DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 32

STANDARD REGULATIONS FOR MANUFACTURED GAS AND GAS SERVICE

[2d Edition]

Issued October 1, 1913

Superseding Circular No. 32, first edition, issued April 1, 1912, entitled "STATE AND MUNICIPAL REGULATIONS FOR THE QUALITY, DISTRIBUTION, AND TESTING OF ILLUMINATING GAS"

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INTRODUCTION

It appears even more important now than it did at the time the first edition of this circular appeared that greater uniformity of gas regulations, as well as of gas testing methods, should prevail. As the Bureau of Standards has had opportunity during the period since the first appearance of this circular to investigate these questions further, it has become more and more apparent that a large proportion of existing regulations are so defective in one or more important parts as to make their enforcement difficult and, in some cases, undesirable.

The study of methods of gas testing and regulations affecting the same was at first made secondary to the study of standards for gas photometry and for gas calorimetry. However, as these methods and regulations are of fundamental importance in a public utility with sales exceeding a hundred million of dollars a year, these investigations have been deemed of sufficient importance to warrant a more thorough treatment. The need of carefully arranged regulations, together with exact definition of methods of testing, has seemed sufficient to warrant revision of this circular on gas regulations. The first edition of the circular on testing methods will be issued later this year.

As in the earlier edition, the opinions and conclusions expressed in the various sections have been reached after many conferences with gas engineers and inspectors who are well qualified to express opinions on these subjects. In each case care has been exercised to confirm the statements and reconcile differences of opinion. Where uncertainty still exists, such fact has been indicated.

The attitude of the Bureau in this work is entirely advisory. It is intended to place in the hands of the technical and general public an impartial and, as nearly as may be, accurate summary of the facts which must be considered in connection with regulations affecting the quality of

gas and gas service. In the preparation of the recommendations on the various phases of this subject the cooperation of many engineers and inspectors has been sought and, in general, very freely given. This assistance has, indeed, been most valuable to the Bureau.

In revising the regulations the Bureau has constantly kept in mind the idea that any expense thrown upon a gas company by reason of rules which increase the cost of gas making or increase the labor or expense of distributing the gas or conducting the business, falls upon the public ultimately. For, under a just regulation of the business by public service commissions or city councils, the price of gas must be high enough to permit a reasonable profit to the stockholders, and if any needless expense so caused does not actually force the price of gas up, it may prevent or retard a reduction which could otherwise be made. Hence more stringent regulations should be made only when they improve the service enough to justify the cost. It is a matter of great importance and no little difficulty to draw the specifications for the gas service of a great city or a State so that, on the whole, the business shall be conducted with a maximum of efficiency; so that the public gets the best service possible, with a sufficiently high standard of quality to give satisfactory service, the plant meanwhile being kept up to a high state of efficiency and the stockholders receiving reasonable dividends.

With this in view the Bureau has recommended requirements lower in some respects than prevail in some cities and higher than prevail in others; not with the idea merely of striking an average, but rather of specifying the conditions most favorable for maximum economy and efficiency. 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.

In the preparation of ordinances and rules for adoption in cities or States, the Bureau, when requested, will be glad to assist by furnishing any information available or by examining the proposed rules and making suggestions as to their form or requirements. The Bureau wishes to serve as a clearing house for information on the technical matters involved in the regulation of gas companies and as a medium through which city and State authorities can cooperate in their separate investigations.

It is hoped that the present revision will increase the usefulness of this publication.

S. W. Stratton, *Director.*

PART I. DISCUSSION OF TECHNICAL SPECIFICATIONS

In order to insure satisfactory service from a gas company three conditions must be met, viz:

First. Gas of good and reasonably uniform quality must be distributed at satisfactory pressure and correctly metered to each customer.

Second. The price of the gas to each class of customers should be reasonable, and as low as is consistent with the maintenance of the works at a high state of efficiency and the earning of a reasonable profit.

Third. All portions of the city or district which are sufficiently populous to warrant gas supply, should be supplied.

In this circular only the technical provisions as to the quality of gas and gas service, as determining the first of these three conditions, will be discussed.

Although the Bureau of Standards has not undertaken an investigation of the price of gas, the fact has been borne in mind that all regulations which are adopted must be carefully considered from the standpoint of their probable effect upon the cost and the selling price of gas. Indeed, the question of the quality of gas which is to be required is one which has necessitated study not only from the scientific and technical standpoint, but also from the economic side. The Bureau has endeavored to study and treat it broadly from these various points of view, and in all phases of the problem has striven to give careful and unbiased consideration to all of the facts which bear upon each question investigated, in order to reach correct and just conclusions.

As a regulatory gas ordinance is really a specification accompanying the contract between the gas company and the public, it should clearly define the quality of the gas and gas service which it is expected that the company will furnish to its customers. The standards set by the law should be such that they define without ambiguity those qualities of the gas and gas service which determine the usefulness of the gas to the purchaser. Furthermore, the law or rules should be sufficiently comprehensive to cover all of those points on which the public can reasonably ask assurance, as to the quality of the gas or the service to be rendered. Because a company is likely without regulation to fulfill certain important conditions, is not

sufficient reason for the omission of these conditions from the legal specifications.

It should be borne in mind that the adoption of stringent regulations may make necessary an increase in the investment in plant or distributing system or may increase operating costs appreciably, and such increases would increase the proper price to be charged for gas. In any event good service should be required; but unreasonable demands on a company will, in the end, cause loss to the public.

The establishment of an ordinance or set of rules for gas service demands that provision also be made for suitable inspection to insure the fulfillment of the conditions imposed; and only those specifications are of value the fulfillment of which can, when necessary, be verified by experimental evidence without undue expenditure of time or money. But it may be well in small cities or towns where no regular inspection is desirable, because of its cost, to make some requirements which shall make definite what the company is expected to do, especially in regard to the important matters of heating value and pressure. These will be valuable in case of unsatisfactory service or disagreement with the company.

Early in the history of gas manufacture, rules were adopted for regulating the quality of the gas and its distribution. The first regulations were very general in character, becoming more specific as knowledge of the subject increased, until at the present time it is possible to make certain regulations very precise. It is desirable to do this, whenever possible, since the uncertainty of the requirements is thus minimized, and the regulation is of greater protection to the public.

The discussion contained in the following sections applies alike to coal gas, carburetted water gas, by-product gas, oil gas made from crude petroleum in the far western part of this country, and mixtures of these. No distinction is made between rules applicable to privately operated plants and those owned and operated by a municipality.

A full revision has been made of the compilation of gas ordinances and rules now in force. The summaries of these are in Part IV of this circular. The careful consideration of these existing regulations and the results of their enforcement has furnished much valuable information, as indicating the probable satisfaction or difficulty with which similar rules could be enforced elsewhere. They have thus been a guide in the preparation of the proposals of this circular; but at the same time summarized data of this or any other character has been used with caution. No conclusions as to the desirability of any procedure are based merely upon its prevalence.

Although methods of enforcing requirements made by State officials may differ from the methods for enforcement of a municipal requirement, yet the quality of service required in the two cases will be about the same. Therefore, for the discussion of the technical requirements no distinction between city and State rules has usually been needed, and, except as otherwise indicated, the statements made in Part I apply to both city and State regulations. The methods of enforcement are separately discussed in Part II of this circular.

In order to better understand the various phases of the subject of gas regulations, some readers may desire a brief discussion of the technical matters involved. A discussion of the principal kinds of illuminating gas and methods of gas distribution has, therefore, been included in this circular (Part V).

A. CANDLEPOWER AND HEATING VALUE

The earliest specific requirements made as to gas quality were as to the candlepower of the gas supplied, and even at the present time this form of regulation is most frequently in force. However, the very general use of gas for gas ranges and incandescent-mantle lighting has raised the question as to whether a calorific standard is not better than a candlepower standard for commercial gas. Except in the larger cities, it has been estimated that less than 10 per cent of the gas is employed in open-flame gas burners, where the candlepower is of primary importance to the consumer. In the larger eastern cities, however, it is believed by some that as high as 20 per cent of the gas may be thus employed. The question as to the comparative advantage of heating value and candlepower specifications, or the necessity for both of these, is therefore of great importance.

It has been assumed that the choice of heating value or of candlepower as the property by which the gas shall be regulated depends upon the following considerations:

(1) Which property can be better regulated by the manufacturer?

(2) Which property is the better measure of the usefulness of the gas to the consumer?

(3) Which can be more accurately determined in testing?

(4) Which causes the smaller testing expense?

(1) At the time this circular was first issued many gas manufacturers had had much less experience in operating to meet a heating value standard than a candlepower specification and hence felt greater confidence in their ability regularly to meet the latter. But in the last two or three years the

increased number of companies which have been taking heating values and the general satisfaction which this method of control has given have so changed the former situation that at recent conferences with many of the most prominent gas engineers in the country they were almost unanimously in favor of the heating value specification. The much smaller proportionate losses of heating value than of candlepower during distribution and the decrease in trouble resulting from varying weather conditions and irregularities in works operation, are some of the practical advantages to the manufacturer which may be expected from a control based on heating value.

(2) The use to which the gas is to be put determines largely which property is the more suitable as a measure of its value. In general, four uses are made of commercial gas, viz, for heating and cooking, for open-flame lighting, for mantle lighting, and for producing power. In the first, the heating value is of chief importance; in the second, the candlepower represents the desired measure; but in the last two groups the temperature attained by the mantle or by the gas in the cylinder of an engine is dependent upon several conditions. The candlepower for incandescent mantles does not exactly follow the heating value of the gas, but in general the relation is so nearly constant that the heating value offers an excellent means of judging the quality of the gas for such use. For gas engines the same condition holds.

Because the gas used for heating, cooking, mantle lighting, and power purposes is in most cases more than 75 per cent and in many cities over 90 per cent of the total consumption, the general tendency is toward heating-value regulations. Candlepower measurements are more and more being made on lighting installations to test the efficiency of various mantles and appliances rather than on the gas to test the quality of the gas itself. In this connection it is assumed that the gas companies, as public-service corporations, will feel that their own interest demands the education of the people to obtain light in the most economical way, i. e., by the incandescent mantle. And, on the other hand, the city ordinance or other regulation, which by enforcement of unduly high candlepower tends to increase the use of the open-flame burner of admittedly low efficiency, can be said to encourage wastefulness.

(3) In the matter of the precision of its determination, the heating value is superior to candlepower. It is generally conceded that an irregularity of more than 3 per cent in the heating-value determination need not occur even in traveling-inspection work, whereas it is only by great care that the candlepower determination can be made with this precision.

When candles are used as a standard, the error in candlepower will often be as much as 5 or 10 per cent, not considering the difference in test burners, which is large. One matter which is important in this connection, especially in State gas regulation, is the fact that the best forms of apparatus used for heating value determinations are readily portable, while most portable gas photometers are not suited for accurate work.

(4) As to the relative expense of candlepower and heating-value determination, very few general conclusions can be drawn, since the grades and types of apparatus vary so widely as to prevent comparison. The comparative skill required for the two kinds of work shows no decided difference, although the greater accuracy of the calorimetric determination would allow somewhat less skillful operation without undue diminution in the value and significance of the results obtained.

From the point of view of the general usefulness of the gas to the customer, there is no doubt that both the heating and the lighting value of the gas should be maintained above certain minimum values. However, some engineers claim that a company should not be required to maintain both candlepower and heating value of specified amount, as they believe that under the present methods of manufacture and with the present-day appliances for gas consumption it is only necessary to regulate one of these qualities and allow the other to be what will correspond, having regard only for economy of manufacture.

At the present time the methods employed in gas making are such that all coal gas and carburetted water gas made on a heating-value basis will also have a reasonable candlepower; but gases of nearly normal heat value and very low open-flame candlepower can be made and wherever it is found practicable to supply these gases at a satisfactory price the question arises as to how far we may disregard the lighting value of the gas. There are those who say that if gas can be made cheaper by this procedure, it is proper even at the present time to wholly disregard the open-flame candlepower of the gas. However, the Bureau has taken the attitude that there are still too many who are utilizing gas in open-flame burners to do so at this time.

There are places for which the open-flame burner may be better suited than is the mantle light. These places are basements, halls, storage, and attic rooms, where the light is little used or where the burner is subject to such rough treatment as to make the mantle impracticable. In places such as laundries, where the air is very moist or full of steam, the mantle

has a very short life and is much less efficient than under ordinary conditions. In combination fixtures where gas is used only in case of interruption of the electric service, the extra investment in mantle lights is not warranted, even if the mantle burner were adapted for use on combination fixtures, which is often not the case. A nominal candlepower gas will be sufficient for use in such places as those just mentioned, and the gas made by the ordinary processes of the present day will be satisfactory in quality even if only heating value is controlled, since the lowest open-flame candlepower would seldom be less than 12 candles if the gas were of 600 Btu or higher.

On the other hand, it is uncertain what would be the result if a gas maker undertook to make considerable modifications in the manufacturing processes. We have not yet reached the time when customers requiring open-flame candlepower in gas are negligible numerically; nor has it yet been proved that the manufacture of a nonluminous gas is most economical or desirable. The Bureau is, therefore, disposed to recommend retaining in city ordinances a minimum candlepower requirement as a secondary standard in addition to the more important heating value standard, such a minimum candlepower value being low enough so that the manufacture of gas is not thereby complicated and its cost is not increased. Whenever such processes are devised that the methane content of the gas can be largely increased, we may be confronted with this problem in a new light; and it is not improbable that such process will be devised in the near future. If the time comes when a nearly nonluminous gas is clearly to the advantage of the public, the price would probably have to be readjusted, and in that case the candlepower requirement can be readjusted also.

The use of a minimum candlepower requirement, together with heating value specification as described above, is not what is usually understood by a "double standard." The latter involves a candlepower requirement as difficult to meet as the heating-value requirement, so that the gas maker must watch and control both calorimetric and photometric values. This is not recommended. It is again emphasized that the candlepower should be made the secondary specification under ordinary conditions, and so low that it will not embarass the manufacturer.

Since the candlepower of a gas is a measure of the usefulness of the gas for open-flame lights, and since a gas of high candlepower will invariably have also a good heating value, it might appear that when only one of the two properties is to be regulated by law the candlepower would be the better one to fix, for a high heating value does not insure any particular

candlepower. Indeed, it is because of the high candlepower requirements which have been in force that the need of heating-value limits in the laws has not been more evident; in cities where 22 candles has been the minimum candlepower allowed, for example, Philadelphia, Chicago, and Washington, the heating value of the gas has been considerably above the value ordinarily fixed by law. (It has usually been from 625–675 Btu in the cities named above.) Now that heating-value limits are replacing candlepower requirements as the principal basis of gas rating, it is evident that for the protection of users of open-flame lights a minimum candlepower limit should be observed. The small percentage of all the gas sold which is used for open-flame lighting is not a measure of the percentage of gas users who desire that the gas supplied to them have a reasonable luminous power in open-flame burners. The great majority of gas consumers utilize some gas in open-flame lights; it is necessary, therefore, to have a reasonable candlepower maintained. To insure this it is desirable to prescribe in city ordinances a value which, though secondary to the heating-power regulation, will indicate clearly what lighting value is expected from the gas. But it is not always essential that the State rules include such provision. A State commission can from time to time amend its rules; therefore, if at any time it were necessary to make a regulation to prevent distribution of unreasonably low candlepower gas, the authority to do this could at once be exercised by the State commission. On the other hand, a city ordinance once established is usually difficult to amend, or it may even run for a fixed period without right of amendment. It is best, therefore, that the original rules of the city be as comprehensive as will by any chance be necessary during the life of the ordinance.

In the following section on "Candlepower requirements" the nominal lighting value which should be required and the conditions under which penalty need be imposed for deficiency in the candlepower are discussed.

B. HEATING VALUE REGULATIONS

1. NET AND TOTAL HEATING VALUE STANDARDS

For a clear understanding of the relative merits of the net and total heating values of gas as standards of specifications, it is necessary to define these terms accurately.[1] The terms "gross heating value" and "total heating value" should be understood as equivalent; however, it is well to

[1] A full discussion of the subject of gross, net, and total heating value standards can be found in the Proceedings of the American Gas Institute, 7, p. 223ff, or in Technologic Paper No. 14 of this Bureau.

distinguish between them and the uncorrected observed value which is often called the gross value.

These three heating values of the gas can be defined as follows:

The *observed* heating value of a gas is the heat measured by an efficient calorimeter when a unit volume of gas is burned, the air supporting combustion entering the calorimeter at the temperature and humidity of the room and the products of combustion leaving saturated at about the same temperature.

The *total* heating value of a gas, often called the "gross" heating value, is the total heat liberated by the combustion at constant pressure of a unit volume of that gas with air of the same temperature when all of the water formed in the flame (and no more) is condensed and the products of combustion are cooled to the original temperature.

The *net* heating value of a gas is the heat produced by the combustion at constant pressure of a unit volume of that gas with air of the same temperature when none of the water formed in the flame is condensed to liquid, but when all of the products of combustion are cooled to the original temperature.

From the observed heating value as above defined we obtain either net or total, the one by a correction depending upon the water condensed in the calorimeter, the other by a correction depending upon atmospheric conditions.

In the rules adopted by the various State commissions which have made heating value regulations, the requirement is made that the "total heating value" be above a specified standard; however, in the 30 or more large cities having heating value limits in ordinances, we have found no city which specifies the "total" heating value. A majority of these cities do not state precisely what is intended; some specify "gross" value and one requires "net."

In laboratory methods and in technical discussions the observed value as measured has generally been used; and in endeavoring to get the highest value possible, the so-called "maximum efficiency," the calorimeters have been so operated that this measured value has usually come very near indeed to the total. Moreover, by the application of a small 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 measured value to the total. In routine testing under average conditions this correction may be ignored, but under unusual conditions or when accurate results are desired, it can easily be applied. The magnitude

of this correction will, of course, depend upon the quantity of air passing through the calorimeter, but if a calorimeter has been calibrated and is used in the manner prescribed, there will be so little variation in the quantity of air that the uncertainty in the correction will be negligible. At the worst, it will be much less uncertain than the uncorrected value.

Briefly restating the advantages of the total heating value as a basis of the specification, the following facts appear:

The total heat is the value specified in several State laws and is the value probably intended in all other laws which say "gross" value, or which do not specify which standard is meant. It is apparently the value which has been sought for in defining conditions of testing and where "gross" is used in practice it is usually taken to be synonymous with total. The total heat depends only upon the character of the gas, and can be obtained from the measured value by the use of a simple correction. For ordinary work the observed heat value of coal gas, water gas, or mixed gas is within 2 per cent of the total value; and unless greater accuracy than this is desired, no correction to the results of the regular test is necessary. When the small discrepancies of observed values are of importance they can be eliminated without difficulty by correction to the total, using a tabular correction as given in the circular on testing methods.

