is one-half the time which has elapsed since last test of meter. Colorado, Illinois, and Oregon have a somewhat similar provision for nonregistering ("stalled") meters. In West Virginia adjustments of bills where meter other than domestic meter is proved defective is by mutual agreement of parties or, on appeal, by commission. In New Hampshire and West Virginia the commission may relieve a utility from making refunds.

i The Connecticut rule provides that the average error shall be determined "by taking one-fifth the sum of (1) the error at approximately full-rated or maximum capacity; (2) the error at light load or rate; (3) three times the error at normal or nominal-rated capacity."

j In cases of emergency responsible manufacturers' tests may be used, provided the utility makes required reports to commission.

k Maryland provides that where a number of meters are tested not more than 15 per cent of the total number shall exceed an error of 1 per cent and no meter shall exceed an error of 2 per cent.

l The Board of Gas and Electric Light Commissioners assesses the cost of gas and meter inspection against the companies, but collects a small fee of 25 cents and up for each meter tested.

m There is the additional provision that when meter is more than 2 per cent in error, and therefore requires readjustment, the meter shall be made accurate within at least 1 per cent.

n Pennsylvania requires, in addition to five-year tests, a cleaning of proportional meters every three months.

o Inspections are by meter men employed by the utility, whose selection has been approved by commission and who have taken the oath of office required of all employees of commission. Orifice meters and orifice plates shall be tested before installation by utility or by meter man employed by manufacturer. For details as to subsequent tests, see West Virginia rule 8 (*f*), (*g*) and (*h*); for details as to proportional meters, see rule 8 (*e*).

p Orifice meters: Gauges, two months; constant of orifice plate, five years; proportional meters, 1 year; others, as determined by commission.

TABLE 5.—Gas Meter Regulations—Continued

B. MUNICIPAL REQUIREMENTS

City	All must be tested by—	Complaint meters to be tested by—	Tolerance in meter accuracy	Fee for complaint tests: Payee and amount [a]	Refund period [b]	Remarks
			Per cent			
Bangor, Me						Meters tested every 5 years.
Battle Creek, Mich	Company	Company	±2		3 months; both ways	
Bay City, Mich	City	City	±2	Loser, $1		
Beaumont, Tex		do		Loser, $2.50		
Burlington, Iowa		do	±2	Loser, 50 cents	¼ period of use	
Cedar Rapids, Iowa	City	do	±2	do	3 months	
Charleston, S. C	do	do	±2	Loser, 25 cents	1 month	Rebate twice the excess; if slow, company entitled to excess.
Cincinnati, Ohio			±2	25 cents and cost of removing meter		
Council Bluffs, Iowa	Company					Meters tested every 2 or 3 years.
Dallas, Tex		City		If consumer loses, 50 cents; if company loses, $1.		
Dayton, Ohio	Company	Company	±2	Loser, cost		
Des Moines, Iowa	do	City	±2	Loser, $1	3 months; both ways	One-half fee to company if meter is correct.
Detroit, Mich		do	±2	do		One-half fee to company if meter not over 2 per cent fast.
Fargo, N. Dak	City	do		do		
Flint, Mich	Company	do	±2	do	½ bills for 3 months	Meters tested every 4 years.
Grand Rapids, Mich	City	do		do		
Greensboro, N. C		do	±2½	do		
Houston, Texas		do	±2	Consumer, $1.50 if meter correct	1 month	Rebate on bill.
Jackson, Mich		do	±2	Loser, $1	½ bills for 6 months; both ways.	
Kalamazoo, Mich	City	do	±2	do	do	
Kansas City, Mo	do	do	±2	do	3 months	$1 to company if correct.

Knoxville, Tenn		do	±2	Loser, 25 cents and expenses		
Lansing, Mich	City	do	±2	Loser, $1	½ period since last test.	One-half fee to company if correct.
Lincoln, Nebr		do	−2 and +3	do	3 months	
Los Angeles, Calif	City	do	−3 and +2	Loser, amount depending on size of meter and cost of hauling.		
Louisville, Ky	Company	do	±2	Loser, 50 cents	3 months	Refund by company or consumer.
Mason City, Iowa	City	do	±2	do	do	
Memphis, Tenn		do	±2	Consumer, 50 cents	6 months	
Minneapolis, Minn	City	do	±2	Loser, $1	do	Fee for routine test, 25 cents from company.
New Orleans, La	Company	Company or board.	±3	Loser, amount depending on size of meter	6 months; both ways	Meters tested every 5 years.
Norfolk, Va	City		±2	Loser, $1		
Omaha, Nebr	do	City	±2	do		
Pasadena, Calif		do	±2	Loser, 50 cents to $3, depending on size of meter and expense of hauling.	3 months	
Philadelphia, Pa		do		Consumer, $1 if correct		
Port Huron, Mich	City		±2	Loser, $1		Do.
Roanoke, Va	Company	City	±2	Consumer, $1	3 months; both ways	Meters tested every 5 years. One-half fee to company if correct; if fast company pays 50 cents, and $1 returned to consumer.
Saginaw, Mich		Company, not over once in 6 months.	±2	$1		If slow or correct, 50 cents to company; if fast, $1 refunded.
St. Paul, Minn	City	City	±2	Consumer, 50 cents	3 months	
San Diego, Calif	do	do	±2	Loser, $1 plus hauling charges		
San Francisco, Calif	do	do	±2	Consumer, $1	3 months	Fee to company if correct.
Santa Barbara, Calif	do	do	±3	Loser, $1		
Savannah, Ga	do	do	±3	do		

[a] "Loser" refers to company if meter is fast beyond allowed tolerance, to consumer if meter is slow or correct.

[b] "Both ways" is used in refund column to mean that when the meter registers fast beyond the maximum allowance the company refunds to the consumer, and when the meter is slow beyond the allowable limit the consumer pays the company.

TABLE 5.—Gas Meter Regulations—Continued

B. MUNICIPAL REQUIREMENTS—Continued

City	All must be tested by—	Complaint meters to be tested by—	Tolerance in meter accuracy	Fee for complaint tests: Payee and amount	Refund period	Remarks
Shreveport, La		do	Per cent ±3; in some cases ±5.	$1		
Sioux City, Iowa	City	do	±2	Loser, $1	6 months	
Sioux Falls, S. Dak	Company	do	±3	do	do	One-half fee to company if correct or slow.
Toledo, Ohio		do		Loser, 50 cents		
Waco, Tex		do	±3			
Waterloo, Iowa		Company	±2	Loser, $1	3 months	Refund by company or consumer.
Wilmington, Del		City		Loser, 25 cents		Must conform with "United States Standard."

TABLE 6.—Municipal Inspection Officials

[Titles of officers in charge of inspection work]

Cities	Titles of officers	Cities	Titles of officers
Ann Arbor, Mich.	Gas inspector.	Lincoln, Nebr.	City health officer.
Atlanta, Ga.	City mechanical engineer.	Los Angeles, Calif.	Gas inspector.
Battle Creek, Mich.	Sealer of weights, meters, and measures.	Louisville, Ky.	City gas inspector.
Bay City, Mich.	City gas inspector.	Mason City, Iowa.	Inspector appointed by City Council.
Beaumont, Tex.	Inspector of water and gas meters.	Memphis, Tenn.	City gas inspector.
Burlington, Iowa.	Plumbing inspector.	Minneapolis, Minn.	Do.
Cedar Rapids, Iowa	Do.	Nashville, Tenn.	Mayor and City Council.
Charleston, S. C.	Inspector of meters.	New Orleans, La.	Board of Public Utilities through official to be designated.
Charlotte, N. C.	City electrical and building inspector.	Newport, Ky.	City engineer.
Cincinnati, Ohio.	Inspector of gas and electric meters.	Norfolk, Va.	City meter inspector.
Cleveland, Ohio.	City chemist (in charge of drug and food inspection).	Oakland, Calif.	Supervising inspector.
Dallas, Tex.	Inspector of weights and measures.	Omaha, Nebr.	City gas commissioner.
Davenport, Iowa.	City electrician.	Pasadena, Calif.	City chemist.
Des Moines, Iowa.	Gas inspector.	Philadelphia, Pa.	Bureau of Gas.
Detroit, Mich.	Gas analyst and inspector.	Port Huron, Mich.	Gas inspector.
El Paso, Tex.	City inspector.	Providence, R. I.	Public service engineer.
Fargo, N. Dak.	Inspector of gas and electric meters.	Roakoke, Va.	Inspector of gas and gas meters.
Flint, Mich.	Gas and meter inspector.	Saginaw, Mich.	Board of Public Works through city engineer.
Fort Worth, Tex.	Plumbing and gas inspector.	St. Paul, Minn.	Bureau of Municipal Testing Laboratories.
Grand Rapids, Mich.	Board of Public Works.	San Diego, Calif.	Inspector of gas and electricity.
Greensboro, N. C.	Inspector of meters.	San Francisco, Calif	Gas inspector.
Houston, Tex.	City plumbing inspector and Public Service Commission.	Santa Barbara, Calif	Do.
Jackson, Mich.	City gas inspector.	Savannah, Ga.	Inspector of meters.
Kalamazoo, Mich.	City engineer.	Shreveport, La.	City gas inspector.
Kansas City, Mo.	City gas inspector.	Sioux City, Iowa.	City engineer.
Knoxville, Tenn.	Inspector of weights, measures, and meters.	Sioux Falls, S. Dak.	Gas inspector.
Lansing, Mich.	City gas inspector.	Toledo, Ohio.	Inspector of gas.
Lexington, Ky.	City plumbing inspector.	Waco, Tex.	City electrician.
		Waterloo, Iowa.	Gas inspector, expert called in by city on complaint.
		Wilmington, Del.	Gas inspector.

XI. MANUFACTURE AND DISTRIBUTION OF GAS

In order to assist those who are unfamiliar with the gas-making processes now in use to understand the reasons for some of the recommendations made in this circular, and to encourage the reasonable interpretation and enforcement of present rules, a brief discussion of the more important commercial methods of gas manufacture and of gas distribution is here included.

1. CONSTITUENTS OF GAS AND THEIR CHARACTERISTICS

In general, gas distributed commercially consists of a mixture of certain chemical elements and compounds, the principal ones

of which are here briefly described with regard to their more important properties.

HYDROGEN is a gas of very low specific gravity, which has a heating value of only about 320 Btu per cubic foot and burns with a hot but nearly nonluminous flame. It is a permanent gas in the sense that it can not be condensed to a liquid at any naturally occurring temperature.

CARBON MONOXIDE, with a heating value per cubic foot almost identical with that of hydrogen, also burns with a nonluminous flame, requiring the same amount of air for combustion as does an equal volume of hydrogen. The flame produced is of greater size but of lower temperature than the hydrogen flame.

METHANE is a permanent gas with a heating value of about 1000 Btu per cubic foot and a very low candlepower in open-flame lights.

ETHANE and other hydrocarbons similar to methane have higher densities and higher heating values and candlepowers, but their properties are so similar to those of methane and they occur in such small amounts that they will be classed with the methane in the following discussion:

ILLUMINANTS.—In commercial practice a large number of the hydrocarbon gases are grouped together under the term "illuminants." Some of these, as ethylene and acetylene, are practically permanent gases; while others, such as benzene, are easily condensed to a liquid, and are, therefore, frequently lost during transmission. They all have high heating values and high candlepowers, but in proportion to their heating values give low flame temperatures.

DILUENTS.—Carbon dioxide, oxygen, and nitrogen, small quantities of which occur in all commercial gas, add nothing to the usefulness of the gas because they do not burn, and, therefore, can not contribute to the heat or light produced. The amounts present are kept as low as practicable in all well-managed works. The reduction in the heating value of the gas due to diluents is in proportion to the quantity in which they are present; that is to say, a reduction in heating value of 1 per cent will result from the admixture of 1 per cent of these constituents. However, because they raise the specific gravity of the gas, excessive quantities of these diluents are very objectionable, since they tend toward poor service conditions only partially connected with the decrease in the heating value. A discussion of this phase of the subject is contained in the section on "Heating Value."

Proportions of Constituents Unimportant.—In view of the number of its constituents, it is evident that the supplies of gas in two different localities may differ considerably with respect to the proportions in which these constituents are present, although the heating value may be the same. Heating value, however, is the property upon which the usefulness to the average consumer depends, and, barring excessive quantities of diluents, the actual proportions of the various constituents are generally not of any importance.

Flame Temperature.—Flame temperature, that is, the local intensity of the heat produced, as distinguished from heating value, the total quantity of heat liberated, is of importance in a few industrial uses of gas.

Mantle Candlepower.—Flame temperature also affects the candlepower of mantle lights, though many other factors enter; among them are the amount of air required for combustion, the size of the flame, and the rate of the explosion wave in the air-gas mixture; but in practice the usefulness of gas in mantle lights is very nearly proportional to its heating value.

Open-flame Candlepower.—Open-flame candlepower is more complicated. Here, carbon particles liberated during the initial stages of combustion are heated to incandescence by the burning of the remaining constituents of the gas and are themselves later burned. These carbon particles, which constitute the source of light, serve the same function as the mantle, the quantity in which they are present, the temperatures to which they are heated, and the length of time before they are burned being some of the factors which determine the intensity of the light obtained—in other words, the open-flame candlepower. The so-called illuminants supply the carbon particles in the flame, and the gas, containing a large proportion of these and at the same time giving a high-flame temperature, is capable of producing the highest open-flame candlepower.