Being a fair measure of the usefulness of the gas to a customer in comparison with other fuels which are all rated on their total heating value, and particularly being the customary standard, the total heating value of the gas has been selected by the Bureau as the most suitable for use in technical specifications. In order to avoid confusion with the "observed value," which is often called "gross" heating value, it is recommended that the term "total heating value" be used, and that the use of the term "gross heating value" be discontinued.

2. METHODS OF TESTING

The instruments most generally used for the determination of the heating value of gases are of the flow calorimeter type, of which the Junker's 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 agreement with one another to 2 per cent or better, and with certain easily taken precautions in their use to within 1 per cent. 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 advantages of the various forms of apparatus and directions for their operation are given in the circular on testing methods. No ordinance provision need be made on these points.

3. HEATING VALUE REQUIRED

Basis of Rating.—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 the so-called "standard conditions," namely, 60° F and 30 inches of mercury pressure. In a city where the gas as metered to the customers is at a pressure equal to 30 inches of mercury and a temperature of 60° F, the customers get the number of heat units per cubic foot which the gas is said to have by this method of rating. On the other hand, if the gas is metered at lower pressure, or at higher temperature, the number of heat units available for use by the customer per cubic foot paid for, is less than the rated number. To take account of this condition it has been proposed that the gas should be rated according to the heat units it actually has at the average customer's meter, and not the number which it would have under some conditions, called the "standard conditions."

The effect of the variation of temperature from 60° F, at time of measurement for testing, upon the density of the gas may be considerable (being about 1 per cent for a change of 5° F), but it is in practice metered to the customers at about 60°. Many meters may be in places warmer and others in cooler locations; in certain parts of the country the meters may be generally at higher or lower temperatures, and during different seasons of the year the meter temperatures will vary; 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. Furthermore, it is not practicable to determine the average meter temperature in any city, since the variations of season, location, etc., are so great. The continuance of the custom of rating the gas as if always measured to customers at 60° is, therefore, recommended by the Bureau.

With respect to the influence of barometric pressure on the density of the gas, a different condition exists. Not only is the barometric pressure nearly uniform through all of any one city, but the pressure is or can usually be accurately known for any time or for the average over any period. Therefore, two possible methods of rating can be specified.

(1) The gas may be measured for the heating-value test under existing conditions and the volume reduced to the pressure which is usually taken as standard, 30 inches of mercury, for purpose of rating it.

(2) The gas may be thus measured and its volume then reduced to the annual average pressure of the gas in customers' meters in the city in which the test is made for purpose of rating it.[2]

To understand the comparative value of these methods of rating as the basis of legal specifications, it is necessary to consider the significance of the two values. When a gas is rated by the first method, the heating value which it would have if under a pressure of 30 inches is given; but the actual amount of heat which the customer can get from a cubic foot of the gas as metered to him is not given unless the city be near sea level. In other words, the customer has no direct measure of the usefulness of the gas delivered to him unless allowance be made for the difference in gas density due to difference in barometric pressure. On the other hand, when gas is rated by the second method, the heating value which the gas would have under average conditions of the particular city in question is at once apparent; customers in two cities, even if at different altitudes, when supplied with gas of the same rated heat value (on the second basis) can get the same quantity of heat per 1000 cubic feet purchased, and the price per 1000 cubic feet is a direct measure of the relative cost per unit of heating service. Looking at it from the viewpoint of the gas maker, if we have gas of 600 Btu, with yields of 5 cubic feet (uncorrected) per pound of coal in one city and yields of 5.2 feet per pound in another, this does not signify that the manufacturer in the second city gets more out of a pound of coal than the one in the first, since in the one case the 5 feet may be measured at 30 inches and in the other the 5.2 feet may be measured at 28 inches. As a matter of fact, the rating of the gas by method (1) alone does not permit a full and direct comparison between cities unless the station meter readings and the customers' meter readings of the two cities are corrected to the same basis as to pressure. If the gas made is rated as of the same quality on the second basis in several places, the yields per pound of coal or per gallon of oil, in cubic feet corrected to local average pressure and 60° F, are an exact measure of the efficiency of gasification. The comparison between operation or service conditions in such different cities where heating value actually delivered is the same is thus most simple on the second basis.

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

The first of these two methods of gas rating has been generally followed in the gas industry, in the same way that in scientific work it has been customary to express the properties of gases in terms of the gas measured under particular conditions. In all scientific work, 760 mm (29.92 inches) and zero degrees centigrade (32° F) are taken as standard conditions for gas measurement, but for technical work 30 inches and 60° F are used. In this way any property is expressed on a common basis which is very convenient for comparison of scientific data; but in the case of commercial illuminating gas rating this is not necessary, as the primary object is to obtain a measure of the usefulness of the gas to the customer. To be sure, this is accomplished indirectly by the common system of rating, but in many cases where the facts are not understood, an uncertainty or misunderstanding of the significance of tests may result.

It should be clearly understood that if the price of gas is properly adjusted on the basis of actual costs either method of rating is perfectly fair to the public. The most severe critic of the customary system would not claim that it is unjust; it may, however, be misleading. In other words, comparisons of price in two or more cities must take account of the barometric pressure of the several places as well as the operating costs and rated gas quality. The argument against the customary method can be otherwise worded by saying that a cubic foot of gas for selling purposes is not the same as the cubic foot for purposes of testing, except in cities nearly at sea level. This is not unfair if the facts be recognized, but it is an awkward condition and often misleading.

In a city at high altitude the customer does not get the number of heat units per cubic foot of gas paid for which is shown by the rated value if the rating be on the basis of measurement at 30-inch pressures. This may give rise to the charge that the company is not delivering full measure. To explain this it is necessary to make clear the property of the gas which causes the expansion at higher altitudes. On the other hand, if gas be rated according to its actual heat value per cubic foot delivered, it may be undesirable to have the value specified as high at high altitude as at low; the customer then is apt to believe the gas to be less satisfactory than a gas of the same composition delivered and rated under higher pressure. In so far as the total quantity of heat available is concerned, this is true; but if the price be fixed on actual costs, as should be done, this gas though of lower value at the high altitude than at the low may nevertheless be of the most desirable character for delivery at the given place. By the state-

ment that with this lower value more heat can be delivered for a dollar than with a richer gas, the advantage of this plan can easily be made clear to the public; and no objection to lower heating values at higher altitude should result.

It is evident that both systems of rating have certain merits for city regulations and it seems possible to combine all of these merits by the proposed arrangement of the ordinance which expresses both values. Thus the regulation itself will make clear the real quality delivered to the customer and also show the quality of the gas when under standard conditions (30 inches of pressure). It is evident that one of the two values should be made of primary significance for testing purposes; and since the heating value actually delivered is of primary importance, it seems best that this be made the principal value. This is done in the proposed ordinance form. The way in which the numerical values which are proper for use in the ordinance can be fixed is discussed in the second section after this.

If it were found desirable for any city to make as the principal basis of rating the rating on the cubic foot measured at 30 inches of mercury pressure, this can be done by a few changes in sections 6, 7, and 8 of the ordinance, using the alternate forms given in the footnotes numbered 13, 15, and 16. In such case the actual heating value and candlepower are also made clear so that no misunderstanding need result. If such alternates are used all of them should be incorporated to give a consistent system of rating.

In the adoption of State rules for gas service about the same conditions prevail as to the basis for heating value rating; but it is not practicable to arrange the simpler State rules in exactly the same way that city ordinances are drawn. However, a clear statement in the rules of the significance of the heating value specified is desirable. The two alternates for the heating value rule are given in the State rule sections; the one or the other of these may be used in any State according to the preferences of the commission. For States where great differences in altitude make necessary modifications in the actual heating value required, the changes can be made as indicated in the section on this subject (p. 114).

By the double system of rating the quality of the gas the following advantages are attained:

(1) The actual heat delivered to the customer per cubic foot paid for is made prominent and clear.

(2) The relation of the actual heating value to the value of the gas measured under standard conditions is defined.

(3) The cubic foot of gas for purpose of testing and for purpose of sale are made the same; or if alternate forms are used, the relation between the two units of measure is clearly recognized.

Having carefully taken account of all of the factors affecting this matter, the Bureau recommends that the rating of the quality of the gas be so made that both its average actual heating value and the heating value reduced to 30 inches of mercury pressure be stated, the first being given greater prominence. In the many places where no heating value rules are in force, this system can be used when rules are adopted; where regulations are now in force a change to this basis of rating should be carefully considered at the next favorable opportunity.

Monthly Averages and Minimum Values.—It is a well-recognized fact that even with the best of management a gas works can not furnish an exactly uniform product. The allowance of "monthly average" values, to determine the question of satisfactory quality of gas, relieves the company of penalty in many cases where they could not fairly be held responsible for unforeseen conditions, causing a temporary drop below the average required. Not only does it allow reasonable time for the company to overcome these irregularities of operation which might affect one or several days' tests, but also it removes the chance of the experimental error of a single determination working an injustice to the company.

Monthly averages with a suitable minimum limit as the basis of specification have been used with success for several years in Wisconsin and have been adopted by some other States, and the Bureau recommends their adoption generally for candlepower and heating values.

The advantage of averages as a basis for specification is obvious to all who know of the difficulties in making an exactly uniform product, but the disadvantage to the user of gas should be recognized. The gas which from day to day or from hour to hour has the least variation in candlepower, heating value, density, and, most important of all, pressure, is the gas which gives to the customer the most satisfactory service. Large variations in quality, density, and pressure are certain to render unsatisfactory a gas which on an average may be very good in quality or pressure; but when suitable minimum allowable values are specified, such irregularities are controlled.

A tolerance of 50 Btu below the average on a single day is customary. This allowance is probably too great for the best service, as such irregularities as may thereby result do not permit the most satisfactory utilization of the gas. It is expected that after a few years of experience in making

gas on a heat unit basis, any gas maker will be able to secure greater uniformity, but for a time when a heating standard is first in force it seems best to permit an ample tolerance. Whether a closer legal restriction will be found necessary is uncertain; for without legal restriction, the gas maker will naturally endeavor to maintain the most uniform gas possible, since this contributes not only to better service but also to greater economy in manufacturing.

Relation of Price and Quality of Gas.—In order to make clear a few of the important considerations in the relation of gas price and gas quality, the following paragraghs are included. The Bureau does not, however, make any recommendations here or elsewhere as to the proper price for gas, since obviously a recommendation on that subject must be based upon an investigation of the actual conditions in the place in question.

Ever since the invention of the first processes for the manufacture of artificial gas, the tendency has been to reduce the price of this product. This has been possible because of increases in manufacturing efficiency, and increase in sales per consumer and per mile of main, all of which operated to reduce costs. During the period immediately after the invention of the water gas process, gas of high candlepower was commonly made; and the heating value during that time was much above that now supplied in the majority of places. In the gradual reduction of quality from 25 candlepower or higher, commonly supplied 20 years ago, to the present figures, economy has resulted, both from a saving of materials and a decrease in the distribution losses. This, too, has assisted the gas maker in reducing the prices charged. As the processes of making and distributing gas have been improved, the risk of the business has been made smaller; this with the close control of public utility company finances by public officials in some States and cities has tended to make the percentage earnings less than in the earlier periods.

During the last few years it has become apparent that improvements in processes could not continue to be made with sufficient rapidity to compensate for increasing costs of fuel, labor, etc.; and in a few cases increases in the price of gas have been found necessary to permit fair returns to the companies. However, in a number of cities a considerable reduction in the quality of the gas supplied has been made in order to meet the higher costs. *It must of course be recognized by the public that gas like any other commodity may increase or decrease in price according to commercial conditions.* The public can not demand regardless of economic or manufacturing conditions that the price for gas service shall never be raised. The method

of regulating the service and price of gas by public service commissions carries with it the necessity for increasing the price when it is too low, just as much as it requires that a decrease in price be made when it is too high.

In many cases the sale of gas in large quantities to manufacturers will make possible reduced rates to this class who may be termed "wholesale" customers. This sale at lower rate for gas in quantity is desirable, for the total sales are thereby increased and greater efficiency of manufacture results. In practically all cities a large proportion of the customers use less than 1000 cubic feet of gas per month, and in many cases the gas company is actually a loser by having these customers on their books, for the small return does not cover the cost of maintaining the service and meter, office expenses, and other charges properly divided "per customer." It is evident, therefore, that in many places the wholesale customer even at the lower rates for gas is more profitable; and indirectly the small customer is benefited by the large. It is claimed that in some cases a low rate to large customers makes it possible, because of increasing business, to give gas at a lower rate, than otherwise possible, to the small customer. This does not go on without limit, but it is an important point to consider. Of course, it is presumed that the same charge will be made to all customers who use a given quantity of gas, in other words, that there be no discrimination between customers of the same class.

In any city with given facilities for fuel supply, labor supply, outlet for by-products, and other factors fixed, there is some certain kind and quality of gas which will permit manufacture and sale of the maximum amount of heat for a dollar. It is often difficult to determine just what is best, but usually a close approximation can be made by an experienced engineer. Knowing this kind and quality, it should be the one selected for that city, because *the desirable quality of gas to be supplied is independent of the price previously charged for gas.* That is, *the price to be charged for gas should be fixed entirely on the operating costs and investment necessary for this gas in the city in question.* Obviously in some cities the price for gas may properly be more than in other cities, even though the quality be the same.

The changes made in price of gas from time to time of course affect the income of the company; but it has been noted that in many, or, perhaps, most cases the average sales, in dollars per meter, are nearly the same before and after a change in price. In other words, with a decrease in price new uses for gas become practicable, and the income of the company is increased very nearly, if not entirely, as much by this as it is decreased

by the lower price per 1000 cubic feet. In many cases this leads to the statement that with a lower price the gas bills are no lower. Where this is true it must be remembered that more service is being had per dollar at the lower than at the higher price, and the customer is proportionally benefited.

Heating Value Required.—In the past, heating values have usually been rated on the basis of reduction to 30-inch pressures. It is preferable, therefore, for purpose of the discussion of the first part of this section, to utilize these "sea-level" values, and when not otherwise indicated such values will be meant. As a matter of fact, the great majority of gas companies deliver gas at a pressure so near to 30 inches that the actual and "sea-level" values are not so different as to appreciably affect the conclusions of this section.

The general tendency toward the selection of 600 Btu per cubic foot as the heating value to be required is apparent from the compilation of present requirements. (See p. 137.) This has been considered the heating value which gives the most heat per dollar of cost to the customer. There are some places in this country where gas of higher heating value is being delivered at less cost to the customer per unit of service than would be necessary for 600 Btu gas. These places exist, however, through unusually favorable local conditions or exceptionally able management. It is also true that in some cases local conditions render delivery of a 600 Btu gas impossible without considerable increase in expense per unit of service.

In any case the problem of selecting the proper heating value is a problem of determining the value which will allow fair returns to the company and deliver to the customer the most service for each dollar of cost to him.[3] As a first guide in this matter it is safe to assume that, in general, the gas which gives the most Btu to the customer for a dollar is the best, although this principle can, as will be shown later, be carried too far. To illustrate just how these factors may be taken into account, the following example is given for an assumed case.

A hypothetical city is taken as the basis of calculation, where gas of 600 Btu is sold at $1 per 1000 cubic feet, with proper returns to all, and it

[3] The Joint Calorimeter Committee of New York State in the report of its investigation as to a proper heating value standard, state the guiding principle of their work similarly, in the following words: "The object constantly in mind has been the selection of a standard for artificial gas which will enable the consumer to obtain the most value for the least money, and will enable the company to obtain its profit at the smallest expense to the consumer."

is presumed that the expenses, taxes, profits, etc., are apportioned as follows:

Manufacture	$0.30
Distribution	.10
General and office	.15
New business	.05
Taxes	.10
Interest, depreciation, and net profit	.30
Net price	1.00

Assuming that the cost of manufacture (net holder cost) will change by ¾ cent per 1000 cubic feet for each change of 10 Btu (this is an assumption which might apply in very few cases) and considering the effect on other factors of cost, the proper net price of gas of another quality can be calculated with some degree of exactness. It is first assumed for this purpose that the change in heating value will make no change in the total number of heat units which must be distributed; in other words, a decrease of 5 per cent in heating value per cubic foot would require a 5 per cent increase in the total volume sold, and vice versa. It is also assumed that this small change in the volume of sales will make an inappreciable difference in the investment necessary for the whole plant. We have then the following apportionment of costs, expressed in cents per 1000 cubic feet for gas of the qualities stated.

Total Heat Constant

	570 Btu	600 Btu	630 Btu
Manufacture [4]	27.75	30.0	32.25
Distribution [5]	9.75	10.0	10.25
General and office [6]	14.25	15.0	15.75
New business [6]	4.75	5.0	5.25
Taxes [6]	9.5	10.0	10.5
Interest, depreciation, and net profit (for same return on investment) [6]	28.5	30.0	31.5
Proper net price for gas	94.5	100.0	105.5
Btu delivered for $1	603 000	600 000	597 000

[4] Changes in manufacturing expense were assumed to be three quarters of a cent for each change of 10 Btu in gas quality.

[5] Distribution expense is dependent on the volume of gas and on the number of customers; the figures given assume the two factors to be of equal importance.

[6] These expense items are assumed to be the same in the aggregate regardless of quality, the change per 1000 being thus greater or less according as total sales are less or greater.

It is evident that slightly more heat would be delivered to the customer for a dollar with the lower heating-value gas under such conditions, and if the heat could be used with equal convenience and efficiency in the several cases, the poorest of the three gases would be by a very narrow margin the most economical (assuming always that the "proper net price" is charged).

Under the same conditions as were just assumed it might be that in most cases the appliances in use would use practically the same volume of gas, regardless of its heating value. In this case the sales would not be changed, and the charges in cents per 1000 cubic feet would be very much as in the normal case, as follows, for gas of the three qualities:

Total Volume of Gas Constant

	570 Btu	600 Btu	630 Btu
Manufacture	27.75	30.0	32.25
Distribution	10.0	10.0	10.0
General and office	15.0	15.0	15.0
New business	5.0	5.0	5.0
Taxes	10.0	10.0	10.0
Interest, depreciation, and net profit	30.0	30.0	30.0
Proper net price	97.75	100.0	102.25
Btu delivered for $1	583 000	600 000	617 000

In this case the higher heating value gas would be much more economical in the sense that the customer would get more heat for a dollar of expense. The assumptions made, however, presume that the gas used would be of the same volume as formerly, regardless of the heating value; and it is evident, therefore, that the bill of each customer would change by 3 per cent either up or down with the change of 5 per cent in heat. Thus, the customer would profit by a greater increase in service than in cost, but at the same time would on this basis pay slightly larger gas bills with the richer gas.