Relation of Characteristics.—Consideration of the characteristics of the various constituents of gas shows that there is no very definite relation between the heating value and the open-flame candlepower produced by burning gases of different composition. For example, starting with carbon monoxide or hydrogen and mixing with methane, a gas having any heating value desired between 320 and 1000 Btu is obtained, but the mixture will always be of a low candlepower. On the other hand, a mixture of hydrogen with just the right amount of "illuminants"

which will provide for the liberation of carbon particles from the latter and the high-flame temperature of the former, will make the gas of high candlepower, although of relatively low heating value; but a gas of this same candlepower composed of methane and the illuminant will have a very high heating value. Comparing open-flame and mantle candlepower, a mixture of hydrogen and methane which will give a maximum mantle candlepower will be nearly nonluminous if burned in the open flame, while an illuminating gas of average composition which gives good open-flame values may give much lower mantle candlepower than the former mixture.

Although, therefore, it is possible to obtain mixtures of gases which will give high heating value, though burning with a nonluminous flame, yet in actual practice manufactured gas furnished under the present day heating-value requirements usually has sufficient open-flame candlepower for use in any places where open-flame burners are justifiable. The one common exception is the case where the illuminants are removed from the gas, as was so generally done during the war to provide material for explosives. Coke-oven plants still continue this practice. In such cases good heating value but very low candlepower is obtained unless part of the illuminants are returned to the gas.

2. METHODS OF MANUFACTURE

Coal Gas.—Coal gas is produced by the destructive distillation of bituminous coal in externally fired retorts of refractory material. As distributed for use it is a colorless gas with a pungent odor caused by the hydrocarbon vapors which it contains. It is of low specific gravity, being usually between 0.45 to 0.50 as heavy as air.

Only such coals as contain a high percentage of volatile matter are reasonably free from sulphur, and will form coke, are considered suitable for the production of coal gas, while a low ash content is very desirable, as the coke recovered has a correspondingly higher value. A typical high-grade gas coal might have an analysis similar to the following, though considerable variation from this may be expected. It should further be noted that the gas-making quality of the coal is very largely dependent upon the quantity of volatile combustible present.

	Per cent
Moisture	3
Volatile matter	35
Fixed carbon	57
Ash	5
	100

Contained in the above analysis is the sulphur, which should not be over 1¼ per cent.

The type of gas-making apparatus used varies from the simple, horizontal, direct-fired bench containing from three to six or sometimes nine D-shaped fire-clay retorts, the coal being charged with shovels and the coke drawn with hand rakes, to the elaborate installations of inclined slot ovens and vertical retorts made of the finest grade silica brick and equipped with labor-saving devices, with gas producers for heating the ovens or retorts, and with various means for utilizing heat that would be wasted under the old systems. However, the fundamental principle in all is the same. A quantity of gas coal, varying in weight from 300 to 400 pounds in the case of horizontal stop-end retorts to several tons in other types of installations, is heated in the retorts or ovens for a period of from 4 to 24 hours, depending on the type of installation, the weight of coal used, the temperature of the retorts, and numerous other factors. The volatile matter and moisture in the coal are driven off in the form of gas, leaving the fixed carbon and ash in the form of coke.

The gas when first produced contains large quantities of tar and ammonia in the form of vapor, while part of the sulphur in the coal passes off with the gas either in the form of hydrogen sulphide or of organic sulphur compounds. Tar and ammonia are first removed in the condensers and scrubbers where the gas is cooled and finally washed with water. The tar and ammonia pass to appropriate settling tanks, where they separate because of their difference in specific gravities. They are then drawn off, the tar stored for sale in a suitable tank, while, except in the smaller plants, the ammonia is concentrated and sold. Tar and ammonia are two valuable by-products of coal-gas manufacture.

The hydrogen sulphide is removed generally by passing the gas through a bed of iron oxide and shavings. The iron oxide removes the hydrogen sulphide, the shavings serving merely to keep the mass open and permit the free passage of gas through it. The organic sulphur compounds are usually not removed. No easy and economical method for doing so has been discovered; and if coals reasonably low in sulphur content are used, the quantity of sulphur compounds left in the gas after the complete removal of the hydrogen sulphide is not sufficient to be objectionable. The use of coals with high sulphur content is thus undesirable, for combined with the very much increased cost of purification because of the larger quantity of hydrogen sulphide in the gas, there is also an increase in the organic sulphur compounds to such a point that they become objectionable.

In this connection it should be mentioned that the introduction of not over 2 per cent of air into the crude gas will greatly increase the efficiency of purification. The oxygen of this air is absorbed in the purifiers and tends to keep the iron oxide in condition to absorb hydrogen sulphide. The nitrogen remaining, though a diluent, is so small in quantity that it is not objectionable. The use of small quantities of air to assist in purification is considered good practice and should be encouraged.

After purification the gas is metered and stored in the holders.

In practice, each pound of coal carbonized may be expected to produce from 4.5 to 5.5 cubic feet of gas; but this varies with the quality of the coal, the temperature and period of carbonization, the type and condition of the equipment, the heating value of the gas produced, and numerous other factors. In general, however, with a given coal, the greater the yield of gas per pound, the lower will be the heating value of the gas produced. Vertical retorts and coke ovens usually give greater yields of gas per pound of coal than do horizontal retorts. Pennsylvania, West Virginia, and eastern Kentucky coals generally give larger yields of higher heating value gas than do coals of the type found in Indiana and Illinois. A great number of factors might thus be discussed.

In general, the factors which influence the yield also affect the heating value of the gas, though certain additional points enter. For example, long exposure to the hot surface of the retort or oven after the gas is once formed tends to break down the illuminants, which, as before stated, have high heating value. Again, the proper cooling and scrubbing of the gas is of importance, for unless suitable apparatus is used and care is exercised, a part of these illuminants will be removed with the tar, and the heating value thus reduced. However, with processes generally in use, and with the higher grade materials available, coal gas may be expected to have a heating value of from about 550 to slightly over 600 Btu per cubic foot.

In this connection it should be noted that the gas produced during the early part of the carbonizing period—that is, the gas first driven off from the coal—contains high percentages of illuminants and methane, and is thus of high heating value. As carbonization progresses, the illuminants almost entirely disappear, the percentage of methane greatly decreases, while hydrogen becomes the principal constituent of the gas. The heating value is thus much decreased. Failure to drive off all the gas from the coal will therefore result in an increase in the heating value of the

gas per cubic foot, though, of course, because of the fact that the gas which could still be extracted from the coal contains some heat, the total Btu yield per pound of coal must decrease. The practice of drawing the coke before practically all the gas is driven off is uneconomical and should be discouraged.

The yield of by-products obtained varies greatly. Usually each net ton of coal will yield from 1250 to 1400 pounds of coke, though usually from 300 to 500 pounds of this will be required to heat the retorts. In some places it is found more economical to buy bituminous coal for this latter purpose and sell the total output of coke.

From each net ton of coal carbonized there should also be obtained from 9 to 15 gallons of tar and from 4 to 7 pounds of ammonia, though the losses in the recovery and concentration of this latter may materially reduce the amount available for sale.