There is no doubt that in many cases the volume of gas used would change very little with changes in quality, but in most cases the total heat used would be constant regardless of quality. Therefore the average condition lies somewhere between the two general assumptions which have been made being nearer the first than the second of the two cases assumed; or, in other words, from the customer's standpoint the quality of gas delivered, the price being proportional, is not of great consequence, so long as the heating value is of about the average now supplied. The two

cases above cited show how data can be applied to a calculation; they are not, however, applicable as a general example of existing conditions.

When the price is correctly fixed, the number of heat units delivered for a dollar is probably not greatly different over the range of 575 to 625 Btu, except under one or more of the following conditions: First, in case that coal or by-product gas is made and it is impossible to make it of the higher heat value without enrichment. Second, in case that high pressure or long distance distribution is necessary. Third, in case a cold climate makes the higher heating value gas "unstable", that is, too rich for distribution without large condensation losses.

In any case the customer will be better served by a gas of uniform and moderately low heating value than by one of high heating value, if the cost per heat unit be the same. This is true for two reasons. The rich gas can not be delivered at different seasons of the year of as uniform quality as the poorer gas; and the poorer gas is more efficient for many appliances, in that the service rendered by each heat unit is slightly greater. This latter fact is true because of the smaller volume of air required for the burning of one volume of the poorer gas than for one volume of the rich gas; thus, when used in mantle burners and certain other appliances the service obtained is greater, in proportion to the heating value, with the poorer gas.

The relative merits of rich and poor gas above referred to apply to gas between the limits 550 and 650 Btu. It is generally unnecessary and undesirable to go outside of these limits for a commercial supply, except possibly for the few places where a run-of-oven by-product gas may be available. In this case, however, enrichment to 550 or 575 Btu is usually desired in order to maintain a moderate candlepower.

The fact that a stable gas is wanted is not questioned, but this does not prove that gases of 500 or 525 Btu are desirable, as is sometimes claimed. A gas of 575 to 600 Btu when made on a heating value basis is stable for all practical purposes even in the northern parts of this country unless high pressure (several pounds) is necessary for suburban service. The large distribution losses so often cited are on gases of high candlepower or enriched gases when candlepower has been the object of the manufacture. The candlepower losses in these cases may be as great as 30 per cent under conditions by no means extreme, but a 600 Btu gas "made for heat units" will lose very little in any low-pressure distribution system, probably not over 5 per cent in the extreme.

To give an idea of the quality of gas which can be economically made under different conditions in this country the following table is given. The limits indicated are only approximate, and it is, of course, impossible to say when one or the other limit may be reached or exceeded.

Reasonable Average Heating Value for Gas of Different Kinds

(Btu per standard cubic foot)

Kind of gas	Range	Normal
Carburetted water gas	600–640	600
Unenriched coal gas (retort)	575–625	585
Enriched coal gas	575–625	600
By-product gas (run-of-oven)	525–575	550
By-product gas (washed)	500–550	525
By-product gas (enriched)	575–600	585
Mixed gas (carburetted water gas and coal gas of any sort, where water gas is made throughout the year)	580–630	600
Oil gas (Lowe or Jones process from crude oil)	575–620	600

It appears to the Bureau that unless by product or unenriched coal gas is to be delivered a requirement of 600 Btu is reasonable and in general more economical than a lower value (except when on local cubic foot basis in a city of low barometric pressure); and although this generalization will not hold in every case, it appears reasonable that when a company desires to distribute gas of less than 600 Btu the burden of proof should rest upon such company to show that the local conditions are such as to permit better service with a lower heating value. If the number of heat units to be delivered for a dollar is greater with less than 600 Btu, then such lower value may be allowed; certain conditions where this may be the case have already been made clear.

In any city where the price of gas is already fixed by franchise, lease, or other agreement the question of gas quality is not subject to the same consideration as when the price can be adjusted on the basis of any new operating costs. Under such conditions the quality may or may not have been previously fixed by law or agreement; and where it has been prescribed it is often on a candlepower basis. Only the case where a new heating value regulation is proper need be considered here. In such case the quality of gas which has been previously supplied is of interest, and a determination of this value is desirable. To require or permit a change from such quality supposes one of four conditions to exist: (1) The old quality is too low to give good service; (2) the old quality is too high, giving an

irregular supply or being unreasonably expensive; (3) the old quality gives good service, but better service could be reasonably demanded without change of price (permitting the company still to make a reasonable profit); (4) the quality required or furnished is better than can be expected at the price charged, and being higher than necessary for good service should be lowered to permit the company to earn a reasonable profit.

There is no doubt that some plants are operating under each one of these four conditions, and it is a question how each such case can be best settled. The four cases will be taken up in turn.

(1) There are very few places where the gas quality is so poor as to make good service impossible, but often in small plants with careless or ignorant management great improvement could be made. In such cases if the profits are sufficient the quality can be raised without change in price; otherwise the service should first be made satisfactory and then the necessary increase in price to permit a fair profit should be made. However, in all cases good service should be assured before a change of price is made either up or down. (This, it is understood, has been the practice in Wisconsin and perhaps elsewhere.) Lack of a reasonably good management should not be allowed to work to the harm of the public, either in poor service or in excessive price.

(2) In a number of cities gas of so high candlepower is sold (the average heating value being 650–675 Btu per cubic foot) that the supply is more irregular and the cost per unit of service is higher than would be the case if the candlepower and heating value were reduced. In such cases a reduction in the quality without a reduction in the price may or may not be desirable, according to the magnitude of the inconvenience which results from the seasonal irregularity in supply. If the lowering of quality would really give the customer better service for a dollar, then such change should be made; but in only rare instances would such improvement be sufficient to counterbalance the loss in total heat available to the customer. Obviously, the most desirable thing to accomplish would be the readjustment of both the quality and the price.

(3) In the case that the service is admitted to be good, but the price is clearly higher than necessary for a good profit to the company, the requirement of a higher quality of gas would be proper if the company refused to reduce the price to what was unquestionably a fair figure. The best quality which could fairly be required for the fixed price should be specified in the regulation.

(4) In some cases it seems that the quality of gas delivered is above that which can reasonably be expected at the price allowed. Obviously, then, the company should be allowed to raise the price if the quality is already as low as is consistent with good service, or the requirement as to quality of gas may be made less severe and the price remain the same. Where changes of operating costs due to increase in price of material or labor make a price formerly fair become too low, similar changes should be made. In this case the company is practically guaranteed a fair return on its investment, and full regulation of its operation is retained by the public. This basis, which is equitable for all, has only recently come to be recognized; it is also recognized that an investment thus more or less guaranteed by the public should be allowed to earn a smaller percentage profit than where the risks of the business are greater.

In any case where a company urges a lower heating value as the best value from an economic standpoint it should be made clear whether the return to the company is presumed now to be too low and is to be raised by the changes, or whether it is proposed to modify the price so that the customer will get more for each dollar of cost. If the price is really too low, it or the quality required should be adjusted, but reductions in gas quality with no change in price are otherwise not warranted. Whenever a reduction in heating value accompanied by a greater proportionate reduction in price can be made such change would be desirable, at least down to 550 Btu gas. In this connection, however, it should be recognized that such great changes in quality as would change the necessary form of appliances might not be desirable.

In some cases regulations are made to cover long periods, as during a contract between city and company; and no amendment of the regulation during the life of the franchise or contract is provided for. It is then very difficult to arrange the regulations for the whole period so that they will be fair to both parties, since changes in fuel supply or methods of manufacture may be necessary, which would make some different quality of gas more desirable for all. To care for such cases an alternate form for the heating value section of the ordinance is proposed.

As has been pointed out, the public would seldom lose much and might gain a great deal, if the heating value and the price were reduced proportionately. It is almost certain that the manufacturer will be the first to see where such a change will result in economy; and it may be desirable in the case of many city ordinances to put in a provision similar

to the following, rather than to go to the expense of a new investigation when such a change is contemplated:

Alternate for Section 7 of Proposed Ordinance: SEC. 7. *Heating Value.*—The gas supplied by the company when tested as herein provided shall show a monthly average total heating value of not less than ——A—— British thermal units per cubic foot: *Provided, however,* That in case the company chooses to supply gas of lower heating value at a proportionate reduction in price, it shall be permitted to make such reduction in the following manner: Ten or more days before the beginning of any calendar month in which such change is to be made the company shall deliver to the inspector and shall cause to be published in one or more of the city papers a statement of the average heating value, called the normal heating value, which the company proposes to maintain during each succeeding month until further announcement is made as here provided, and a statement of the corresponding price for gas, which price shall have the same (or a smaller) ratio to the price charged for gas of ——A—— British thermal units as the proposed normal heating value shall have to ——A—— British thermal units. The normal heating value thus fixed shall be the monthly average total heating value required to be maintained by the company; and no daily average total heating value of the gas shall be more than fifty British thermal units lower than the required normal heating value. The normal heating value shall in no case be fixed lower than ——B——[7] British thermal units.

Effect of Altitude on Heating Value Required.—As the pressure on a gas is reduced its volume increases proportionately, so that the gas which fills nine-tenths of a cubic foot of space at 30 inches barometric pressure will occupy 1 cubic foot at 27 inches. It is evident, therefore, that a gas of the composition to be of 600 Btu at sea level has a lower heating value per cubic foot when delivered at higher altitudes, this change amounting to about 20 Btu for each 1000 feet of altitude.

When the heating value of the gas as delivered is the basis of rating, it is not practicable to require the same value at all altitudes even if other factors are equal. Where there is thus a considerable difference due to barometric pressure the value required may be modified; for example, it would be well to change the numerical value by 25 Btu for each 1200 feet above sea level. For small changes in altitude, no change is necessary.

Heating Value Standards for State Rules.—In a State where considerable differences of altitude exist between the various gas plants, the numerical

[7] The value B should be 50 to 100 lower than the principal requirement chosen, marked "A," above.

value need not be the same for all; the plants at higher altitude could be required to deliver gas which under similar conditions of measurement would have the same heating value, but at the higher altitudes the heat actually delivered would be less per cubic foot metered to the customer. In any such case the State commission should have the authority to modify the general value required for difference of altitude in the same way that it would amend the rules for special kinds of gas, as for instance, allowing lower heating values where a cheap by-product gas were available. Indeed, the effect of altitude upon the numerical value to be specified should be regarded as only one of the several factors which must be taken into account in establishing the standard for a State or for various parts of a State, and in some cases differences of altitude and differences in kind of gas made would counterbalance each other, while under other circumstances they may operate to change the desirable value in the same direction.

The form of rules proposed for State regulation of heating values assumes that a single numerical value will be fixed for the whole State. This may be proper in many of the States, but in those where more than one value is necessary or where special rulings are made for one or several companies, the modifications can easily be made.

Summary of Recommendation.[8]—Gas of 600 Btu per cubic foot or higher is being furnished in the majority of places in this country, and in some places the heating value has been as high as 650 or 675, on the average. Unless the present price in any given case is shown to be too low, the reduction in the heating value below what is now furnished, would not be fair to the public, unless the price be reduced. It is doubtful, however, whether

[8] The Joint Calorimeter Committee of New York State make the following recommendation: "Taking all these conflicting factors into consideration, it is the judgment of the committee that a total heat value not exceeding 570 Btu monthly average measured at the point where the gas leaves the manufacturing plant, corrected to a temperature of 60° F, and to a pressure of 30 inches of mercury, as measured by the rules of the committee accompanying this report, is the standard which will best serve the interest of the people of New York State."

However, the data presented by the committee shows that each of the companies under investigation delivered on the average gas of more than 600 Btu in heating value. In every case where the monthly average heating value was, at any time, below 600 this lower value occurred during one of the summer months (May to October). This shows that it was not a matter of necessity that the heating value was low but it was due to the fact that operation on the candlepower basis permitted gas of less than 600 Btu to be supplied, while the candlepower was still maintained up to standard.

It appears certain that if operation had been on the heating value basis throughout the period in question none of the monthly averages need have differed from the general average as greatly as they do in the case of those companies reporting below 600 during some of the summer months. In other words, in operating on the heating value basis with the desire to supply a uniform quality of gas, which is, of course, the most economical and desirable procedure, no monthly average need differ greatly from the general average unless conditions be very unusual. It appears that all of the companies in question could supply gas up to 600 Btu, monthly average, at all times of the year without increase in expense above the present cost of manufacture, and in many cases such quality could be delivered at a saving over the cost now necessary in meeting a candlepower specification.

Especially where carburetted water gas or mixed gas is distributed, it is doubtful whether less than 600 Btu can be supplied as economically in heat units delivered for the dollar as a gas of 600 Btu or higher. Exceptions in case of coal gas or by-product gas are made clear in the text of this circular.

gas companies could generally afford to make a proportionate reduction in the price of gas if they were allowed to reduce the heating value. In other words, the saving in making and distributing gas of, say, 10 per cent less heating value, would not generally be as much as 10 per cent of the selling price.

Since, except in special cases, it appears that gas of 600 Btu is more economical than a cheaper grade of gas, a reduction in the value should be made only when there are special reasons that justify it, such as the availability of a low-heating value gas at a particularly low cost. In cases where unenriched coal gas or by-product gas are to be sold, the best heating value may be as low as 570 or 550 Btu, and the regulations should take account of any such conditions. However, it is questionable whether a general regulation allowing gas of such quality is best, for a majority of companies will probably make more or less water gas for some time to come, and under these circumstances the low value is not necessary. If a water-gas plant were operating under a requirement of 570 Btu, and chose to supply gas of only slightly above this quality, this would mean a loss of 5 to 10 per cent for the customers as compared with 600 to 650 Btu. To compensate for this, the price could be lowered by 5 to 10 per cent; but in some, or perhaps most, cases this would not be desired by the gas company. Therefore it may often be desirable to set a different limit for unenriched coal gas and by-product gas than for mixed gas or water gas. This would make it possible in each case to supply the gas which would allow delivery of the most heat for a dollar.

When different values are thus fixed for different kinds of gas, there is some danger that by fixing the value so as to be best suited to the one kind of gas another process of manufacture could not be subsequently used, even though the second process would permit delivery of more heat for a dollar than the first, because the quality would be other than that specified for the gas made by the first process. The quality of gas best suited to the immediate needs in any locality should be selected and the proper price fixed for this quality. If, however, the alternate form of regulation given on page 32 is used, the company can choose not only the process of manufacture, but also the quality of gas, and it can thus deliver the gas, which really will, under any given local conditions give the most heat in the gas for a dollar of cost.

C. CANDLEPOWER REQUIREMENTS

1. THE SIGNIFICANCE OF GAS CANDLEPOWER

It is customary to refer to gas as having certain candlepower, without any statement as to the conditions under which it must be burned to get this value. However, gas has no intrinsic lighting value except as it is burned under definite conditions. These conditions include the burner, the gas pressure, and the state of the atmosphere. In this respect the candlepower of the gas differs from heating value, since the heat given out in burning a gas is the same regardless of the character of the burner or room conditions, assuming only complete combustion. That is to say, the whole heat of combustion is actually given out even though a test may not detect all of it; but the quantity of light yielded in a flame depends largely on other contions than the quality of the gas. It is thus apparent that in order to specify the quality of gas by its candlepower it is necessary to define the conditions of testing. How important some of these conditions are, will appear in the following sections. Since some of these conditions must be clearly defined at the time of enactment of the gas regulations, it is preferable to discuss in this circular those conditions which must be specified in the law or rule; however, the details of the operation of the testing apparatus thus specified will be given in the circular on gas-testing methods.

General Plan of Testing.—The taking of gas candlepower consists in the comparison of the light given by the gas when burning from the test burner with the light of a standard flame, the value of which has been determined by the Bureau of Standards or other testing laboratory. Thus, if a standard light is rated as 10 candlepower and the gas when tested is found to give one and one-half times as much light, the gas is said to be of 15 candlepower. This means that the gas when burning at the given rate from the particular burner used, has, in the direction from which the light was observed for the test, an intensity 15 times as great as an International candle. (This unit is defined in the next section).

The quantity of light given out is proportional to the intensity of the light, and therefore the candlepower of the gas, if correctly defined and determined, is a measure of the total quantity of light which can be obtained on burning the gas, this total quantity of light including that given out in all directions from the flame.

The Unit of Candlepower.—Careful distinction should be made in this connection between a unit and a standard. An international unit maintained by the cooperative effort of several national standardizing institutions

and checked from time to time by means of all the best primary standards in use is more likely to be maintained constant than if it were defined to be represented by any single primary standard, unless such a primary standard were reproducible to a very high degree of precision. Such a unit can be continued permanent, even though all present primary standards are ultimately superseded by better ones. Uniformity among different countries and continuity of value are prime necessities with respect to the unit; but the particular standard by which the unit is realized in practice is largely a matter of convenience and circumstance. In the photometry of electric lamps electric standards are most suitable. In gas photometry one form of flame standard or another, according to circumstances, is generally employed.

After extended comparison of their standards the National Physical Laboratory, London, the Laboratoire Central d'Electricité, Paris, and the Bureau of Standards, Washington, agreed to adopt on April, 1909, a common unit and to cooperate in maintaining the common value constant. The unit adopted was called the "international candle."

The accepted relation between the various units in use is:

1 International candle = 1 Pentane (or English) candle.
1 International candle = 1 Bougie décimale.
1 International candle = 1 American candle.
1 International candle = 1.11 Hefner unit.
1 International candle = 0.104 Carcel unit.
Therefore 1 Hefner unit = 0.90 International candle.

The pentane and other photometric standards in use in America are now standardized by the Bureau of Standards in terms of this unit. This, within the limits of experimental error, brings the photometric units for both gas and electrical industries in America and Great Britain and for the electrical industry in France to a single value, and the Hefner unit is in the simple ratio of nine-tenths to the International candle.

The proposal to call the common unit of light to be maintained jointly by the national standardizing laboratories of America, France, and Great Britain the "International candle" has been submitted to the International Electrotechnical Commission, and it is hoped to secure the indorsement of the proposal by all countries of the world which are represented on that commission.

The above-described agreement between the national laboratories of France, England, and the United States marked an important step forward in the history of photometric measurements. For many years the British

parliamentary candle was the unit recognized in this country, but the lack of precision in practical photometry did not permit its value to be very accurately expressed or reproduced. In recent years the gas industry has employed the 1-candlepower sperm candle, the 10-candlepower Harcourt pentane lamp, the Hefner lamp, and various secondary standards, while the electrical industry has employed incandescent electric lamps either certified by the Bureau of Standards or rated in terms of standards that are consistent with those of the Bureau. *The use of the new unit, although requiring no change in the value of the flame standards, is of great importance, since it lends greater definiteness to their values.* The value specified in the proposed ordinance is therefore given in terms of the International candle. (See Circular 15 of this Bureau for further details on this subject.)