Before leaving the subject of coal gas, a word should be said about naphthalene. This troublesome substance, when present in the gas in considerable quantities, crystallizes on the inside of the works and distribution gas mains, causing stoppage. Its elimination from a distribution system can only be accomplished at great trouble and expense, while the dissatisfaction caused by the poor service resulting is in itself a serious matter. Excessive quantities of naphthalene are usually caused by high retort or oven temperatures, though the character of the coal used is often partially responsible for its presence. Where changes in operating practice are impracticable or fail to remove the cause of the trouble, the installation of a scrubber suitable for removing naphthalene from the gas is usual.

By-product coke oven gas is a coal gas made in ovens designed primarily for the production of a high-grade coke that is suitable for use in blast furnaces or for other metallurgical purposes. The coke is usually considered the primary product and the gas merely one of the by-products.

The distinction between the by-product coke oven and the old-fashioned beehive coke oven should be clearly kept in mind. A by-product coke-oven plant is an elaborate installation, equipped with all possible labor-saving devices and methods of effecting economies in heat utilization, and capable of recovering and handling the various by-products, which in fact provide one of the chief sources of revenue. A beehive coke oven, on the other hand, is built for the production of coke alone. It is of comparatively crude construction; gas is usually wasted and other by-products are not recovered.

While most by-product oven plants are operated by manufacturing companies, and are in no sense of the word public utilities, they have more and more come to sell the surplus gas which they produce to public-utility companies for distribution by them. Thus an entirely satisfactory commercial gas is obtained at usually a slightly lower cost, while from the standpoint of conservation, if for no other reason, this practice should be encouraged.

A by-product coke oven is merely a special type of coal-gas retort, the principle of its operation being identical with that of a coal-gas installation. The ovens themselves where the coal is heated are rectangular in cross section, usually from 13 to 20 inches wide, 8 to 10 feet high, and 35 to 40 feet long. Each oven will thus hold from 10 to 15 tons of coal. The ovens are placed side by side with only the necessary refractory construction between them, any number up to about 60 usually forming a unit or "battery." The coal capacity of the oven being large, the carbonizing time is naturally long; that is to say, from 16 to 24 hours. The same considerations enter as to the selection of coal as in coal-gas manufacture, though on account of the nature of the business, the coking quality of the coal rather than ability to produce high yields of gas is most desired. As a matter of fact, however, the yield of gas per pound of coal is usually higher in a coke oven than in a coal-gas retort, though the heating value is correspondingly lower.

Since coke is the primary product, all that is made is usually sold, part of the gas being burned under the ovens to maintain them at the proper temperature. In modern efficiently operated plants approximately one-half of the gas produced is thus used.

As stated above under the subject of coal gas, the gas produced during early stages of carbonization is of higher heating value than that coming off later. In certain cases advantage has been taken of this fact, and the gas produced during the first part of the carbonizing period is separated from that produced during the latter part, the former, having high heating value, being supplied to the city, the latter, of low heating value, being used to heat the ovens.

The by-products recovered are the same as in coal gas, and the method of recovery is quite similar. Frequently, however, the ammonia is recovered by washing the gas with sulphuric acid instead of water, the ammonia being separated as solid ammonium sulphate, which is then dried, bagged, and sold.

In coke-oven plants it is also usual to extract the illuminants from the gas by washing it with so-called "straw oil." The illuminants are dissolved in this oil and are later distilled off, forming "light oil." The light oil is then separated by fractional distillation into crude benzol, crude toluol, and crude solvent naphtha; these are washed with sulphuric acid, caustic soda, and water, the washed benzol and toluol being then distilled to pure benzol and toluol suitable for use in the manufacture of chemicals or explosives, while by proper distillation the washed solvent naphtha may be separated into the xylols and other products.

The effect of the recovery of light oil is to decrease the heating value of the gas, usually by about 5 per cent, while the open-flame candlepower is reduced to almost nothing. However, if so desired, a part of the illuminants may be left in the gas by the proper manipulation of the apparatus, or, if actually removed, some of the crude products, in the past usually benzol, may be returned to bring up the candlepower or heating value to the desired standard; however, the economy or desirability of re-enrichment is usually questionable.

When operated for the production of gas as the primary product, the ovens are sometimes heated by producer gas generated in independent producers; thus all the gas obtained from the carbonization of the coal is made available for distribution. Under such circumstances the ovens are usually called gas ovens. Occasionally regular coke ovens operated for the production of gas rather than of coke are spoken of as gas ovens. In such case there is no difference in the method of construction, and the operation is changed only in so far as it may appear economically advantageous under the circumstances. Slot ovens and chamber ovens are merely modifications of the coke oven, the principles of construction and the general character of the gas obtained being the same.

Carbureted Water Gas is formed by the action of steam on highly heated coke or anthracite coal with enrichment by the addition of a high heating value oil gas simultaneously generated. It contains the same constituents as coal gas, but in quite different proportions. Like coal gas, it is colorless and has a pungent odor, but it is considerably heavier, being usually from 0.60 to 0.65 as heavy as air.

The more modern types of water-gas making apparatus generally consist of three cylindrical steel chambers, lined with fire

brick, and provided with appropriate gas, steam, oil, and air-blast connections. The first of these chambers, the generator, contains a coke or anthracite coal fire, usually from 4 to 9 feet deep, laid on a grate. A door at the top of the generator provides for replenishing the fire, while doors near the bottom allow the removal of clinker and ash. The second chamber, the carbureter, is provided with an oil spray at the top, and is filled with a checker-work of fire brick. The superheater, which is the third chamber, is filled with fire brick checkerwork in a similar manner to the carbureter.

The size of a water-gas set is determined by the diameter of the steel chambers, not by the internal diameter of the fire-brick lining. In practice, sizes run from about 3 feet 6 inches to 12 feet, the larger sets, of course, giving higher capacities and usually slightly better efficiencies.

Actual manufacture of gas is intermittent, and is divided into the "blow," during which period the set is brought up to proper gas-making temperatures, and the "run," the period when gas is actually made. During the blow, air is forced through the generator fire, burning some of the coke or coal and thus raising the temperature of that which remains. The products of combustion, themselves at high temperature, pass to the carbureter and superheater, where they give up part of their heat to the checker brick there, and finally pass out the stack at the top of the superheater into the air. Some carbon monoxide is formed in the generator during the blow and is burned in the carbureter by an air blast. This secondary combustion affords an important additional source of heat for raising the temperature of the checker brick. The adjustment of conditions so that all parts of the set will come to the proper temperatures at the same time is one of the factors requiring skill in operation. This condition being attained, the air is shut off, steam and oil turned on, and the stack at the top of the superheater closed. The steam, acting on the highly heated coke or coal and partially combining with it chemically, produces "blue water gas." At the same time, the gas oil, a petroleum distillate, admitted at the top of the carbureter through the spray provided for that purpose, is vaporized by coming in contact with the hot checker brick in the carbureter and superheater. The oil gas as formed mixes with the blue water gas, the mixture forming the crude carburetted water gas. The formation of blue water gas and the gassification of oil both absorb heat, so that the run can only continue for a certain length of time

before the temperatures become too low for efficient gas generation. The oil is therefore turned off after the desired quantity has been admitted, while the admission of steam usually is continued for a certain definite total length of time. It is then shut off, the stack opened, and another blow is made.

As in the case of coal gas, the crude water gas contains tar, hydrogen sulphide, and organic sulphur compounds, but there is no ammonia. The tar, which is produced in gassifying the oil, is quite different in composition from coal tar and of much less value. However, it is removed from the gas in the same general manner as coal tar. The sulphur comes from both the generator fuel and the oil, but the quantities of both hydrogen sulphide and organic sulphur are usually considerably less than in coal gas. Hydrogen sulphide is removed by iron oxide, as in the case of coal gas. Since water-gas tar may be extracted from the gas at higher temperatures than coal tar, since there is no ammonia to recover, and since the quantity of hydrogen sulphide is less, it is evident that the removal of impurities from water gas is much less difficult than from coal gas.

In view of the fact that the process is intermittent, and it is desirable to maintain a continuous flow of gas through the tar-extracting and purifying apparatus, as well as to decrease the operating pressures in the gas-generating apparatus, it is customary to provide a so-called relief holder, which is merely a small gas holder, into which the crude gas is conducted after passing through a water seal and sometimes a scrubber or condenser. From the relief holder it is pumped through the remaining apparatus to the storage holder, and from there distributed.

Theoretically the blue water gas should consist of equal volumes of hydrogen and carbon monoxide; in practice, however, the percentage of carbon monoxide is usually somewhat lower, and a small amount of carbon dioxide is present. Blue water gas is thus of relatively low heating value, averaging about 300 Btu per cubic foot. When burned, its flame is nonluminous, while the gas itself has no odor.

The oil gas, on the other hand, containing a very high percentage of illuminants, is of high heating value and high open flame candlepower, and also imparts to the gas its characteristic odor.

Generally speaking, the heating value of carburetted water gas is dependent upon the proportion of blue gas and oil gas which it contains. In other words, the greater the quantity of oil used per 1000 cubic feet of gas made, the higher should be the heating

value. In practice from 3 to 4½ gallons are usually used per 1000 cubic feet of gas, and with such quantities of oil, the heating value should be between 525 and 650 Btu per cubic foot. It should be noted that within reasonable limits, the lower the quantity of oil used per 1000 cubic feet of gas the higher will be the efficiency of its utilization; that is to say, the greater will be the number of heat units each gallon of oil will contribute to the gas. The whole question of oil efficiency, however, is extremely complicated, and in addition to the proper gassifying temperatures, so many other factors enter that no further discussion of the subject is here attempted.

Proper regulation of generator fire conditions so as to obtain maximum fuel efficiency likewise requires considerable technical skill. In actual practice, about 30 to 45 pounds of coke or anthracite coal are required per 1000 cubic feet of gas made.

Tar, which is usually the only important by-product of water-gas manufacture, is recovered in amounts equal to about 15 per cent of the oil used.

Mixed Gas.—In general, the term "mixed gas" is understood to mean a mixture of carburetted water gas and coal or coke-oven gas. Due to its economic advantages, it is supplied in many of the larger cities in the United States.

The manufacturing installation for mixed gas consists, in fact, of two complete installations, one for coal or coke-oven gas and the other for carburetted water gas. Each is equipped with auxiliary scrubbing, condensing, purifying, and metering apparatus entirely independent and separate. The two gases are usually mixed at the inlet of the storage holders, and are, of course, delivered through a single distribution system.

Advantages of Coal and Water Gas.—The advantages of coal, water, and mixed gas must be considered primarily from the economic or manufacturing standpoint, since the advantages of each to the user are in most cases only the indirect result of the economy of manufacture.

The actual cost of manufacturing coal gas is high, and were it not for the valuable by-products obtained—that is to say, coke, tar, ammonia, and occasionally light oil and cyanide—it could not usually compete with water gas. Unless the coal-gas by-products are intelligently and economically handled, and unless a favorable market for them is available, the net cost of coal gas will generally be relatively high. The greatest difficulty in extension of large coal-gas works is the lack of suitable outlet for the coke, as the

coke produced is ordinarily not suitable for foundry or metallurgical purposes. It is, however, suitable for domestic consumption, and since in such cases it usually replaces anthracite coal, its use should be encouraged from a conservation standpoint, if for no other reason.

In the beginning of the industry coal gas was the only kind produced, but the rapidity with which water gas was introduced after the invention of the Lowe process was remarkable. At the time of its introduction by far the major part of all gas used was burned in open flame, and both municipal requirements and popular demand called for high candlepower. Under the commercial conditions then existing, especially the cheap supply of naphtha, for which there was practically no other use, manufacturers were able to meet this demand very economically. Some of the other factors which may be mentioned as contributing to the rapid growth of the water-gas industry are: The abundant production of anthracite coal at reasonable price (in certain parts of the country); the lower investment required for manufacturing plant (approximately only half that for coal gas); greater flexibility of operation from hour to hour or day to day (allowing rapid change in rate of manufacture to meet the changes in demand); the smaller number of men necessary to operate a water-gas plant; and the very important fact that no difficulty is met in the disposal of the very small amounts of by-products formed.

The advantages of mixed gas were also very influential in increasing the amount of water gas made. In a mixed-gas plant the coke made in the coal-gas works can be used to make water gas, the heating value of the mixture can be readily and quickly raised by the use of high heating value water gas; the coal gas is usually somewhat cheaper when a uniform rate of make and a good coke outlet are assured, the water-gas part taking care of the variations in demand and utilizing surplus coke. The relative amounts of coal and water gas in a mixture are determined by a number of factors. Mixed gas of varying proportions is distributed to a greater or less extent in most of the large cities of this country.

The conditions which caused the water-gas industry to grow rapidly to such large proportions have been gradually changing. The open-flame light has largely disappeared, and candlepower requirements have been replaced by heating-value standards. The candlepower of water gas of a given heating value is considerably higher than the candlepower of coal gas having the same

heating value, so that the general change in requirements has been favorable to coal gas. Furthermore, the increasing price of gas oil and the discovery of other important uses for this oil, which was formerly regarded as nearly worthless, except for gas enrichment, together with the constantly increasing demand for the by-products of coal-gas manufacture, are factors which are causing the cost of water gas to increase relative to that of coal gas. At the same time coke ovens and new and improved types of coal-gas equipment are being developed and installed. The result is that a new impetus has been given to the manufacture of coal gas, although the quantity of water gas made has not yet greatly decreased.

Natural Gas is one of the natural resources of the country. It is found in many different localities, Pennsylvania, West Virginia, Oklahoma, and California having some of the more extensive fields.