Effect of Atmospheric Conditions.—When a gas flame burns in air of greater humidity than average or on a day when the barometric pressure is below normal, the light given is less than would be given by the same quantity of the gas (of the same quality) burned in the same burner on a day of average humidity and average barometer, and vice versa. It is obvious, therefore, that the comparison of the light from a gas flame with the light from some source which is not affected by the weather, such as an incandescent electric light, will give the gas credit for more or less lighting value according to atmospheric conditions at the time of testing the gas. To avoid this irregularity in rating the gas and to make the value obtained practically independent of the weather, the gas flame is usually compared with another flame, such as that of the pentane lamp, Hefner lamp, or candle. These flames give more or less light under different conditions of burning, and the ratio of their intensity to the intensity of the gas flame is assumed to be practically the same under different weather conditions. Therefore, if we call a pentane lamp a "10-candlepower standard" at all times, because it will give 10 candles under certain conditions taken as average, then a gas flame which is twice as intense will always be called a 20-candlepower flame when compared with it, even though at the particular time of test the gas light may be only 18 or as much as 22 candles.

This procedure is perfectly fair to the company and to consumer, since it rates the gas according to the quality—that is, its candlepower—under average conditions. When conditions are unfavorable, the consumer gets less light than the average; when more favorable, more light than the normal amount. On the average through the year the customer gets as much light as would be obtained from the gas if always burned under average conditions.

For the same reason that the light of a gas flame varies with room conditions the light of the standard lamp also changes (unless an electric standard be used), and it is probable that the humidity and the barometric pressure affect these standard lights to about the same extent as they affect the gas flame. Thus pentane lamps have always been rated in candlepower at a normal humidity of 8 liters of water vapor per cubic meter of air and 760 millimeters of mercury barometric pressure, which is approximately a mean condition for this country (at sea level) and which is taken to be the standard condition of humidity and barometric pressure.

If, therefore, the lamp operates on the average under these atmospheric conditions, the average actual candlepower of the lamp will be equal to the rated candlepower. In many cities, however, the average conditions through the year differ materially from the conditions for which the standard lamps are rated, and a lamp which would be rated by the customary methods, as of 10 candlepower, might have on the average through the year in these cities an actual candlepower of 9 to 9.9. Using the value 10 candlepower in all, the gas is then rated from 1 to 10 per cent higher than its actual value from this cause, and if the further correction for the effect of barometric pressure on gas density is made, the rated candlepower of the gas may be as much as 40 per cent greater than the actual candlepower in some cities at high altitude. This overrating has been made on the supposition that the value obtained for any gas should be the same regardless of conditions at time of test or of use, and it was thought that by the customary corrections the rated candlepower would be equal to the actual value which the gas would have if burned under the conditions taken as standard, viz, 760 millimeters (30 inches) barometric pressure and 0.8 per cent by volume of water vapor in the air (8 liters per cubic meter).

Two Bases of Gas Rating.—The candlepower of a gas may be considered either as (1) the amount of light which the gas would give if burned under some condition taken as standard for the whole country, or (2) the amount given under the average conditions of use by the consumer. On the first basis a gas of definite composition would always be rated as of the same candlepower regardless of the actual average conditions, either at the time of test or at the point of consumption (this is a theoretical method not realized in practice); on the other basis the same gas might be differently rated if delivered at different cities, but in each individual test the rating would indicate the actual lighting value of the gas to the average customer. There is some difference of opinion as to which of these various values is best to be used.

The current method of testing gas for candlepower is neither of the above methods, but is such that the candlepower reported for gas at high altitudes is not only greater than its actual value, but also greater than the sea level value for gas of the same composition. To illustrate quantitively how this operates, consider the following example: If we assume that the luminous efficiency of the gas flame does not change with pressure, then we would have the following results from tests made in different ways. Given a gas of 15 actual candlepower when burned at 30 inches pressure and normal humidity, the rated candlepower would be 15 at sea level. The same gas burned under 25 inches pressure at the rate of 5 cubic feet per hour will have an actual candlepower of 12.5 and a rated candlepower (by current methods of calculation) of 17.3. On the other hand, if we assume that the luminous efficiency of the gas flame is only 90 per cent as great under 25 inches barometric pressure as at 30 inches (the value 90 per cent is purely an assumption), then we would have the following results on the above gas: The real and rated candlepower by test at 30 inches would be 15, and the real candlepower at 25 inches (5 cubic feet per hour) 11.25; but the rated candlepower from this latter test (by customary calculation) 15.5.

Probably neither of the above assumptions as to the luminous efficiency of a gas flame with varying barometric pressure is exactly correct, but the conclusion is trustworthy nevertheless that the present method of computing candlepower from the observed data is unsatisfactory in that it does not show directly by the result of a test the amount of light given by the test burner, either under the conditions of the test or at sea level. Nor does it show the luminous power of the gas under any particular conditions. Furthermore, the principal object of the candlepower test, namely, determination of the usefulness of the gas to the customer for lighting in open flames is by the current method of testing made secondary to the convenience of the tester or the desire of the gas maker to retain a higher numerical value. The actual candlepower of the gas delivered should, if possible, be the basis of rating on the same basis that the actual heat delivered should be the basis of the heating value to be specified.

Humidity Corrections.—As has been shown, the variation in humidity from day to day has only a slight effect upon the candlepower credited to a gas when the gas is tested by comparison with a flame standard. Furthermore, even if the average humidity is higher or lower in any city than normal for the whole country, the gas, when tested against a flame standard whose value is fixed for the normal humidity conditions, is in such city given

the same value regardless of the average or existing local humidity conditions. It is evident, therefore, that the gas company neither gains nor loses by having the standard rated as under normal conditions of humidity. The customer gets a gas of the same real quality as the rated quality would imply; and if because the local humidity averages more or less than normal for the whole country, and therefore the gas burns with somewhat less or greater efficiency in lighting appliances, the company should not be, and by the current system is not, penalized or credited in the gas rating, since the atmospheric conditions are wholly responsible for this effect.

Barometric Pressure Corrections.—The effect of barometric pressure on the basis of gas rating has been discussed in connection with heating value requirements (pp. 18, 32), and the same conclusions apply here except that in this case the effect of pressure on the value of the standard lamp also enters. In general, if the basis of rating be clearly and simply defined and an appropriate value fixed, we can see no reason why the use of the actual candlepower instead of a larger nominal value will be any embarrassment to the gasmaker. When the altitude is considerably above sea level, a different value would, of course, need to be specified.

One common application of the candlepower rating is the use of it as a basis by which comparisons can be made between one city or gas works and another, to compare either manufacturing costs and efficiencies or the quality of service rendered. It is in the application of the candlepower values to these comparisons that a great misconception of the facts has developed. In the first place, it has been wrongly assumed that the present method of correcting candlepower measurements gives to a gas a definite candlepower value regardless of the conditions at the time of test. As far as the effect of humidity is concerned, this assumption is nearly, if not exactly, correct; but in the case of variation of pressure, it is not true. As a matter of fact, a gas is, by the present system of rating, given a higher nominal value whenever tested under a pressure less than 30 inches than if tested at 30 inches; and this difference is so great that greater apparent manufacturing efficiencies have been noted at high than at low altitude. (This is true even when correction is made for pressure in the cubic feet of make). The present system thus gives inadequate data for comparison of manufacturing results, even when all values are corrected to the so-called "standard conditions."

When the average rated candlepower of a gas supply is stated, it is necessary to know the barometric pressure of the place before the quality of the service rendered in this particular can be known; and two places receiving gas of the same rated quality are not necessarily getting equally good service.

Moreover, this may lead to a great difference in the net profits of two companies working under conditions apparently identical in every way except for the barometric pressure under which they test and sell their product; and this discrepancy is caused wholly by the peculiar system of rating the gas candlepower.

Not only has this irregularity in costs passed without due consideration in enacting legislation where comparisons of price and quality of service have been the basis of action, but also many comparisons made by engineers have neglected this factor. It has unconsciously been taken into account where operating costs have been the basis of rate-making legislation, but in this case the differences in the real quality of service may have been overlooked.

On the basis of the facts above presented it seems fair to state that the present system of gas rating gives results which are not suitable either for judging the usefulness of the gas to the customer, or for comparison of the operating results, or for judging of the quality of service rendered in two places of different barometric pressure.

To overcome this difficulty it is proposed that the candlepower be based upon the actual light which is available to the customer when the gas is burned at 5 cubic feet per hour under the average barometric pressure conditions of the city. This can be done very simply by correcting gas measurements to the average local barometric pressure and rating the standard lamp for this pressure. Moreover, the results of tests are not only simply obtained, but they are of real significance, as can be seen from the following facts:

(1) The candlepower value thus fixed is a direct measure of the usefulness of the gas for open-flame lighting.

(2) The real efficiency of manufacture is shown by multiplying "make" (uncorrected for pressure) by rated candlepower. The candle-feet per pound of coal or gallon of oil thus obtained will be of the same significance in all cities (except possibly at very high altitude), which is not the case when the present method is followed.

(3) The values assigned to flame standards will be the same for both mantle and open-flame photometry and at normal humidity would agree with electric standards.

(4) Direct comparison of the quality of two gas supplies can be made on the basis of the rated candlepowers without recorrecting each to any new standard.

(5) The candlepower as rated will be an actual value, measuring the gas quality in a way which all can understand, and thus the company can

not be charged with delivering "short measure," as might be done when the real and rated values are found not to be the same.

The proposed ordinance and rules of Part III show the manner in which this can be fixed simply and clearly in the law.

2. METHODS SPECIFIED FOR TESTS

Only a few points determining the methods of candlepower testing which need be taken into account in the ordinance itself are included in the discussion of this section. All other points are discussed in the testing methods circular.

The Standard Light.—The term "candlepower" should not be understood as implying that sperm candles must be used as the standard light source; on the contrary, the use of candles where accuracy is desired should be avoided. The use of candles in the past was necessary, but the pentane lamp is a much better standard, and even a kerosene-oil standard is superior to candles. An electric standard is sometimes used for gas testing, and it has much merit where the laboratory facilities permit its use.

Of the various flame standards which can be used each one has some advantage over others. The choice of standard will be discussed in the circular on gas-testing methods. For the present discussion and for enactment of an ordinance it is sufficient to decide, if a flame standard is to be used, the way in which the value of this standard shall be fixed. This question has been discussed in the preceding section on the significance of candlepower measurements (p 35), and the corresponding ordinance forms are given on page 102. Whether a flame or an electric standard should be used need not be stated in the ordinance.

The Test Burner.—As the quantity and intensity of the light of a gas flame is largely dependent upon the character of the burner used, a candlepower specification should include a statement as to what burner is to be used in testing the gas. In choosing a test burner the following facts should be taken into account:

(1) The primary object of a candlepower requirement is to afford protection to users of open-flame lights.

(2) The best way in which the usefulness of a gas for open-flame lights can be determined is by testing the gas in an open-flame burner.

(3) The specification of some particular burner to be used in testing the gas is essential for definiteness of specification. The use of the phrase "the burner best suited to the gas," or "the burner must be suitable for domestic use," should be avoided as too indefinite.

(4) The fact that the burner selected gives a lower candlepower than some other burner which might be used is not unfair to the company, since the nominal candlepower fixed should be such as is economically obtainable when the particular burner selected is used.

(5) The light of an open-flame burner is practically uniformly intense in all directions (except directly downward, where the burner itself casts a shadow), and measurement in the one direction, as ordinarily made for a candlepower test, represents fairly the real lighting value of the flame.

(6) The light of an Argand burner, which has often been used for gas testing, gives a higher nominal candlepower to any given gas of less than 16 or 18 candlepower than does the open-flame test burner; but this is partly due to the fact that the horizontal candlepower is much higher than the average in all directions (known as mean spherical candlepower). The average intensity in all directions is very little, if any, higher than from the open-flame light, and therefore any advantage in nominal lighting value which the Argand gives to the gas is largely due to the different distribution of the light and not to an increase in the total quantity of light. This higher rating is therefore not a real advantage, since the object of the test is to determine the usefulness of the gas to the open-flame user.

Very few, if any, Argand burners are in use in this country for domestic lighting, and therefore the value obtained from them on testing does not represent the ordinary value obtained in practical use of the gas.

On the basis of these facts the Bureau recommends that testing regulations should specify that the candlepower of the gas be measured with an open-flame test burner burning at the rate of 5 cubic feet of gas per hour, as usual. In general, the ordinance can be stated as on page —, the name of the burner selected being given in the ordinance, in order to avoid uncertainty as to the selection. The question as to which burner should thus be specified is discussed in the testing methods circular. The selection of tips for use will also be discussed there.

Form of Photometer.—The question of form of photometer is fully discussed in the circular on approved methods of gas testing. The methods of test are confined mainly to the open and closed bar instruments. As ventilation of the space about the flames is of great importance in gas photometry, the open bar, which is generally used, is much to be preferred.

For official testing the jet photometer is not suitable, since it is not really a photometer, but must itself be frequently calibrated by a photometer in order to give trustworthy results. If properly used, it may be a useful guide to the gas manufacturer in a coal or oil gas works; but for

water gas it is not generally applicable, since the density and flame height of this kind of gas does not change regularly with the candlepower.

The portable photometer in many cases may be useful, but the necessities of its form of construction render it less reliable than the stationary open-bar type. In large cities where a permanent equipment is necessary the portable form is not used. In general, it should not be used for official results when a fixed apparatus can be secured. It is suitable for official use in traveling work of State inspectors, but it should be frequently calibrated by comparison with a good stationary instrument.

3. NOMINAL CANDLEPOWER REQUIRED

In specification of the candlepower it is possible either to make the requirement as to the minimum lighting value to be allowed at any time or to regulate the average quality of gas to be delivered.

A tolerance of two candles below the average required in the illuminating power of the gas on any one day is not unreasonable to provide for unusual conditions of weather or accidents beyond the control of the company. It is expected that reasonable efforts will be made to keep the gas up to the average value required.

If the candlepower regulation is supplementary to a heating value requirement, as will usually be the case, it will not be necessary to set any minimum daily candlepower limit, since the minimum allowable heating value fixed will prevent undue fluctuation in the lighting value as well as in the heating value of the gas.

Candlepower Required.—As may be noted in the tabulation of candlepower requirements now in force, on page 138, the values demanded by various cities range from 14 to 23 candlepower. The variation is due to difference in the kind of gas made and in the local conditions, and in some measure to misunderstandings of the proper function of a candlepower requirement.

In so far as a generalization is possible, it seems certain that with the present American practice any water-gas plant can regularly furnish 18 candlepower gas and any coal-gas plant 12 to 15 open-flame candlepower gas without undue difficulty or expense;[9] but it does not follow that such quality should always be required under present conditions. As has been previously stated, the candlepower requirement should be secondary to the

[9] Unenriched coal gas will usually be less than 15 candlepower on the open-flame burner.

heating value regulation; and the legal limit of candlepower should be somewhat lower than it is expected the gas will naturally have if the heating value is maintained. Thus, if a gas is of 600 Btu in heating value, it would probably under the present conditions of manufacture be of about 15 candlepower if it were coal gas and about 18 candlepower if water gas. However, to require by law that it be of 15 or 18 candlepower would be undesirable, as this would increase the difficulty and perhaps the expense of manufacture. In this case the requirement of 12 or 16 candlepower open-flame would not be at all severe and yet would afford to the open-flame user ample protection.

If the candlepower requirement is made without an accompanying heating value regulation, a higher candlepower should be required for water gas than for coal gas in order that the heating value may be about the same; but when the candlepower specified is secondary to a heating value rule there is less need to make distinction between coal and water gas.

At the present time very few of the larger cities of this country are supplied with a gas of less than 18 candlepower, and a considerable number of these and other cities have requirements of 20 and 22 candlepower. There is considerable evidence that such high values increase the cost of manufacture to such an extent that the cost to the customer per unit of service is greater than it would be for a gas of 18 candlepower. Moreover, for ordinary use in mantle lighting the high candlepower gas is often less desirable, as it tends to blacken the mantles and shorten their life; and also high candlepower gas can not be made and distributed with as great uniformity of product at point of consumption as can gas of lower candlepower. Since uniformity of quality is very desirable, especially for mantle lights, stoves, and other burners of the Bunsen type, high candlepower gas is, in this respect at least, less satisfactory to users.

On the above basis a requirement of 18 candlepower would be the highest which should be made for any ordinary condition. If a reduction of the candlepower to this figure is allowed in cities now receiving more, the price of the gas would be expected to be lowered correspondingly. This lowering of price would not be proportional to the lowering of candlepower, but it might be more than proportional to the lowering of heating value.

If an 18 candlepower requirement be the maximum which will be needed in the great majority of the cities of this country, it is probable that in many of them only 12 to 15 candlepower should be required. The

reasons for this reduction in the apparent candlepower may be summarized as follows:

(1) The heating value, not the candlepower, of the gas should be the factor determining the methods of works operation, and this can be the case only when fairly low candlepower is the legal limit.

(2) Under modern conditions of gas consumption there is an almost negligible proportion of the gas which should be used in open-flames where a quality of more than 12 to 15 candles is needed. Where more than this amount of light is needed, a mantle burner is or should be used.

(3) High candlepower gas can not be distributed of as uniform quality as can that of lower candlepower, and as a result of the irregularity in high-candlepower gas the usefulness of this product in mantle lights, stoves, and all other appliances with Bunsen burners is much impaired.

(4) The rating of gas of moderate or low lighting value on its open-flame candlepower makes the apparent quality somewhat less than by the old system. This is perfectly fair, as it gives more nearly the real value desired; but of course the nominal value specified appears lower than it otherwise would.

(5) Moderately low-candlepower gas can usually give more heat for a dollar than high-candlepower enriched gas; and this is what is wanted in probably 90 per cent of the gas used. The necessity of utilizing poorer fuel supplies will make the lower candlepower more essential for economy from year to year.

On the basis of these facts the Bureau recommends that those larger cities which desire a full regulatory gas ordinance specify in connection with a calorific standard that the gas supplied be of not less than 16 candlepower measured on the open-flame, unless, as will be the case in the few cities where only coal gas is made, this value is higher than corresponding to 575 to 600 Btu gas, or unless the gas supplied is of especially low heating value to permit use of by-product or unenriched coal gas. In the latter case 12 to 14 candlepower may be required. For cities at higher altitudes the values should be lower, being reduced by about one candle for each 1000 feet of altitude.

D. PURITY—CHEMICAL REQUIREMENTS

From the standpoint of the consumer it is immaterial what the chemical composition of the gas is so long as it contains no injurious constituents and possesses the specified heating value and candlepower.

At the present time there are only three impurities which receive much consideration in municipal control of the quality of the gas, namely, hydrogen sulphide, total sulphur, and ammonia. It is now recognized that the presence of carbon dioxide, nitrogen, and oxygen, while not beneficial to the gas, do not demand special control, since the specification of candlepower and heating value (either one or both) necessitates a control by the company of the amount of these diluents. The question as to the control of the amount of carbon monoxide will, however, be discussed.

1. HYDROGEN SULPHIDE

The question whether or not a regulation concerning the presence of hydrogen sulphide should be made has been carefully considered, and the conclusions reached are expressed in the ordinance proposed. The important facts and opinions on this question may be briefly stated as follows:

First. As *opposed* to hydrogen sulphide restriction:

Hydrogen sulphide and other sulphur compounds form the same objectionable products of combustion, namely, sulphur dioxide and sulphuric acid; therefore, hydrogen sulphide is no worse than other sulphur compounds.

Hydrogen sulphide when burned with illuminating gas does not, as sometimes claimed, give odors other than that of sulphur dioxide.

The amount of hydrogen sulphide present is not sufficient to be poisonous, especially when compared with the amounts of carbon monoxide present.

The bad odor due to the presence of hydrogen sulphide is beneficial rather than otherwise, since it makes leaks more noticeable, and thus minimizes the danger of fire or asphyxiation, which is greater with faintly odored gases.

Second. As *favoring* a hydrogen sulphide restriction:

The hydrogen sulphide can be removed with comparative ease and with very small expense.

The hydrogen sulphide will increase the sulphur dioxide in the products of combustion, and hence should be removed if possible. It should be noted that the other sulphur compounds can not be reduced by purification methods below a certain figure fixed by quality of coal and operating methods, except at prohibitive expense.

Even small amounts of hydrogen sulphide corrode brass and silver ware when minute leaks are allowed.

The test proposed is not severe, as it will allow the unavoidable traces of hydrogen sulphide to pass without detection.

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Because of its unpleasant odor the presence of hydrogen sulphide in the gas is conducive to unfriendly relations between company and consumer.

Finally, and what is most important of all, the removal of hydrogen sulphide necessitates careful management in all previous parts of the purification of the gas—i. e., condensing and scrubbing—and thus its absence is indicative of careful work through the whole process of manufacture.

The possibility of setting some more definite numerical limit—e. g., 1 grain of hydrogen sulphide per 100 cubic feet—has been carefully considered, but it was rejected as undesirable for several reasons: (*a*) No information is at present available as to the exact sensitiveness of the tests with lead acetate paper when used under the various conditions of test often recommended. The benefit of past experience would thus be lost by use of a new test which had not previously had wide application. (*b*) The quantitative determination of such amounts of hydrogen sulphide as could be allowed in an illuminating gas is a much more difficult and lengthy process than would be practicable in any but the large works where a trained chemist is employed. (*c*) There are no conclusive experiments at present available by which to determine what quantity per 100 cubic feet of gas would be reasonable.

A more detailed discussion of the hydrogen sulphide test is not within the scope of this circular, but will be included in the circular on methods of testing. An idea of the comparative sensitiveness of the various tests specified for this impurity can be obtained from an article in the Proceedings of the American Gas Institute for 1909, page 453. Some doubt has been expressed as to the absolute sensitiveness claimed in that article for the methods of test described; but there is no question as to the reliability of their comparative sensitiveness as there described.

A daily test for hydrogen sulphide is essential; but since the whole test requires less than five minutes, its frequency works no hardship.

Since it requires about two days after detection of hydrogen sulphide to insure its removal from the system, it is but reasonable to commence penalty for its presence only after such period. However, when the company does not remove the trouble within three days of its discovery, fear of penalty seems to be the most effective agent to insure an effort on its part to remove the casue of such trouble. As specified in section 14 (p. 106), "each day" should begin with the first observation of the presence of hydrogen sulphide and continue, counting Sundays and holidays, until the gas is again

free from the impurity, for there is no reason to suppose that if hydrogen sulphide was present both on Saturday and Monday that it was not present on the Sunday intervening.

2. TOTAL SULPHUR

The question as to total sulphur limits has come to be not what amount of sulphur is dangerous to either health or property, but rather, what is the least sulphur readily obtainable in good practice with the present coal supplies. The amount of total sulphur present in the purified gas is not wholly within the control of the company, as it depends not only on the methods of works operation, but also on the character of the coal or oil employed. The sulphur limitation in coal-gas manufacture becomes in effect a limitation upon the quality of coal purchased. It is desirable, therefore, that the limits set be not unduly severe, lest a coal which otherwise would be very economical for gas making may be excluded; but some limit should be in force to exclude an unnecessarily high sulphur gas. The public has a right to demand and should be assured of the lowest quantity of sulphur and ammonia practicable. Because of the growing scarcity of high-grade gas coal many companies are being compelled to use an inferior grade, and the resulting gas is thus higher in sulphur. If a supply of poor coal were received by a small company, it might be impossible for it to furnish a gas of normal purity until this stock was exhausted.

With the fuel supplies which are available at the present time coal gas can not be made as low in sulphur compounds, other than hydrogen sulphide, as can water gas; but there is no difficulty in maintaining the sulphur in water gas below 20 grains per 100 cubic feet. The public should be assured by proper regulations that this limit will be observed; but such limit might at times be too severe for coal gas. However, the allowance of 30 grains to give relief in certain localities where high sulphur coals are used will permit other companies to meet this requirement with the lower grades of coal which some of them will, of necessity, use in the near future.

A restriction of the total sulphur should always be made to prevent the distribution of high-sulphur gas, such as would result from the use of the poorer grades of coal

3. AMMONIA

In large gas works the reduction of the ammonia in the gas to a very small amount is usual, because of the value of the recovered ammonia; with the smaller works the use of a large excess of scrubbing water is customary, and the amount of ammonia passing into the gas is therefore small. The

harm which may result from the presence of considerable ammonia in the gas is sometimes disputed; but it is generally believed that it has an injurious effect upon the meters and also upon the fixtures, and it should therefore be eliminated from the gas as completely as possible. The determination is simple and the requirement proposed is not hard to meet.

The retention of the ammonia limit in the law has been criticized on the ground that it is unnecessary or that gas companies will remove this impurity because it is too valuable to lose. This is true of probably over 90 per cent of the gas companies, and these need not be worried by the retention of the limit, but even at the present time some companies do not remove the ammonia with sufficient care. It is said that for its own protection a company must remove the ammonia or it will ruin its meters; but if this happens, the gas consumers will ultimately bear the expense. It is therefore best to retain the limit, even though it is probable that without it the results would be the same. If it is retained, there is no question as to what the company is expected to do.

In the case of most coal-gas plants the same limits would be possible for ammonia as are used for water gas, and in these plants a 5-grain limit would be proper; but in a few coal-gas plants it may be necessary to permit as much as 10 grains, especially if the scrubbing capacity of a plant is limited, either through scarcity of water or because of insufficient installation. For ordinary conditions there will be no difficulty with the limit as set. In a few cases difficulty may be met in preventing the gas from being contaminated by ammonia taken up from the water in the holders and the distributing system; this, however, would be a very exceptional condition and could occur only in hot weather in a coal-gas works.

The daily determination of sulphur and ammonia (required in some cities) gives an excellent control of the quality of the gas in these respects; but it adds very much to the time, and therefore the expense, of inspection, with scarcely the equivalent advantage in protection of the consumer. Since the weekly test may be made without notice to the company at any time during the week, the company must always be prepared to meet the requirement, and such frequency will thus offer ample surety of the proper conditions at all times.

The determination of sulphur and ammonia can be made with sufficient accuracy to insure the company against criticism when not deserved, and the limits have been set enough higher than otherwise necessary to cover errors in the determination.

4. CARBON MONOXIDE

A review of existing legislation shows no tendency to limit the carbon monoxide content of gas. The question as to the limitation of the carbon monoxide content of the gas distributed is based upon the fact that this substance is the only constituent of illuminating gas which, in the amounts ordinarily found, is poisonous. Other constituents would produce suffocation, but not poisoning.

Coal gas contains from 5 to 10 per cent of carbon monoxide; water gas from 25 to 30 per cent. The limiting of the amount of carbon monoxide in the gas sold, therefore, may operate to limit the amount of water gas made. It is apparent that such regulations as would prevent the operation of water-gas plants now in existence would be very radical.

In this connection it may be noted that the increasing cost of gas oil will probably lead to a decrease in the water gas made, and thus ultimately it may do away with the need of even considering legislation limiting the carbon monoxide content of gas.

The use of water gas necessitates the use of a gas more toxic in character than coal gas. Just how far this fact can be used as an argument for restricting the use of water gas is not clear; but at this time it is not amiss to point out some of the facts which indicate that the use of water gas may possibly not be much more dangerous than coal gas. Briefly stated, these facts are as follows: A large proportion of the cases of death or illness caused by gas poisoning are suicidal, or are due to irresponsible condition such as drunkenness, or to gross ignorance; and in the majority of these cases the character of the gas would perhaps have only a small influence upon the seriousness of the result. A smaller number of deaths and cases of gas poisoning are due, not to the illuminating gas itself, but to the carbon monoxide formed by combustion of the gas with insufficient supply of air, due to a faulty appliance or to an appliance improperly set or connected with insufficient or improper flues. These matters all have an important bearing upon the subject, and it is possible 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.

E. GAS-PRESSURE LIMITS

The pressure at which gas is supplied to the consumer is a primary element of good service. Discussing this point the Wisconsin Railroad Commission make the following statement in their third annual report (1909):

> It has been shown that in general the gas furnished in cities of this State has been of good quality and the value has been uniform. In spite of this fact, complaint is frequently heard of "poor gas." The summary of gas complaints and our own experience have shown "poor gas," as the consumer uses the term, to be synonymous with "poor pressure," and may be due to one or more of a number of causes. It may be that the pressure furnished to the mains is inadequate, that the service or house piping is inadequate or otherwise faulty, or that the pressure is unsuited to the adjustment of the appliances in which gas is used. In most cases, however, it goes back to the matter of pressure. For this reason the control of the gas pressure is the most important single factor in securing satisfactory service.
>
> The use of gas has been greatly extended in the last few years and all of the appliances which have come into use require a higher pressure than the old open flame burner. It is stated in the discussion of gas pressure in bulletin U-21 that the pressure under 1½ inches is unsatisfactory. Most of the companies in the State maintain a standard pressure of above 2½ inches, and it has been noticed that in general, where the pressure drops below 2 inches, complaints are heard.

There are three values of the gas pressure commonly specified—viz, the maximum pressure, the minimum pressure, and the variation in pressure allowable. In this discussion only the conditions which are most frequently met can be considered; special conditions may require variation from the general rule. However, such variations will oftener be variations as to the time necessary before a company can comply with the rules than variations in the rules themselves. It will usually be best to require that the efforts of the company be directed toward eventually meeting these generally applicable limitations.

Recently the question of limiting the momentary or pulsating variations of pressure has been taken up, particularly by the Public Service Commission of the first district of New York; and this problem is one which demands consideration in many, if not all, large cities.

In the recommendations of this Bureau no conclusions have as yet been expressed on the question of momentary and pulsating variations of pressure, but the proposed ordinance and rules include regulations as to maximum and minimum pressures and allowable daily variations. It must be recognized that such a regulation as that proposed can not be put in force at once in any city unless gas-distribution conditions are such as to make it possible to distribute the necessary quantity of gas at these pressures. No company, however willing, can make considerable alteration in its distribution system without a reasonable allowance of time. It seems advisable to make few, if any, specifications as to how the company

shall meet the new requirements. If ample time is allowed and temporary pressure regulations (less rigid than those ultimately intended) are at once enforced, the company should be allowed to choose its own method of accomplishing the final result. Whether they wish to use more holders, high-pressure belt lines, the booster system of feeding mains, local or district governors, or larger low-pressure mains is immaterial if the final requirement is met.

As a supplement to the following discussion of pressure regulations there is included in Part V of this circular a brief summary of the gas-distribution methods in use in this country.

1. MAXIMUM PRESSURE LIMITS

The present tendency in gas distribution is toward maintaining higher pressures. The cause of this is twofold: First, the increased amount of gas which can be sent through a pipe of fixed size, thus continuing the use of mains otherwise insufficient in capacity; and, second, the greater efficiency of some gas appliances at the higher pressure.

This increase in pressure can be carried too far, even considering only the resulting increase in capacity of mains, for the increase in leakage may become serious, especially on old systems. When otherwise desirable to use pressures up to 12 or 15 inches, this latter difficulty should be met by replacement of the worn-out or defective portions of the system rather than by sacrificing efficiency in use of the gas for the immediate economy in distribution. It is, of course, understood that when use of pressures of 1 pound or more is necessary the present style system will usually, if not always, have to be replaced by one designed for such higher pressure.

A large majority of present-day gas appliances (mantle lamps, stoves, and industrial appliances) when set and operated at pressures of 4 to 6 inches, or even higher, are more economical than when used at 1 to 2 inch pressures as formerly generally used. However, at the higher pressure most open-flame lights blow badly and are very inefficient and unsatisfactory. The small percentage of gas used in open flames makes them of less importance in determining the desirable pressure to maintain, but their needs can not be wholly ignored. At the present time the majority of appliances are designed for use at 2 to 6 inch pressures, and when higher pressures are used it is often necessary to replace the gas outlets on them with those of smaller size.

There is no doubt that the objections to high-pressure gas will gradually be overcome; but for a number of years, at least, it is probable that pressures below 6 to 8 inches will be used in practically all cities. However, there is some question as to the desirability of legal limitation of the maximum pressure to be maintained. After the very careful consideration of all the facts presented to it the Bureau has come to the conclusions that it will usually, if not always, be best to set some upper pressure limits in the rules or to give to the commission or city inspector authority to fix this maximum as may be from time to time desirable. The advantages of this plan are briefly set forth as follows:

(1) The average gas consumer cannot be trusted to regulate his appliances when the pressure goes above 6 to 8 inches, and he is, furthermore, incompetent to judge when higher pressures are desirable for his use. The commission or city inspector, being familiar with the technical points involved, is in position to pass judgment on the various cases that may arise and can determine when high pressures are desirable.

(2) Ordinary gas burners for both stoves and mantle lights are set for the normal pressure of 2 to 6 inches. If pressures higher than these are used, readjustment is necessary, and unless some authority supervises this adjustment and determines that it has been properly made for all customers affected, the application of high-pressure gas to systems formerly at low pressure should not be made.

(3) The allowance of unlimited maximum pressure would permit gas companies to distribute gas through their mains without feeders or auxiliary holders, and so cause great irregularities in pressure throughout the city. Close to the distribution centers high pressures would prevail, while at great distances only low pressure would be maintained. It would thus be impossible for any dealer to sell appliances suitable for all parts of the city and the public would not be able to purchase fittings already properly adjusted. With some authority in control over the maximum pressure maintained at any point the public and appliance dealers will always have an official to whom appeal can be made either to determine what pressure will generally prevail at the point where appliances are to be used or for relief from unduly high pressures, when it appears that these are to the disadvantage of the customer.

(4) By the use of high pressure lines or a booster system and gas governors (the latter for the district or for each meter as circumstances may require) the gas company can meet such requirements as are proposed and still utilize the most modern methods of distribution. Indeed, it is doubt-

ful whether or not a gas company can, without such control as will enable it to maintain pressures always below a 6 or 8 inch maximum, maintain anything like reasonable uniformity in pressure at all points on its system. A higher pressure, if desired, could be maintained with the same uniformity.

(5) Six to 8 inch pressures in the customers' house piping are sufficient to assure the operation of ordinary domestic appliances with good efficiency. Where high pressure appliances are in use and can be supplied from the high pressure mains, there is no objection whatever to such supply, if requested by the customer. To provide for such cases it is desirable in city ordinances to distinctly specify this, as is proposed in section 10, paragraph 3 (p. 104).

In connection with the discussion of maximum pressure limits, there is one point of interest not often mentioned. If the company increases the average gas pressure in the meters of its customers by an amount equal to 4 inches of water, this is equivalent to making all of the meters run 1 per cent slower, since the mass of gas which will thus be passed per 1000 cubic feet is 1 per cent greater at the higher than at the lower pressure. The return to the company would thus be decreased by 1 per cent. Moreover, if such increase in pressure were made without careful readjustment of the appliances supplied, the waste of gas resulting might more than overcome any apparent advantage to the customer which the increase in density would bring. However, if less than 6 to 8 inch maxima are maintained this is not a serious factor. It may be mentioned in this connection that a rating such as is proposed by the Bureau will care for this variation, as the total gas pressure in the average meter is the pressure taken for measurement in the rating of the gas. Thus what is measured to the customer is at actually the same pressure as the gas which is measured for the purpose of testing. The loss in volume is made up by increase in rating, and gas meeting the specifications will thus give the same return to the company regardless of the distribution pressure.

When a particularly high area is to be supplied and the maximum pressure is limited, the use of governors may be necessary to prevent undue increase in pressure at the higher level. The increase in gas pressure due to elevation above the holder or governor outlet is from ½ to 1 inch of water pressure for each 100 feet difference in level, varying with the density of gas, being larger with coal gas than water gas. The differences actually occurring depend not only on specific gravity of the gas, but also on the loss of pressure due to friction of flow.

In a city where considerable differences of elevation exist and where in the higher parts of the city the streets are not lighted with gas, it may be necessary to allow higher pressures than normal between midnight and 5 or 6 a. m. in the higher parts of the city, since at this time of night pressures build up, even beyond governors, in a way that a company can not always control because practically no gas is being used. At these hours when very little gas is used the higher pressures, say up to 12 or 15 inches, will certainly not be dangerous, and even the inconvenience to the few using gas at these hours will not be serious.

There may be a few medium sized cities in which low pressure distributing systems are becoming inadequate before the installation of the auxiliary belt line or booster system seems practicable, and in such cases greater latitude in pressure may be needed. In these cases the authority granted the city officials should permit the higher pressures as the needs of the companies might demand, and no supplementary legislation would be required to bring about changes in the rule to be applied.

2. MINIMUM PRESSURE LIMITS

A gas consumer has a right to expect a sufficient gas pressure at his meter so that, with a reasonable size of house piping, appliances and burners of the ordinary forms can be operated conveniently and efficiently. In a great many places a minimum of 1.5 inches is specified, and sometimes it is as low as 1 inch. It is generally believed, however, that fair satisfaction in operation of incandescent mantles and gas stoves can be obtained only with pressures greater than 2 inches. Where a normal pressure of 3 to 3.5 is carried, the difficulties of operation of these appliances is apparent where the pressure drops below 2 inches.