Natural gas is obtained from wells similar to oil wells and is frequently piped for long distances. As found it is ready for use without purification, it being merely necessary to deliver it to the customer at proper pressure. It is a colorless gas, composed principally of methane with small quantities of other hydrocarbon vapors. It therefore has a very high heating value, the heating value of pure methane being about 1000 Btu per cubic foot.

Oil Gas.—An important process of gas manufacture, confined principally to the Southwestern and Pacific Coast States, is the manufacture of gas from crude oil. The magnitude of the industry may be judged from the fact that in 1911, 20 per cent more oil gas than unmixed coal gas was distributed in the United States.

Oil gas is essentially the product of destructive distillation of petroleum. This accounts for the great similarity in composition of oil gas and coal gas, the former being produced from oil, the latter from bituminous coal, under such conditions that somewhat similar reactions occur. The generating machinery used for production of oil gas resembles markedly the water-gas machinery. Oil is gassified in cylindrical steel shells lined with fire brick and filled with a checkerwork of fire brick. The process bears a further resemblance to water gas in that it is carried out in alternate heating and gas-making periods. However, the chemical processes involved and the effect of various factors are so different from those found in the case of water gas that it is undesirable to make comparison with the latter when considering oil gas. Com-

parison may be made with the carburetting process used in water-gas manufacture, but even this has led to some misunderstandings.

There are three distinct processes in use for the manufacture of oil gas: First, the "straight-shot process," in which a single-shell machine is utilized; second, the two-shell process, in which the second shell is used only to conserve heat, no gas being made in it; third, the two-shell machine, in which gas is made in both shells.

There are many variations in each of these processes; for example, the heating oil may be introduced at the top or at the bottom; the making oil may be introduced at the same point as the heating oil or at the opposite end of the machine; gas may be taken off at one end of one shell or at the side of the larger of the two; a secondary blast may be used or not.

The process of making oil gas takes place in alternate periods of heating the generator and of gas making; the heating period is made up of the interval during which the blast (without oil) is introduced to burn out the carbon collected in the machine, and the interval during which oil for heating the machine is introduced. The true making period is followed by a period of purging, during which steam is introduced to eliminate the gas remaining in the machine. The total as well as the relative time of these several periods varies greatly in different plants. In addition to this regular cycle it is occasionally necessary to have a long period of blasting in order to more thoroughly burn out the carbon collected in the generator. At intervals of 5 to 10 days it is, in some plants, necessary to entirely shut down manufacture and burn out this carbon under natural drafts.

The temperature maintained in the generator varies with the character of oil employed and with the quality of gas which is to be made. In general, a higher temperature produces a larger quantity of poorer gas; and, within limits, the converse is true that the lower the temperature at which the generator can be operated the higher will be the quality of the gas. This condition results from the fact that the decomposition of the oil into gas is a progressive process.

The heating oil is introduced into the generator with steam or under high pressure without steam; and, if properly injected, it enters practically atomized. This fine oil spray is quickly vaporized by the hot checker brick and the decomposition of the vapor begins at once. The higher the temperature to which the

oil vapor is subjected and the longer the time at the high temperature the more complete will be the decomposition. Practically speaking, if this decomposition went to completion the oil would be converted into hydrogen and lampblack. As a matter of fact a small portion of the oil is always decomposed in this manner, but of course a much larger part is decomposed only into those hydrocarbon gases which make up the methane, ethylene, and benzene series. In addition there are also formed complex hydrocarbons, such as napthalene.

The significance of this successive decomposition is apparent if we consider that a specification of a certain heating value for the gas will necessitate that the generator be operated at such temperature as to produce gas at least of the richness specified. The standard fixed is therefore a determining factor in controlling the works operation. Moreover, if the quality be fixed too high, it will be found that certain difficulties of operation are introduced because of the low temperature which must be maintained in the generator. For example, when operating at a lower temperature a smaller amount of lampblack may be made; but this as produced is mixed with the tar, and the resulting tar and lamp black mixture is difficult to handle.

The numerous variations in detail make it impossible to give any generalizations as to the present operating practice in many particulars. However, two particular points on which striking differences in operating practice have been noted, should be considered in connection with standards for oil-gas service. The first of these points has to do with the method of introducing the oil into the generator, the second with the manner of handling the gas in wash boxes and condensers.

With care it is possible to introduce the oil in a very fine spray, which permits almost immediate vaporization in the generator; practically none of the spray drops in liquid form into the checker brick, and thus the "stewing" of the oil is eliminated. It is essential, as is recognized by all water-gas makers in connection with the carburetting process, that the oil be immediately vaporized when it enters the hot checker brick or the liquid will be greatly superheated in some parts and very incompletely heated in others before it can be converted into gas. The result of this so-called stewing is the production of a tar very difficult to handle, the carbonization of the checker work with resulting lowering of generator efficiency, and a general operating difficulty due to

irregularity of temperatures throughout the generators, a condition which is most detrimental to good operation.

When the gas leaves the generator it carries suspended in it a considerable amount of lampblack, varying in quantity from 5 to 50 pounds of carbon per 1000 cubic feet of the gas. It also carries a considerable amount of tar and napthelene, which also must be eliminated before the gas can be purified and placed in the holder. The gas leaving the generator bubbles through water in the wash box, and most of the lampblack is separated from the gas by this process. Proper operation at this point will eliminate subsequent difficulty in condensing; if the gas is not properly freed from lampblack in the wash box, the mixture obtained in condensing is made up of tar, water, and lampblack in proportions that are very difficult to separate and handle. Notable progress has been made in the operation of the wash box in some of the California plants, where the gas is passed for the distance of 5 to 15 feet under water in order that practically all of the lampblack may be removed before the gas enters the scrubber. This elimination of lampblack greatly facilitates condensing and results in the production of a tar which can be easily handled.

Considerable attention has been given to the two points above, since one of the most important points to be considered in the adoption of a heating-value standard for oil gas has been whether or not a company could operate without serious works difficulty when making a gas of moderately high heating value.

3. DISTRIBUTION METHODS [21]

In the early days of the gas industry gas was distributed through pipes usually at the pressures of the works holders, probably rarely in excess of 3 or 4 inches and often as low as 1 inch of water column. At that time gas was mostly used for lighting, and the types of burners in use were so designed as to operate most economically and efficiently at the low pressure then in vogue. But with the development and improvement of gas appliances, especially the extensive application of the Bunsen burner to varied uses, it was found that better service could be obtained by the use of gas supplied at higher pressures. This fact, together with certain advantages in the way of economy and uniformity of distribution, has led to a very general increase in the pressures maintained.

[21] In the following discussion of gas distribution we have followed and made free use of the report of William A. Baehr upon his investigation of gas-pressure conditions in New York City.

Under ideal conditions the pressure at each burner would be constant and such that the maximum efficiency would be obtained for that particular burner. Such a condition could only be obtained by supplying gas to each burner through an individual governor. This is not practicable at the present time. The nearest approach to the ideal condition that can be accomplished by legal regulation is to require the company to deliver gas to the consumer's house piping at a reasonably uniform pressure, as nearly as practicable, such as to give maximum efficiency with the appliances in general use.

Most gas appliances can be adjusted for different pressures, while all of them permit of a certain amount of variation from the most favorable condition without any serious loss of efficiency. To give a concrete example, an appliance which is adjusted for a 6-inch pressure may not give noticeably poorer service when supplied with gas at 4 or 8 inch pressures, but may be seriously inefficient at a 10-inch pressure, and perhaps, without adjustment, entirely worthless at 2 inches. The same apparatus could probably be adjusted for an 8-inch pressure when it would give good service between 6 and 10 inches, or for a 3-inch pressure when a 2 to 4 inch variation would not cause trouble. The consumer has a right to expect the company to furnish gas at a pressure which will be at all times sufficient and never too great for good service with the appliances in common use. The pressure should not vary greatly; but is it not a matter of great concern whether the average value is (within reasonable limits) high or low, provided always the appliances are properly adjusted for the average pressure.

It should be recognized that low pressure at the burners is not always the fault of the gas company. It very frequently happens, especially in old houses, that the house piping is inadequate or in poor condition—a situation for which the company is not responsible and which should be remedied at the consumer's expense. When the piping is placed in a new building it seems desirable that the company should be allowed to have something to say, at least in an advisory way, about the size of pipe and other matters affecting satisfactory service, especially as it should best know the piping requirements requisite to obtaining such service. In such cases its interests are identical with those of the consumer.

The distributing systems in general use may be divided into two classes—*low-pressure* distributing systems and *high-pressure* distributing systems. By low-pressure distributing systems are generally meant all those from which the gas is introduced from

the mains directly into the house piping without passing through a regulating device. High-pressure systems are those in which the gas in the mains is maintained at higher pressure than that at which it is used, and the pressure reduced by house governors, before passing through the meter. Obviously, all variations in the street main pressures are of great importance in low-pressure systems; while in high-pressure systems (provided the governors work properly, which is, unfortunately, not always the case) it is important only that the pressure should never fall below that which it is desired to maintain in the house piping.

The amount of gas which can be delivered through a pipe of a given diameter and length depends, other things being equal, upon the difference between the pressure at the two ends. Hence, for the sake of economy, in the size of mains required, there is a tendency to maintain as high pressures as possible near the distributing center and as low as possible in the remote districts supplied. This is especially true during times of maximum load. If the rate of gas consumption were always constant, it would be a simple matter to maintain a constant pressure at every point in the system, but the rate of consumption (called the load) varies from a very low figure, a short time after midnight, to a very high figure (called the peak load) at some other time, usually either about noon or in the evening when the maximum amount of cooking is being done. At the time of minimum load there is so little gas flowing through the pipes that the friction becomes negligible, and all parts of the system on the same level supplied from one regulating or distributing center have practically the same pressure; but at times of peak load gas is being taken out of the mains all along the line and the pressure in the outlying districts becomes less, while that in the mains near the center of distribution is increased to keep the gas supply at a distance from failing entirely. At points between the two extremes the pressure may be kept nearly constant. Thus we see there are three zones—the outer zone in which the pressure is high during minimum load and low during maximum load; the inner zone with low pressures during minimum and high during maximum load; and an intermediate zone, where the variation is small. In order to reduce this difference it has been found economical in many cases to install high or medium pressure lines feeding the low-pressure system through district holders or district pressure regulators at points remote from the works. These high or medium pressure lines can usually be made of the smaller sizes of pipe, and thus larger expenditure for low-pressure pipe of

sufficient size to give satisfactory pressure in the outlying districts is avoided. The use of feeder systems and high-pressure belt lines is frequently a distinct step in the direction of economy and good service.

The elevation of different localities supplied is another, though less troublesome, factor in the distribution problem, because it is constant. All illuminating gas is lighter than air, and consequently the pressures in the pipes at high elevation is greater than at lower ones. In some cases where the plant is situated on low ground, this may be of considerable aid in supplying gas to the distant parts of the city at a greater elevation. In other cases it may make governors necessary to keep the pressure down to a proper figure in certain districts.

So far we have been considering only variations that extend over considerable periods of time. Momentary variations deserve separate consideration. There are many causes for sudden changes in pressure, among which may be named the sudden opening or closing of valves, tapping mains to connect new services, breakage of mains, and the effect of gusts of wind upon the gas holder. Some of these accidents are entirely beyond the control of the company, while others are avoidable. The regular pulsations, generally caused by a gas engine on the line, may be so small or so rapid as not to affect the operation of any burner; but they can be largely avoided by the use of proper appliances in connection with the engine, and should never be permitted to become troublesome to other consumers.

It will be seen that it is impossible for any company to supply gas at an absolutely constant pressure to all of its consumers. All that can be required is that the pressure should never vary beyond certain limits within which the operation of the appliances in common use is satisfactory and which can be maintained by the company without undue expense. The methods of maintaining satisfactory pressures should be left to the gas companies, and a reasonable length of time should be allowed, after unsatisfactory conditions are discovered, for the company to make the necessary changes in its distribution system. It may frequently happen that the rapid growth of one section of a city, or other cause for a sudden increased demand, will make a portion of the system inadequate and will require changes which can not be made quickly. In every case, however, the company should be expected and required to give the matter immediate attention

and to make the necessary changes as rapidly as may be without undue expense.

The recommendations made in this circular as to the quality and pressure of gas which the companies should be required to furnish are intended to be such that the companies will be allowed the greatest degree of freedom in modifying their methods of manufacture and distribution to meet changing conditions in fuel supply, new inventions, and other variable factors affecting gas manufacture.

APPENDIX

The following tables are given in the hope that the information thus summarized will be of value to those interested in the manufacture and distribution of gas. The data in Tables 7, 8, and 9 have been previously presented in reports of the U. S. Geological Survey and furnish an idea of the magnitude of the gas industry, as well as of its development in the past few years. In the remaining tables, only those companies operating as public utilities have been included since they alone of the companies manufacturing gas are concerned with the previously described standards for service. As was the case in the third edition of this circular, a table based on data presented in Brown's "Directory of American Gas Companies," which classes the companies by size and kind of gas, is included. For the purpose of comparison, so that a general idea of the growth of the manufacturing and distributing companies practicing as public utilities may be readily obtained, the table in the third edition, giving statistics for 1911, has been reprinted here. Table 11 summarizes some of the distribution data given in the directory.