A sudden drop in pressure with a subsequent rise to normal, which sometimes occurs, is the most serious menace to be guarded against. Such a sudden drop may in rare cases extinguish lights, and the subsequent increase of pressure will then fill the room with unburned gas, with attendant danger of fire and asphyxiation. Lights would probably not be extinguished at pressures above 1 inch; but the less serious though quite appreciable difficulty of "snapping back" of stove or mantle burners occurs even above 1 inch pressures, especially when the burner is set for relatively high pressures. It is not intended that the minimum pressure limit set shall guard particularly against dangerously low pressures, although it does do this in any event; the idea is rather to prevent such low pressures as will not permit efficient operation of domestic appliances. When a minimum pressure

regulation of the form proposed is in force, the protection of the company demands that it shall have control of the service pipes to all houses, at least to the extent of determining their minimum size. Otherwise the company should not be held liable for low pressures in such house, as, for example, when the insufficient size of service pipe prevent the maintenance of such pressures when the consumption is a maximum. Where the company installs and is responsible for the services, it can be held to a minimum limit without qualifying it, as is often done, by the phrase, "when no gas is being used by said consumer."

In case the pressure falls below the allowed minimum in any one house due to the installation without the knowledge of the company of an appliance using gas so rapidly that a service pipe which was otherwise adequate is too small, then the company must be relieved from penalty for such failure to meet the pressure requirements, as the case is clearly one beyond the control of the company. Whether under such circumstances a company which is usually required to furnish and maintain the service pipes should be expected to install a new service would depend largely on the total amount of gas to be used by the new appliance.

3. ALLOWABLE PRESSURE VARIATIONS

More important than either the maximum or the minimum pressure is the variation in pressure. If an appliance be set for any particular pressure, it does not render best service at a pressure much different from this value, and hence the necessity of uniformity. A large number of gas companies in this country, including both large and small, maintain such reasonable uniformity as is required by the proposed rule, and companies who do not, unless prevented by some unusual condition, could properly be compelled to meet such requirement. It is of course understood that some time will be necessary to accomplish such alterations, but the sooner pressure regulation is required the sooner will good service be established.

The limitation set upon the variation of gas pressure has usually been fixed as 100 per cent of the minimum pressure in the same period. This operates with good satisfaction when the minimum is from 1½ to 2½ inches; but as higher pressures are used, say, 3 or 4 inch minimum, it is better to fix the variation in terms of the number of inches difference between maximum and minimum pressure. In any case where no maximum pressure limit is fixed this would be especially important and may well be applied in all cases.

The plan of leaving it entirely optional with the company as to what pressures shall be maintained in different districts of the city is a novel one. However, the Bureau believes that the company engineers are usually best fitted to judge as to the proper pressures to be maintained in different parts of the city, and within limits can be permitted to determine these values. Under the rule proposed, if the normal pressure be fixed as 4 inches, the limits 2 to 6 inches, and the variation of 100 per cent of the minimum, which have been commonly set, will in effect be unchanged.

At high pressures the increasing amount of gas entering an appliance is no greater than at low pressures with proportionate change of pressure, i. e., if the pressure be doubled by raising from 2 to 4 inches, the effect upon amount of gas consumed is just as bad as the change from 6 to 12 inches. It is often argued, therefore, that the variation of 100 per cent of the minimum is just as fair at high pressure as at low pressure. However, the Bureau believes that since at the higher pressures smaller variations can in practice be economically maintained, it is only fair to assure the customer that the company will prevent such great variation. This policy of requiring the very best service which the company can economically and practicably furnish the customer differs somewhat from the policy of certain State and city officials, but the Bureau believes that since the customer is usually wholly in ignorance of the technical points involved and entirely helpless in fixing the quality of service rendered him, the regulations controlling the companies' operations should be sufficiently rigid to insure such customer the very best service which he can reasonably expect.

It is customary for the pressure variation to be limited on the basis of the pressures during any one day. This is usually 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 really determines the severity of the limitations imposed. As will be noted in the proposed rule, the Bureau follows this system in general, but would limit changes in normal pressure at any part of the city in such a way that the customers affected would be assured of good service at the new pressure. It appears desirable that this be done, since the tendency to gradually raise the pressure throughout a whole city may operate to the disadvantage of certain customers who previously were served at low pressure satisfactorily, but at the higher pressure, unless readjustment of their appliances is made, will be unsatisfactorily served. The proposed rules give the company full authority to fix the new normal pressure at any

time if only they satisfy the simple requirement that the customers affected shall be cared for so that the change will not result in any serious inconvenience.

4. MOMENTARY OR 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.

With one exception, no attempt has been made to restrict these momentary or pulsating pressures by official regulations; but the need of such restriction, especially in larger cities, may become obvious. In the report by Mr. 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 rules which are now in force there are given on page 143 of this circular.

Since there is thus only the one city from which to gather data as to the usefulness of such a regulation, the Bureau can do no better than present this case at this time. In later editions of this circular a more complete treatment may be possible.

5. ALTERNATE FORMS FOR PRESSURE RULE

It is possible that the older form of pressure rules may be preferred in some places. For such use either of the two following forms may be employed. Of course, similar forms may also be used in section 10 of the city ordinance.

First Alternate.—The pressure of the gas distributed in this State, as measured at the outlet of the company's service pipe to any customer, shall never be less than two inches nor more than —— inches of water pressure; and the daily variation in such pressure at any such outlet shall never exceed the following amounts, viz: During the period of one year after the time this rule shall take effect, not greater than equivalent to three inches of water pressure; during the second period of one year after the time when this rule shall take effect, not greater than equivalent to two and one-half inches of water pressure; and during the period more than two years after this rule shall take effect, so long as this rule shall be in force, not greater than equivalent to two inches of water pressure.

Second Alternate.—The pressure of the gas distributed in this State, as measured at the outlet of the company's service pipe to any customer, shall never be less than two inches nor more than —— inches of water pressure; and the daily variation in such pressure at any such outlet shall never exceed one hundred per cent of the minimum pressure on that day at that outlet.

F. METERS AND METER TESTING

Since the record given by a meter of the amount of gas passed is the basis of all settlements between company and customer, the importance of correct registration is evident. The most satisfactory method of protecting the company and satisfying the customer of the reliability of the meter, is a regular test. With these objects in mind the proposed regulation on this subject was drawn after very careful study of the requirements and practice of some of the largest and most progressive companies of the country.

There is, perhaps, no basis on which it can be claimed that the total net loss to customers from incorrect meters is of a magnitude commensurate with the cost of meter inspection. However, it is not an equitable procedure to compel those consumers who unfortunately have a "fast" meter to make up to the company losses sustained by it through the incorrect registration of the "slow" and "D. R." (don't register) meters. No company desires such an arrangement, 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 due to meter error. With careful planning and proper management this testing work is probably worth all that it costs, while its cost is distributed, as it should be, over all gas users.

1. ACCURACY AND TESTING REQUIRED

The tolerance of 1 or 2 per cent fast or slow at time of installation of a meter is sufficient for any company which does careful work in its meter repair shop. A meter can easily be adjusted to within 1 per cent of correct, and this should be done before a meter is put into use. A very few old-style meters can not be set within one-half per cent on every adjustment, but they can be set within 1 per cent.

After having been in service for several years a meter is liable to certain errors, and if it stays within 2 or 3 per cent of correct the loss to either company or customer is so small as to be practically negligible on any one

customer's bills. The company is protected from large loss in the aggregate, since the plus and minus errors will naturally almost balance.

The plan commonly followed of calling any meter "correct" if in error by 2 per cent or less is not as logical as the one now proposed, requiring greater accuracy at time of installation, but allowing reasonable variation after use. This new scheme will start meters in service in good condition, and if they become fast or slow later the chance of serious error is in some measure lessened. Furthermore, if a company exercises care in original adjustment, subsequent variations of the meter up to 2 or 3 per cent should be considered only the natural result of the commercial conditions. The allowance of certain variations from correctness on the meters does not mean that meters will be set in error by the amount of the tolerance; the tolerance allows only for the necessary irregularities in the work on a commercial scale. Meters will be adjusted as nearly as practicable to absolute correctness, the variations from this being never greater than the limits set. The average of the errors will be zero practically, for as many will be slightly slow as are slightly fast.

The sealing of the meters can be done in several ways, which will be described under methods of testing. When the regular inspection is done by the company, it should seal the meters in some way in order that both company and customer can see at once the date of the last test.

When a new ordinance goes into effect, the initial testing of old meters is one of the most serious considerations. As drawn, the proposed section arranges for the testing first of those meters which have been longest in use. Unless the company can at once furnish "tested and sealed meters" for the use of new customers, it must of course be allowed to set meters contrary to the provision of the ordinance until arrangements can be made to test and seal the meters as required for use.

The testing of a meter just purchased from the manufacturer may seem unreasonable, since these meters are supposed to be very carefully adjusted. If this adjustment could always be depended upon, the rule would be needless, but the experience of many inspectors and company meter testers shows the rule to be a good one. The investigations of the Bureau have shown that the large majority of new meters are tested by the companies purchasing them before installation. This practice has been almost invariably found in the larger and better companies, as well as in many smaller companies, and it is strongly defended by most meter testers (both of cities and companies) on the ground that the check test given a meter by a manufacturer can not be depended upon satisfactorily to eliminate all

incorrect meters. The Bureau has, from the facts presented up to the present time, been compelled to conclude that all new, repaired, adjusted, as well as other meters must be tested before installation for a customer's use, except perhaps when the meter is manufactured in the same city where it is to be used. In this latter case, when the meters are not shipped or handled much after adjustment at the factory, a few (e. g. 10 per cent) of each lot purchased can be tested and if found correct the whole lot accepted on this test.

2. FREQUENCY OF RETEST

The choice of a definite number of years as a limit of time between testings is, of course, arbitrary. The experience of those who have set three years for this limit would scarcely warrant recommending this throughout the country, and a longer period than five years would be undesirable generally. A meter must be tested in some way for time deterioration, and four or five years seems to be a reasonable limit to set for such inspection. It may be thought that the company for its own protection will care for the meters sufficiently well, but in actual practice it is often found that the companies neglect their meters.

If after longer experience it is found that meters will continue for longer than five years in a satisfactory condition, then the time during which a meter may be left in service without test may be extended. The use of "dipping meters" has been very successful in this respect in some places.

The system used by some companies by which experts are constantly going over the ledgers to see in what meters the consumption of gas is falling off and to investigate such cases does in a measure protect the company, but such a process does not offer the consumer any protection against "fast" meters. In fact, such plan tends necessarily to increase the percentage of "fast" meters by weeding out those which are "slow." Just how successful such plan would be in eliminating both "fast" and "slow" meters by noting changes of consumption is not known, although it has been attempted by some companies and some credit given to it. We believe, however, that such precautions at best are of very limited value and should only be depended upon between actual tests at not too infrequent intervals.

When the five-year removal rule is in force it can be assumed that each year there must be as many meters tested as are equivalent to 25 per cent of the total number installed. This includes complaints, removals due to change of consumer, repairs, and new meters. The reason that a shorter period might work a hardship on the company is evident when we realize

that a four-year removal rule means over 30 per cent to be tested each year, a three-year removal rule about 40 per cent a year, etc.

Because of their greater importance meters larger than the "10-light size" will usually be tested more often than the smaller sizes. This can be left to the company, however, as it must watch these large meters closely for its own protection.

Since a large part of the expense of testing is due to time required to remove a meter and replace it by a new one it works no hardship on the company to require test on a meter, which has for any cause been removed after even a short period of service. Indeed, a great many companies never reset a meter without testing it, even though it may have been out only a few months.

The expense of removal and hauling meters to and from the testing shops is obviously a part of the company's expense of distribution. Since the company owns and is responsible for all meters, no one but its employees or agents should be allowed to disconnect or install any meter.

The proposed refund to customers is so arranged that the customer recovers only the probable excess in charge during the previous six months. We can not assume that the meter has been uniformly coming to the error found at the time of test and that, therefore, the refund should be for half the time which this meter has been in use. Although this practice is followed in some cities, it seems better to use a uniform period of six months for determining the amount of refund. This latter plan saves much quibbling between company and complainant, to the advantage of both.

3. TESTS ON REQUEST OF CUSTOMER

A number of cities require that the company shall test any meter upon request of the customer using it, rather than that the inspector shall make all complaint tests. The proposed regulation incorporates this idea in a modified form. There are probably only a small number of complaints which will come under this rule, since if the customer, after explanation, is not convinced that his meter is correct, he would prefer to make the required deposit and have an official test. However, certain complaints which are well founded will be met by it, and the company will gain more by its enforcement than they will lose in expense. It is also fair that the company should have this opportunity to deal justly with its customers, rather than that all complaints should go directly to the city inspector and the company be given no previous opportunity to adjust them.

Testing oftener than once a year is unnecessary. Few cases will ever be met where this frequency of test is demanded, and it can scarcely work any hardship to the company. A second test within a year should be made when demanded, but the charges must then fall on the customer, unless the meter shall prove to be fast.

A rule has been in force in Wisconsin for four years requiring the company to make a test on request of any customer, not oftener than once in six months, and it has been found to work no hardship there.

If the complaining customer will not agree to accept the results of the company's test, it is best he should be served by the inspector's test, whose accuracy he can not question. If such test is desired under city control, the fee of $1 is reasonable, and it should be shared with the company, if the meter is not fast, since the company will bear the expense of removal of his meter and replacement by one recently tested. The basis of settlement referred to here should be the same as that described in paragraph (e), unless the particular case gives obvious reason for choice of other terms.

Under State control the fee may be larger in order to encourage the settlement by the customer with the company without appeal to the commission, except in extreme cases; and for large meters the fee should be the cost of the test, so that no company will ask the State to do its routine testing on large meters for a nominal fee, which might for these meters be less than the actual expense if done by the company.

It would seem rather unnecessary to include in the section on meter testing the requirement that the inspector give written notice both to the customer and to the company before testing a complaint meter. These notices are required in a few cities, but where the proper sort of inspection is provided they are not needed, even as a matter of form. Similarly, a statement that the customer may be present at the time of testing of his meter seems unnecessary, although such privilege should be granted by the inspector when it is requested.

PART II.—ENFORCEMENT OF TECHNICAL REGULATIONS

For the full enforcement of the technical regulations, such as are discussed in Part I 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 bring redress for inexcusable noncompliance found. Although the three parts of the enforcement procedure often follow so closely as to be indistinguishable, it is nevertheless an advantage to bear in mind the three essential parts. In fact, the neglect of one or another of the three parts is often the cause of serious friction in such matters. This is especially true if the second part of the work is neglected. In this latter case any action which may be taken to enforce compliance with the letter of a regulation without preliminary consideration of all the facts involved usually will result only in needless friction between company and city or possibly even in expensive litigation to no useful purpose.

A. CITY v. STATE CONTROL OF GAS SERVICE

Two considerations will determine the comparative advantage of State and city control of gas conditions: First, which authority can and will enact the most suitable form of technical requirement; and second, which will be able to carry out most efficiently the inspection work necessary for the enforcement of these requirements.

The experience of several States which have successfully undertaken the enforcement of technical gas regulations indicates that it is possible for a State to adopt suitable regulations for enforcement. It seems probable that, through its larger resources, a State legislature or State commission could gather the information necessary to enact proper control laws better than the average municipal legislative body. Moreover, a State has greater incentive, because of the larger influence of its decisions, to make the preliminary study necessary for proper legislation, and through this study made by experts each small city gains the benefit of the large experience of men whom it could not employ if acting alone. If the desirability of having

certain gas laws generally in force be admitted, it must be recognized that such laws are more likely to be enacted by a State than by all of the cities of the State acting separately.

The particular advantage of State regulations lies in their flexibility. The rules adopted by the public-service commissions have been, in general, applied to all companies in a State alike; but as need for variation from the general rule arises the authority of the commission is sufficient to grant special concession or to make special regulations, thus meeting promptly the needs of each case. A municipal regulation can, of course, be amended by city authorities, but in practice a city council, busy with the many lines of work brought before it, either can not or will not give to such matters the time necessary for an understanding of the technical points involved. The result is a lack of prompt action on matters which could be easily disposed of by the State authorities, who are themselves or by their inspection departments already familiar with the technical details.

The more important considerations in determining the efficiency of State inspection are: The number of companies in the State, the size of each, and the distance between the cities in which they operate. A consideration of the results obtained in the States where commissions have been active in this work shows that State-inspection service can be made very efficient, and the methods by which general schemes can be adapted to local conditions are clearly shown by the work of these State bodies. This point will be taken up under the discussion of State enforcement methods.

The selection of a technical requirement suitable for enforcement throughout a whole State might appear very difficult, but the experience of the various commissions proves that it is practicable to do so. It will be noted that in each of the States all of the companies are required to conform to the same limits as to gas quality and service. Moreover, as far as can be learned, this uniformity of regulation has produced no hardships. To be sure, a small company may find greater expense attendant upon certain operations to meet the requirements than does the larger company; but the commissions invariably recognize such differences by allowing different prices to be charged by the different companies. In the selection of requirements for State enforcement the same considerations apply as have been discussed under municipal regulations; in fact, a State gas law appears to be little more than a municipal regulation applied over larger territory, the methods of enforcement and the inspection routine having proven to be the main points of difference.

The Bureau has familiarized itself with the work of many State and city inspection offices, and almost without exception, the State work has seemed to operate to the advantage of the public. The utility commissions usually have authority to regulate rates of charge as well as quality of service furnished; the investigations for rate making purposes make so clear the economic or practical side of the service regulations, that the latter can be considered as most intelligently treated only when enacted by authorities who have had rate regulation experience as well.

Although having no authority in this matter, the Bureau wishes to exert its influence in favor of State, rather than city, control of regulations as to quality of gas and gas service. At the same time the Bureau would emphasize the great advantage of having the technical regulations made by the State commission, and not having the regulations written into the State law itself.

B. 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 or necessity of penalty. 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 technical commission.

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 probably 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.

1. INSPECTOR—APPOINTMENT, DEPUTIES, ETC.

The advantage derived from examining the inspector before appointment leaves no doubt as to its advisability (see p. 98). Where a city has an established 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.

An ordinance requirement similar to the one proposed was recently adopted in Minneapolis, according to which the examining board was constituted as follows: "That the head of the department of chemistry and the head of the department of physics of the Minnesota State University and the principal of the Minneapolis Central High School shall constitute a board for the examination of all persons desiring to apply for such position of inspector." A similar membership would not always be possible, but the same idea can be applied in a very large number of cases. The members of this 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. None of the members of such board should be connected either with the political offices of the city or the city council, without good reason. 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.

It is an open question whether or not the gas company should be represented upon the examining board. The best results will probably be gained, not only for the city but also for the 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.

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.

No uniform rule can be made as to the remuneration of the examiners. In many cases no compensation is necessary, as when those selected to serve in this capacity will consider it their duty as citizens to render such service. The fee might vary between $10 and $50 per member, and would have to be paid usually not oftener than once in several years.

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.

The oath of office and the bond required can be adjusted to meet local conditions. The amount of the bond, if this is desired, will vary with the amount of funds handled by the inspector.

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.

A provision for deputies is necessary, in order that in the absence of the inspector the regular official testing can be done. The deputies should be

able to carry out the regulations of the ordinance even in the absence of the inspector, but the assistants, while competent to make any one form of test, need not be familiar with all the various duties of the inspector. In small cities no deputies or assistants may be necessary, but at least one deputy may be appointed, even though he may take no regular part in the official work nor be upon the pay roll of the city, except in the absence of the inspector.

Such deputies could be appointed after examination in the same way as the inspector in order to insure their competency.

2. TESTING STATIONS

The location of the testing station at the proper point has an important bearing upon the efficiency of the testing done, for, if the gas tested does not really represent that throughout the station's district, the results are misleading and unfair either to the company or to the public. Definite requirements as to location of the station are often made in the ordinance in order to insure that these essential conditions are met.

Geographic considerations are very important, since in a closely settled city such 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. The reverse case is found in many middle-western cities where six or eight million cubic feet per day is distributed over an area nearly as great as that covered by twenty million in an eastern city.

The location of testing stations will, in a measure, determine their number, 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. In general, there should be at least one station for each manufacturing plant.

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.

In small cities the location of the testing equipment in the office of some other city official can advantageously be made. Under these circumstances the restriction of distance from the works may be impossible. Since the gas during its first mile of travel may change appreciably in quality this restriction should be complied with, if possible; unless, indeed, the large

majority of the consumers are located as near the works of the company as the testing station itself.

The proposed city ordinance requires that the testing station be not less than 1 mile "measured in a direct line from" any manufacturing plant of the company. "Measured along the shortest line of gas mains from, etc.," may be preferable in a city where measurement in a straight line would allow the location of a station at a point more than 2 miles away from the works by the nearest line of gas mains, which at the same time was only about a mile away in a straight line; however, measurement in a straight line prevents ambiguity, chance for dispute as to which line of main shall be chosen for measurement, and necessity of change of measurement and location, because of possible changes in main connections after the station has been selected. For large cities the minimum distance of 1 mile is satisfactory; but in State rules adapted for small plants as well as large the distance is better placed at one-half to 1 mile.

Tests of candlepower or heating value when made at the manufacturing works would often be useless, for an improperly condensed gas might give good values at the works and yet be very low in heating or lighting power when delivered. Tests after exposure to the ground temperatures for a half mile or more will eliminate the greater part of this effect.

After a laboratory is properly located the lack of a proper 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 connection.

No pains should be spared to make the tests required representative of the gas of the district in which such tests are made. The inspector, when properly qualified for his position, is well fitted to superintend the purchase and installation of the necessary equipment. Therefore, his recommendations as to the laboratory, the office, and their equipment should have great 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.

3. REGULAR INSPECTION REQUIRED

The regular gas-inspection work of a city would fall under five heads, viz: Candlepower tests, heating value determination, tests of purity, pressure record taking, and tests of meters.

Candlepower Tests.—In order to maintain a reasonable supervision of the quality of the gas in a large city, the photometric determination should be made, if possible, daily. A single test would be sufficient unless the gas were found to be below the standard specified, in which case a repetition of test is desirable. These tests, when made at only one point, do not necessarily represent the gas throughout the whole city, but since this test is less important than the heating-value determination, one station is sufficient, and the requirement of only a single photometer will materially reduce the expense of inspection apparatus and the time required for regular tests. When no heating-value determinations are made, a larger number of candlepower tests would be desirable.

When more than one company operates in a city, one test should be made upon the gas furnished by each, which can usually be done on a single photometer. However, the difficulty in the use of a single wet meter for more than one gas would suggest the necessity of employing a separate meter for each gas to be tested.

It may be that in cities of moderate or small size only occasional tests or even no active enforcement of the regulation as to gas candlepower will be necessary. In these cities if the company regularly supplies a gas of reasonable lighting value, an occasional test of candlepower would be sufficient; and this would be especially true in case the heating value of the gas was regularly tested. If the company understands from the ordinance requirement that a certain nominal candlepower is expected, it will doubtless regularly supply gas of this specified quality; and in case it appears that it is not doing so, the city can promptly begin the enforcement of this section, making regularly the requisite tests of the candlepower to ascertain whether or not the requirement is being met.

Whether or not a city makes candlepower tests, the company operating under regulations involving a candlepower limit will usually find it desirable to make regular if not frequent tests of the candlepower of the gas delivered by it.

Heating-Value Determinations.—With proper location of the testing station, tests of heating value should show the heat received by the average customer. In order to determine whether or not this is the case, it is well

for an inspector to make tests at other points in the city. These tests would not be used for basis of penalty in case lower values were found at points other than the regular testing station, but they might well be the cause of relocation of the station or addition of other stations, if the results obtained at the first location were found not to be truly representative of all parts of the city.

Regardless of the number of tests made by the company the inspector could well make two or more determinations of the heating value per day. 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.

Purity Determinations.—The frequency and methods of testing for the purity of the gas are included 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.

Records of Gas Pressure.—In order to maintain proper pressure conditions throughout the district supplied with gas, a company must first make a considerable number of pressure measurements so that the prevailing conditions may be known. To do this a continuous record of the pressure at various points must be taken by recording pressure gauges. Scattered readings or even regular readings for a few days only are very unsatisfactory and may even be misleading. Recognizing this need of regular records some State commissions have required the companies to take records according to a certain plan, and certain cities provide for pressure records to be taken by the city gas inspector.

In the municipal control of gas service conditions, a satisfactory plan is to provide for a few 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 record is specified, gauges must be so located that no consumer will be more than 3800 feet from a gauge station; for many cities such concentration will

not be needed. On the other hand, it is important that all parts of the district supplied with gas be carefully watched, as changes from year to year may develop serious deficiencies in one part or another. It is not practicable to give any general rule as determining the number of gauges for use in a city, but some of the factors affecting this matter will be discussed in the circular on testing methods.

In addition to the gauges used for regular tests, one or more for use in investigation of complaints of service are needed. The requirement of "additional gauges" 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 gauges should be used to check up outside conditions when this is required.

Since a gas company has control of the gas until it leaves the customer's meter, it is fair to expect that the pressure of the supply up to this point will be regulated properly by the company; indeed, it has been from time to time proposed that regulations should apply to the gas pressure at this point. The measurement at the outlet, rather than as is usually done at the inlet, of the meter would operate, in a measure, to control the repair work on meters, since with such regulation the company would take greater care that the meters do not require more than a small pressure difference to operate them. However, a result obtained by test at a meter outlet is less likely to represent the condition of a district than if the measurement is made at the meter inlet, since it would be affected by the irregularities in the particular meter through which the gas is supplied; and as it is desired that a pressure record should show more than the condition existing on the premises of one consumer, tests at the meter outlet are not usually desirable for the routine records. In complaint investigations they may, however, be valuable.

In the large majority of cases the outlet of the company's service pipe is at the inlet of the consumer's meter, but in apartments and stores a long run of piping within basement or other part of the building may connect the company's service to the meter. In this latter event, it is not infrequently the case that the company has had no part in the installation of this piping, and has no control over it; the company can not, therefore, control the pressure conditions at the meter if such piping happens to be inadequate in size or improperly installed or maintained. In order, therefore, to make the rule generally applicable, it is best to require that the company maintain the specified gas pressures at the outlet of its service

pipes. As a matter of fact, even when the regulation states that the specification applies to pressure at the meter inlet, it is usual to take the records of pressure at the outlet of the service pipe. As has been said, these two points are usually, but not always, the same. The plug which is almost invariably placed at the end of the service pipe just beyond the point where this enters the basement of the building, can be removed and a connection for the gauge substituted. This offers a most convenient point for the test, and unless this particular service pipe is stopped or inadequate for the consumer supplied through it, the test represents the condition of the supply to the whole neighborhood. Because of these facts, the usual custom of testing at service outlet has been recommended by the Bureau.

The objection to measurement of the pressures on the mains only is that this does not permit easy access to places for testing. The rule proposed will allow the inspector to place his recording instruments at any convenient point on the distributing system, and a test of pressure at the service outlet gives practically a record of main pressure.

The gauges used by the city should be located at the discretion of the inspector at various points on the distribution system. It is, of course, understood that permission must be had from the owner when these gauges are located upon private property. The removal of gauges from one place to another should not ordinarily be made oftener than once a week, since the conditions can not be judged properly by observations covering a shorter period. Unless any particular location seems specially suited as a pressure testing station for a neighborhood, it would be well to move all gauges at least once in three months, since a longer observation at one point will rarely offer new information which could not be equally well gained elsewhere in the vicinity; and the more points in a neighborhood examined the better can the inspector judge the true conditions and determine the area over which any particular condition prevails.

This does not apply to the gauges used by the company for routine work, which may often be located permanently at various points on the distributing system, so that by comparison of records from the gauges at different seasons or from one year to the next the company can be forewarned as to necessary extensions of its distributing system to maintain proper pressure at all points. Under these circumstances special service pipes to the gauges will be desirable, so that the main pressures will be recorded.

In setting test gauges great care must be exercised by the inspector, for leakage of gas resulting from his opening the service head may be serious.

However, with careful work no danger need be feared. Since the company is responsible for the condition of the service pipe at all times, it should be represented when it is necessary to open the service head to make a connection for a recording gauge. If leakage results under these circumstances, the company and not the city is responsible for the work.

The specific statement that the inspector may go out and search for irregularities of service might prevent dispute on this point and avoid legal complication, but since the inspector is a public official appointed to secure the safety and financial welfare of the public on these matters, it is assumed that he will be allowed and, indeed, expected to search out irregularities and report them.

The surprising percentage of the complaints of "poor gas," which on investigation resolve themselves into poor pressure, is sufficient reason for the uses of gauges for complaint investigation. However, poor pressure may be due to insufficient size or stoppage of service pipe or to improper adjustment of the appliance as often as to inadequate gas supply.

Meter Testing.—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. Since a choice between the two must be largely dependent upon the attitude of the company and the ability of the city to provide facilities for such testing, what is best in one place may not be in another. The choice of city inspection will require some extra expense for assistants and testing shops, but will give to the city full control over the accuracy and regularity of the tests. However, if a company makes a practice of regular removal and testing of the meters in service, such as would correspond with the requirements of the proposed rule, and does this work in connection with a good meter-repair shop, there is every reason to believe that they can and will usually do as good work as is possible by official testing.

It is sometimes urged that when the city tests all meters the company is too largely relieved of the responsibility for their accuracy, and careless work in meter repairing results. Those of this opinion favor having the company carry on all of the testing and giving the inspector the privilege of supervision and of retest of a few meters at any time he may wish, in addition to testing complaint meters. In any event, the company should be held responsible for the condition of its meters.

The Bureau recommends that the routine testing of meters be done in all cases by the company, but that authority for supervision of this work

be given to the inspector. Some city or State official would be expected to make the complaint meter tests, when the company did the routine work. For State work this plan is unquestionably the better; for cities it seems also preferable. In any city where the 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. This applies, of course, only where no city official tests the meters. For such 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.

Although some of the meter inspection work which appeared 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 supervision of the company's meter-testing work is probably never unfair. Indeed, such supervision may be a necessary thing in some cases, and in all it would be such a valuable protection for the company against unfair public opinion which might arise that the slight inconvenience to the company would be more than compensated thereby.

4. SPECIAL INSPECTION WORK

The proposed section on duties of the inspector is drawn to cover the most comprehensive cases and may be shortened or modified to fit the other sections as they are adopted in any city. However, there is very little that will need change for even 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. From the standpoint of the inspector, these duties should be guarded by two precautions: First, every effort should be made to avoid giving cause for an antagonistic attitude on the part of the company, since it is only by friendly cooperation in such testing and inspection work that the greatest success can be attained; second, great care must be exercised in handling complaints, even though they are often based upon imaginary trouble, in order to protect the company and the inspector from unjust criticism

The customers of gas companies often have excellent ground for complaint, but, due to their unfamiliarity with meters and the difficulties of gas distribution, they sometimes complain without reason. However, the public pays both for the gas it uses and for the cost of inspection and is entitled to courteous and patient treatment when complaints are made.

In those cities where both company and city inspector make full, careful, and courteous investigation of complaints the relation between public and company has been more agreeable than elsewhere.

The idea of cooperation of company and inspector in the investigation of complaints and irregularities of service is not new, although it is not generally followed. We believe 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 service rendered. The plan of cooperation of the public officials with the company in 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.

5. RECORDS AND REPORTS

Company Records.—The requirement of keeping records, as proposed in section 12, is reasonable. Similar records should be kept by all progressive companies, without requirement. This section, then, becomes, in effect, a requirement that the company shall allow access to its records. The necessity for this use of company records by the inspector will be apparent in connection with complaints which come to his office. The data required to be kept are essential to intelligent action in many cases and will furnish the inspector with the necessary facts for action on each case as it arises. It will also insure that the inspector sees "the other side of the story" when a complaint is made to him.

The first two records combined give full information in the meter-testing work. There is no more ready means of dealing with meter problems than by having full data of each meter and a full record of each customer on a card which can be found in an instant by reference to a file.

The complaint file, arranged by the residences of complainants, provides a defense for the company against the charge that is often made that no attention was paid to complaints made by the customers. When such file is examined with reference to subjects of complaint it is an instructive means of showing the necessary changes in equipment or policy needed to bring about friendly relations between the company and its customers. It should be noted that no record of a complaint is required except when a violation of this ordinance is charged. Complaints as to "high bills" and "poor gas," when supported by no definite information, are often due to a misunderstanding of the facts. Even when disposed of by a simple explanation

it is desirable, although not necessary, that they be recorded. However, the company must not disregard such complaints, as the provisions of section 14 include "all complaints." The use of such files by the company's "complaint department" will amply repay the time and expense of its installation and maintenance, and when this file is open to the inspector he can more fully appreciate the company's standpoint in each situation which may demand investigation on his part.

Inspector's Records.—The inspector would naturally preserve a record of all tests made under the provisions of the ordinance, and since the data of these records are the basis on which penalty may be collected, it is fair that the company have access to them. When special tests are being made by the inspector without the cooperation of the company, such as special heating value measurements in various parts of the city, the results may be given freely to the company; there may be times, however, when the inspector will find it desirable to withhold such data. In this latter event he may do so under the provision proposed in section 6 (the last sentence of the first paragraph).

Reports.—The proposed ordinance gives what is considered a satisfactory system of reports, giving as full publicity as is necessary. The system of rendering a monthly statement of fees, fines, and charges, rather than arrest and prosecution in the city courts of the company by its officers, is especially recommended. When such settlement as is indicated is made, the city does not suffer, and the company and city are both saved the expense and other unpleasant results of litigation.

6. GAS-TESTING EXPENSE

The expense of gas testing may be divided as follows.

(1) Equipment expense, consisting of service pipe and blow-off connection, laboratory apparatus, office furnishings, and meter-testing equipment.

(2) Current expense, including rent of testing stations, rent of meter shop, salaries of inspector and assistants, and supplies for office and laboratory.

Certain parts of each kind of expense seem to be reasonably chargeable to the company and others to be chargeable to the city treasury. However, no general rule can be laid down for the distribution of the expense. In some cities the expense is borne entirely by the city, in others chiefly by the gas companies, and in still others the expense is divided.

7. DISPUTES OVER TESTING METHODS

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 largely to eliminate such difficulty 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. This course has proven very satisfactory for the English cities; 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 less satisfactory.

In order to furnish to the American gas inspectors a source of information on standard testing methods, the Bureau of Standards will soon issue a circular on this subject which will represent 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 at all times represent the latest available information.

In the preparation of this circular all conclusions expressed as to apparatus or methods of testing have and will be first confirmed either by actual experience of the Bureau with such apparatus or by the agreement of the majority of those who have given fair trial to the method in question.

When prepared on this basis, it seems certain that the reference to such circular as a basis for settlement can be made with the assurance that the result of such reference would be as fair to both parties as is possible with the existing knowledge and experience. 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.

Section 15 provides also a technical board of last resort. 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 more desirable that this be done by the arbitration board 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.

8. PENALTIES

The failure to observe regulations made as to gas quality or service may be due to accident, carelessness, or intentional 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.

In case the violation of a regulation is not due to causes beyond the prevention of the company by reasonable care and forethought, some means should be taken to reimburse the public for the loss or inconvenience which results from the violation. The method of reimbursement for such damage may be by direct rebate on the charges for service or by the payment of a fine or penalty to the city. A rebate to be paid to all customers is a cumbersome method of adjustment and with a proper ordinance it should never be necessary. For city enforcement of gas regulations the fine for failure to comply with the ordinance or franchise requirements is usually better than the rebate; under State supervision of gas companies no penalty requirements are needed except as are provided in the penalty for disobedience to orders of the commission. In the following paragraphs the discussion of penalties applies only to city enforcement.

It is often said that publicity is the best penalty for failure to meet requirements, and in a measure this is true. In two ways, however, a penalty expressed by a fine of a certain number of dollars, chargeable to the company, has an advantage: First, such penalty provision gives the customer an idea of the seriousness of the offense, preventing an undue amount of criticism resulting from rather minor infractions of the law and subjecting the company to more severe criticism when really deserved; second, a company can, by the payment of penalties assessed under the law, recompense, more or less completely, the public for the inferior quality of service rendered, thus making good losses actually occurring through its negligence, and in a measure relieving itself from further criticism on the score of profiting at the expense of the public.

There is no doubt that an ordinance can be made so complicated and so overburdened with penalties as to be unfair to the company; but

in general all points on which the public wishes assurance as to the company's methods of operation should be prescribed, and penalty of suitable severity for failure to meet the requirements is proper. The fact that a company will probably without requirement meet certain essential conditions as to the quality of service does not make the provision in the law for such service unnecessary; the specifications as between seller and purchaser should be complete and clear on all points. It is, of course, understood that the enforcement of penalties shall be made only in case of repeated offense or gross violation on the part of the company.

The fines are stated in the proposed section as $X and $Y, according to the seriousness of the offense, $X being a larger sum than $Y. The obvious advantage of making a distinction between an offense causing serious loss or danger to the consumers and one involving only inconvenience of rather temporary character needs no emphasis.

As the size of a company's business largely determines the seriousness of offense, X and Y can be varied to fit local conditions. As an approximation as to the size of fines now in use or desirable we would submit the following:

Companies of class 1,[10] $X = $200–1000, $Y = $50–200
Companies of class 2, $X = 50– 200, $Y = 20– 50
Companies of class 3, $X = 20– 50, $Y = 5– 20

The conditions for penalties have already been sufficiently discussed under the sections where the corresponding requirements are made.

The cases of exemption from penalty described cover all of the cases in which reasonable objection can be made. If the tests made with the privilege of supervision by a representative of the company are not satisfactory to the company, the method of settlement is provided elsewhere (sec. 15); unless it avails itself of such method it should be held to the fines as here required.