TABLE 7.—Manufactured Gas and By-Products Marketed in 1915 and 1917

[Data from U. S. Geological Survey Press Bulletin, February, 1919, based on a report in preparation by C. E. Lesher]

Product [a]	1915		1917	
	Quantity sold	Value of sales	Quantity sold	Value of sales
Gas (M cubic feet):				
Coal gas	43 747 432	$40 257 108	42 927 728	.....
Water gas	124 129 569	112 281 956	153 457 318	.....
Oil gas	13 971 333	12 668 169	14 739 508	.....
By-product gas	84 355 914	8 624 899	131 026 575	.....
Total	266 204 248	173 832 132	342 151 129	.....
Coke (net tons):				
Coal gas	1 662 552	7 198 377	1 857 248	$10 953 693
By-product	14 072 895	48 558 325	22 439 280	138 643 153
Total	15 735 447	55 756 702	24 296 528	149 596 846

[a] Other products not included in this table, valued at $396,007 in 1915 and $1,145,633 in 1917, were: From coal-gas plants, creosote, tar distillery products, pitch, coke breeze, and spent oxide; from oil-gas plants, lampblack, petroleum coke, briquets, and yellow prussiate of soda; from by-product coke-oven plants, coke breeze, sodium ferrocyanide, residue, drip oil, and spent oxide.

TABLE 7.—Manufactured Gas and By-Products Marketed in 1915 and 1917—Contd

Product	1915		1917	
	Quantity sold	Value of sales	Quantity sold	Value of sales
Tar (gallons):				
Coal gas	47 863 192	$1 555 363	53 318 413	$1 774 326
Water gas	51 381 911	1 118 656	59 533 208	1 258 683
Oil gas	64 433	4 268	727 556	32 682
By-product	138 414 601	3 568 384	221 999 264	5 566 302
Total	237 724 137	6 246 671	335 578 441	8 631 993
Ammonia sulphate or equivalent (pounds):				
Coal gas	103 842 035	1 329 651	91 540 590	1 362 125
By-product	394 256 000	9 867 475	560 792 322	17 903 864
Total	498 098 035	11 197 126	652 332 912	19 265 989
Light oils (gallons): [a]				
Coal gas	526 651	39 004	770 298	448 855
Water gas	788 876	59 840	6 420 717	1 655 204
Oil gas			205 475	74 035
By-products	16 600 857	7 337 371	54 427 266	28 655 204
Total	17 916 384	7 436 215	61 823 756	30 833 298
Crude naphthalene (pounds):				
Coal gas	222 925	3565	383 349	9584
Water gas			16 548	103
By-product	465 865	46 959	17 276 044	569 449
Total	688 790	50 524	17 675 941	579 136
Retort carbon (net tons):				
Coal gas	120	1362	252	2733
Water gas	741	8511	1068	12 067
Oil gas	19 500	167 700	21 991	204 536
Total	20 361	177 573	23 311	219 336

[a] Includes crude light oil, secondary light oil, benzol, toluol, and solvent naphtha.

TABLE 8.—Production of Manufactured Gas and Fuels Consumed in Its Manufacture

Fuel and output	Coal gas	Water gas	Oil gas	By-product gas
Anthracite gross tons		1 486 305		
Bituminous net tons	4 960 297	7815		31 505 759
Coke do		1 448 173		
Oil gallons	[a] 106 627	684 620 637	137 484 874	
Cannel net tons	[a] 1 296			
Gas produced M cu. feet	47 525 148	174 357 536	17 552 855	337 728 251

[a] Used as enricher.

TABLE 9.—Natural Gas Produced in the United States in 1916 and 1917

[Data from U. S. Geological Survey Press Bulletin, February, 1919, based on a report in preparation by J. D. Northrop]

Year	Volume	Value	Average price
	M ft.³		Cents per M ft.³
1916	753 170 253	$120 227 468	15.96
1917	795 110 376	142 089 334	17.87

TABLE 10.—Companies Producing or Distributing Manufactured Gas as Public Utilities in the United States

[Classified by size and kind of gas]

A. DATA FROM BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES, 1912

Kind of gas	Number of gas companies grouped according to volume of annual sales (in millions of cubic feet)								Total sales (approximate)
	More than 1000	500 to 1000	200 to 500	100 to 200	50 to 100	20 to 50	Less than 20	Total of all sizes	
									Million ft.³
Coal	.....	1	4	6	23	93	169	296	8500
By-product	1	1	1	2	3	.....	1	9	2500
Water	7	10	24	28	29	68	228	394	52 100
Mixed coal and water	18	19	29	24	25	29	19	163	105 550
Oil	4	.....	6	5	7	15	92	129	13 200
Character not stated	.....	.....	.....	.....	.....	1	9	10	70
Total	30	31	64	65	87	206	519	1001	182 000

Table 10.—Companies Producing or Distributing Manufactured Gas as Public Utilities in the United States—Continued

B. DATA FROM BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES, 1919[a]

Kind of gas	Number of gas companies grouped according to volume of annual sales (in millions of cubic feet)								Total sales (approximate)
	More than 1000	500 to 1000	200 to 500	100 to 200	50 to 100	20 to 50	Less than 20	Total of all sizes	
									Million ft.[3]
Coal			2	7	36	87	118	250	8050
By-product coke-oven	2		1	2		2	6	13	4330
Water	14	14	32	27	38	92	198	415	72 600
Oil	5		5	2	6	22	55	95	19 300
Wood							1	1	6
Coal and coke-oven					1			1	90
Coal and water	19	13	28	32	21	28	13	154	93 200
Coal and oil			2		2	1	1	6	750
Coal and natural		1						1	920
Coal, water, and coke-oven	4	1	1	2				8	23 700
Water and coke-oven	8	2	3		1			14	53 600
Water and oil					1			1	54
Water and natural		1						1	540
Oil and natural	1		1	1	1			4	4720
Character not stated						1		1	40
Total	53	32	75	73	107	233	392	965	281 900

[a] The table includes only those companies for which the information is sufficiently complete to permit classification. In addition to the plants listed in the table, the directory also reports the following:

Natural gas companies	779
Acetylene town plants	108
Gasoline town plants	48
Parent or operating companies	158

TABLE 11.—Gas Distribution Data for Companies of Various Outputs

[Data from Brown's Directory of American Gas Companies, 1919]

Classification of companies based upon volume of gas sold annually (millions of cubic feet)	Annual sales per mile of main			Number of consumers per mile of main			Annual sales per consumer		
	Maximum	Minimum	Average [a]	Maximum	Minimum	Average [b]	Maximum	Minimum	Average [c]
Greater than 1000	21.4	1.9	6.4	683	22	180	136	24	39
1000 to 500	10.6	1.7	4.5	284	43	141	77	18	34
500 to 200	6.4	.3	3.3	236	6	108	95	17	33
200 to 100	8.6	.7	2.7	346	31	103	53	16	27
100 to 50	4.2	.2	2.0	214	11	81	85	12	26
50 to 20	5.3	.3	1.6	337	8	77	300	9	23
Less than 20	5.0	.04	1.05	300	1	61	101	2	18

[a] General average, 2.02. [b] General average, 83.1. [c] General average, 23.8.

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