By the system advocated and described in section 14 the company can pay the penalty and without any court proceedings settle the matter. However, when it desires to defend itself against the charges made it will have ample opportunity to do so by mere refusal to pay within 30 days and the use of the regular methods of defense in the proper courts.

The suit for payment of the amount claimed can be brought in any proper court of the city by any officer to whom the city council wishes to assign this duty. Since the city clerk receives a copy of the report, he

[10] For this purpose companies are classified as follows: Class 1, annual sales 500 million or more cubic feet; class 2, annual sales 50 to 500 million cubic feet; class 3, annual sales less than 50 million cubic feet.

should be responsible for bringing it to the notice of the officer who takes the legal action whenever the company should thus be compelled to make payment. A delay of payment may be allowed by the city council in order to settle any dispute by means of the arbitration methods elsewhere described. When such arbitration proceedings are pending the fines affected by their decision should be made subject to such decision. Furthermore, when a company disputes several monthly statements these can be combined in a single suit, so that action in the courts would not be necessary more than once a year at the most.

Provision is made in section 4, paragraph (d), that the monthly report of the inspector, or an abstract of it, shall be published. This would give considerable publicity to the matter and might offer an added incentive to the company to furnish gas always within the specified limits. An exaggerated advertisement of a slight deficiency in a way to subject the company to unfair criticism of course is to be condemned; however, the simple statement that the quality of the gas was found to be above standard or deficient to a certain degree might be of some advantage in any city.

C. STATE INSPECTION SERVICE

As the experience of most of the States in control of gas-company operations has been confined to a very few years, the inspection practice is not generally in what could be called its established form. It is not desirable, therefore, to attempt a full discussion of the present practice of the various States, but rather desirable to take up the several phases of the subject and indicate the plan for each which appears to have given greatest satisfaction. The scheme which is being followed in most States which are active in gas inspection has been carefully investigated by the Bureau and the conclusions expressed in the following sections represent the results of this investigation. In Part IV a report on each State active in this work is given.

1. FORM AND POWERS OF COMMISSION

For the purposes of this circular it is of no consequence what form of State commission is chosen, since we are considering only the technical gas requirements and their enforcement. Thus, in a State which would choose to have a general public-utilities commission, with a department of heat and light, under which would be a bureau of gas, and by still further classification of this bureau into divisions, one to be a division of gas testing, the data of this circular would relate to work of this last subdivision. Therefore, in the following portions of this circular the word "commission"

refers to that subdivision or those representatives of the State commission who are in charge of the technical gas matters.

Since it seems certain that the adoption and enforcement by a State of uniform requirements as to gas quality and service would demand that the State also have authority in the matter of price, and since such jurisdiction has been given to all commissions thus far established, the following discussion is based on the assumption that such condition will exist.

The grant of limited legislative powers which has been made to all the State commissions thus far established has been attended by considerable advantage and in some respects is essential to the success of any State gas inspection. Its limitation is accomplished in some States by fixing the maximum or minimum requirement which may be made of any company in respect to certain of the more important technical matters. The advantage of this method of limitation is the assurance to the companies concerned that their interests will be protected by the State law; but with a commission of technical experts the disadvantage of limiting their technical authority is apparent, for in many cases no opportunity is allowed for the adoption of requirements specially suited to a particular company concerned. Indeed, the fixing by State law of a limit of the requirements to be made of the companies is generally interpreted to mean that this limit of the requirement shall be the requirement itself.

For the purposes of this discussion it will be assumed that the commission is to be empowered to fix the requirements to be met by the companies under its jurisdiction. The present tendency seems to be strongly toward granting such authority to the State commission.

In certain States the commission is empowered to order changes in methods of manufacture, and is actively exercising such right. When considered from certain points of view this authority may seem unnecessary and perhaps unwise. The object of a gas law is to insure the public a gas supply of good quality, properly delivered at a reasonable price. These results may, in general, be accomplished by any effective method a company may desire to use, and the commission, while perhaps advising means of best accomplishment, will usually need to influence the method chosen no further than to insist upon attainment of the proper results.

The following statement from the chief inspector of one of the commissions having this authority is probably a fair conclusion:

> In regard to giving commissions authority to order specific changes in operating practices, it would seem that such authority should be exercised with great caution. Generally it would probably be sufficient to require good service and to make, if necessary, general suggestions as to how this should be accomplished. It is believed, however, that occasions arise where it is of great advantage for the commission to have the authority to order specific changes.

2. PROCEDURE IN ADOPTION OF REGULATIONS

As an illustration of the steps which may be preliminary to the establishment of a set of service regulations, the following section, taken from a report of the Wisconsin Railroad Commission, is given. This outlines the particular plan followed in one State and shows very clearly some of the more important steps in the adoption of regulations.

The provisions of the public utilities law relating to standards for public utilities operating in Wisconsin read as follows:

"1. The commission shall ascertain and fix adequate and serviceable standards for the measurement of quality, pressure, initial voltage, or other condition pertaining to the supply of the product or service rendered by any public utility and prescribe reasonable regulations for examination and testing of such product or service and for the measurement thereof.

"2. It shall establish reasonable rules, regulations, specifications, and standards to secure the accuracy of all meters and appliances for measurements, and every public utility is required to carry into effect all orders issued by the commission relative thereto." (Sec. 1797m–23, ch. 499, Laws of 1907.)

With a view to performing the duties imposed upon the commission by the above-quoted paragraphs of the public utilities law, a number of experts were added to its engineering staff, who, under the immediate supervision and direction of W. D. Pence, chief engineer, and C. F. Burgess, expert on light and heat, undertook comprehensive laboratory and field investigations.

After sufficient progress had been made in different lines of investigation to reflect the general situation in this State, a conference of representatives of gas and electric companies was called for the purpose of arriving at a better understanding of the problems involved in the establishment of standards for gas and electric service. This conference was held at Madison March 3, 1908, and was attended by about 200 representatives of gas and electric companies, as well as by other experts from different parts of the country. The Bureau of Standards, of Washington, also sent a representative.

The conference proceedings have since been supplemented by letters and communications, all of which have been carefully considered. The results of this consideration have been formulated in the shape of formal rules and annotations, which are now published for the guidance of the managements of the various gas and electric plants in Wisconsin. If any management anticipates or experiences difficulty in complying fully with such rules and regulations, it is expected that application for a modification of the rule or rules with regard to which difficulties are encountered will be made to the commission; but until a modification of any rule or regulation herein prescribed has been expressly authorized by the commission the gas and electric companies will be expected to comply strictly with the terms of every rule and regulation ordered herein. It is possible that certain plants are operated under conditions which make it impracticable or not to the best interest of the public to meet all the requirements of all the rules. Under such conditions it devolves upon the utility to show to the commission by complete and convincing evidence that a modification of some rule or rules should be made.

The rules which were selected and announced July 24, 1908, remained in force until August 9, 1913, when they were superseded by the ones printed on page 164. The enforcement of these rules has been more or less fully provided for by State inspectors. The rules which are proposed by the Bureau for State adoption can be used as a starting point for any commission, but they would probably not be adopted for any State without some investigation

as to their applicability to that particular State. As an argument against general rules, the statement has often been made that certain provisions which are generally applicable do not fit all situations. This is of course true; but when the facts of various situations are carefully considered, it appears that what constitutes good service in one city will almost invariably be good service elsewhere. Certainly very much greater uniformity of regulations than is now found is practicable.

3. INSPECTION ROUTINE

The systematic testing of gas 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 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 New York State, for example, five or more gas inspectors and at least 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.

Regular Testing by Companies.—The rules proposed 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 their gas supply for hydrogen sulphide; further determinations of purity and heating value would be made by the larger companies as indicated in the proposed rules.

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 in case there were 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 number of records and frequency of tests to be made by the companies can be left to the companies themselves in the majority of cases. If any company does not make as many or as frequent tests as may seem to the State commissions to be desirable, an informal request by the latter that the frequency or number be increased would usually be sufficient to bring satisfactory results. It will be noted that no candlepower tests are required of any company by the rules proposed. At any time when the quality of the gas with respect to candlepower is apparently not satisfactory, the rules may be supplemented by the State authorities requiring candlepower tests. This will seldom be necessary.

The proposed requirement of tests of heating value is very similar to that made in Wisconsin. In some States companies making less than 20 000 000 cubic feet of gas annually could well be required to purchase and use a calorimeter. The expense of such purchase and use would scarcely be excessive for any company making 10 000 000 cubic feet per year, if it were sure that such small company could and would afford the time of a competent man to use the instrument properly.

The rule proposed for hydrogen sulphide is perhaps less rigid than that in force in New York and corresponds fairly closely with the practice of Wisconsin inspectors. The test specified for this impurity is not too severe and yet will give sufficient information to permit good control.

The setting of two limits for sulphur and ammonia has been considered; it is different from the usual practice of providing one limit for all kinds of gas. As water gas can be economically made with a lower sulphur and ammonia content than coal gas, the limits for the two might be different in order to insure the best service practically attainable in each case; however, a uniform value for all kinds of gas has been chosen, similar to those now in force in all States making any such regulations, since this appears to be the best plan for practical application.

The plan followed by States in requiring regular and full surveys of gas-pressure conditions to be made by the companies is excellent where the State authorities are in charge and can supervise or check up records of

this sort. It is impossible for most State commissions to take these records by their own inspectors, and the records taken by the company are usually a satisfactory substitute if the work is properly supervised. Occasional records taken by the State officials are, of course, desirable.

In very few cases the State commissions fix the number of records which must be made by the company; it is usual to fix the requirement in rather general terms, for example, "each company shall make frequent measurements of the pressure and pressure variations." This rule is then interpreted to each company affected in a way suited to the local conditions.

Supervision of Companies' Testing.—When the routine tests are made by the companies, it is assumed that State inspectors will 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 test may be subject to frequent 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, either intentionally or because of poor management, continually fails to conform to the regulations.

This 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

gauges 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 portion of the traveling inspection work is the calibration or standardization of the companies' testing apparatus and instruments. For all of the company tests and for many of those by the inspectors this apparatus will be used, and its calibration is essential previous to any inspection work. One of the most satisfactory ways of calibration will doubtless be by comparison of results obtained by the company's apparatus with those resulting from the use of a portable outfit, which latter would also be required for use at small works where no apparatus is provided by the companies. Such comparison 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, will form a part of the circular on 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 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.

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. The number tested should be such as will give an indication of the actual condition of those in service, and be an effective check upon the company's practice. It is believed in this manner the State insures, at comparatively slight expense, the accuracy of service meters. 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.

It is provided, besides, that a consumer may have his meter tested by the company at any time he may desire (provided this is not oftener than once in 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.

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 works as done by the companies. As some other States may wish to follow this plan, a brief review is included of the plan followed in New York State and Massachusetts.

The board of commissioners of gas and electric light in Massachusetts make regularly a large number of tests, which are here summarized, for a period of five years.

	1907	1908	1909	1910	1911
Number of inspections	977	1018	929	890	899
Number of companies subject to inspection	67	68	68	68	68
Number of meters tested	[11] 59 475	58 875	73 994	82 643	86 730
Number of complaint meters tested	[11] 356	438	415	328	457

[11] For eleven months.

The inspection work of this State is done by the inspector of gas and his assistants, who are appointed by the governor for a term of three years, and are responsible to the board. The board, however, is authorized to appoint deputies to aid in the inspection, but such appointment can be only for one year or a shorter period. All of the expense of the board and the work of inspection is assessed against the companies concerned, in proportion to their gross earnings, except such expense as is met by special fees required by the law.

The inspection consists of a determination of candlepower, sulphur, and ammonia, and a test for hydrogen sulphide. For the use of the inspecting officer, each company making more than 15 000 000 cubic feet of gas per year is required to provide a testing station at least a quarter of a mile from the gas works, and equip this station with a disk photometer.

In the State law the fees for certain meter tests are fixed as follows:

> For examining, comparing and testing meters, with or without stamping them, the board may collect a fee of twenty-five cents for each meter delivering not more than a cubic foot of gas in four revolutions, vibrations or complete repetitions of its action, and for each meter so delivering more than a cubic foot, a fee of thirty cents with twenty cents added for every additional cubic foot so delivered. For examining, testing, comparing or calibrating meter provers and tests of photometer meters, with or without sealing or certifying to the same, the board may collect such fees as it may from time to time establish therefor.

Under the provisions of this last sentence the board has fixed fees as follows: "For meter provers, five dollars for each two-foot prover, with an additional fifty cents for every additional foot of capacity, and for photometer meters, two dollars per meter."

During the year 1911 the testing of meters gave an income of over $22 000, and the operating expenses, including salaries of gas and gas-meter inspectors, was only about $15 000. The board thus had a surplus of $7000 for that year from its gas-inspection department.

The systematic testing of the gas quality and service is accomplished in the second district of New York by visits of traveling inspectors, who at each visit determine candlepower, amount of sulphur and ammonia, test for hydrogen sulphide, and take one or more pressure records. In this manner each company making annually less than 10 000 000 cubic feet of gas is visited six times per year and for each additional 10 000 000 cubic feet an additional test is made, up to a maximum of 26 per year. This system required about 750 tests for the supervision of the 81 companies visited in 1908. For convenience of operation the State is subdivided into three gas-inspection districts with headquarters as follows: One at Albany, with the chief inspector and two assistant gas inspectors; one at Mount Vernon, with one assistant gas inspector, and one at Rochester, with one assistant gas inspector.

In a similar manner the meter testing is done by districts, of which there are four, with headquarters as follows: One at Albany, with the chief inspector and two meter inspectors; one at Brooklyn, with one meter inspector; one at Syracuse, with one inspector; and one district with three inspectors operating from Rochester, Buffalo, and Jamestown.

Every Saturday each inspector receives from the chief inspector the outline of his work for the next week, and this is so arranged as to bring him back to his headquarters at the end of the week's trip.

The results of these tests for candlepower, hydrogen sulphide, and ammonia are communicated to the company by the inspector immediately upon completion of the test; and if later correction is found necessary, this is made upon the official report from the commission, which also gives the result of tests for sulphur. On receipt of the official notice the company is required to explain deficiencies reported, if any, and to state what remedy has been applied.

This State requires that all meters be tested by a State official before installation by any company. The inspection work is carried on by seven meter inspectors, located in four districts, aided occasionally by the gas inspectors, and is so organized that practically no delay occurs either in testing at request of the companies or in inspection of complaint meters. Each company provides the apparatus and shop needed for the meter work, and when they desire to have testing done they are required to notify

the commission. Thus, no regular routes are laid out, but the inspectors are given instructions weekly by the chief inspector as to their trips for the following week. The provers provided by the companies are tested by the commission and then used for its routine work. Thus, during the year 1908 over 100 000 meters were tested by the commission. Of this number less than 300 were tested on complaint of a customer.

The expenses of the gas and gas-meter inspection of the State are met by appropriation from the State treasury. No fees are charged except for testing of complaint meters.

It is assumed that under such system each inspection made by a traveling inspector would include determination of sulphur, ammonia, 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 provides 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. Based on the experience of these States, the following statement has been prepared as a suggestion of the minimum frequency suitable for normal conditions if the commission wishes to do all of the testing, variation in frequency being made according to size of company.

	Annual sales (million cubic feet.)
Bimonthly test	Less than 20.
Monthly test	20–50.
Semimonthly test	50–200.
Weekly test	Over 200.

Having determined the frequency of test necessary in each city, the division of the work into inspection districts similar to the arrangement made by the New York commission 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 in his 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 by the chief inspector from week to week, as is done by the New York officials.

In addition to the tests by traveling inspectors it might be desirable that in each city where a gas works is located the commission appoint a

deputy to carry out a few simple tests and to act as their local representative. Such work would correspond to the work of a municipal inspector in a small city. Such duties would require only a small amount of time and no special technical training would be needed. This plan has, as far as the Bureau is informed, never been in use, but it appears to offer considerable advantage in watching at least two of the matters which the commission has in charge.

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 they wished 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 success in the New York inspection work.

If we assume that because of complaint, repairs, purchase of new meters, etc., the equivalent of one-fourth 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.

Records and Reports.—The records required of each company are given in sufficient detail in the proposed rules. They are also discussed in connection with municipal enforcement.

Each inspector, meter tester, and deputy should make two reports on each test or inspection made by him. The first of these reports should be rendered to the company at once at the conclusion of the test and the second should be sent to the commission as a part of the weekly report. The

immediate report to the company would enable it to undertake at once the correction of any irregularity which might be indicated thereby, and it would be subject to correction, as noted later. The weekly report to the commission would serve as the permanent record of tests after it had been verified by the chief inspector. This follows the New York system of reports closely.

The technical records of the commission would be of three classes: Records of routine tests and inspection, periodic reports of each company under their supervision, and records of the complaints made and the investigation or hearing proceedings necessary for their settlement. The first of these records is merely a file of the inspectors' reports, suggested in the preceding paragraph, with such summaries of these as may be desirable for reference purposes. Similarly, the reports required from the companies constitute the second record of the commission.

4. SPECIAL PROVISIONS FOR ENFORCEMENT

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

The complaints of customers 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 disputes by public hearing and subsequent ruling of the commission is an expeditious and satisfactory method, since matters with which it 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.

Penalties.—It will be observed that no penalties are proposed in case of failure to meet the requirements. Penalties have been found unnecessary under State commissions. The influence of public opinion and the knowledge that persistent failure will subject them to penalty for noncompliance with orders of the State commission have always proven sufficient to insure good results from gas companies without penalties directly imposed by the commissions.

Special Investigations.—Whenever it appears that a company can not, with its current methods of operation, comply with the provisions made by the State, it may become 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 such 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 the special case.

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PART III.—PROPOSED ORDINANCES AND RULES

In order to give in convenient form a summary of the recommendations of the Bureau on municipal and State gas regulations, an ordinance suitable for adoption by a city and a set of rules suitable for enforcement by a State commission have been prepared.

If these proposed forms can not be adopted as a whole, they can at least be followed closely in most places, modifications being made to adapt them to local needs in the manner indicated in the earlier sections of this circular.

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 given be made only after careful consideration. The numerical values specified must, of course, be modified to meet local needs, but the general form proposed has been carefully arranged so that it will be generally applicable. Every effort has been made to simplify the form of the proposed regulation and further abbreviation might result in omitting an essential part; but the ordinance and rules proposed must be considered in the light of the discussion, and any necessary changes made to meet special conditions.

A. PROPOSED CITY ORDINANCE

After an examination of nearly all existing gas ordinances the Bureau has attempted to embody in the following model the best features of existing ordinances and such additional matter as seemed necessary and to arrange the several sections in a logical and convenient form. The proposed ordinance is intended for use under ordinary conditions, and should be modified where necessary to meet unusual conditions, as is indicated in the preceding discussion. Although the regulations are not as severe as have been enforced in some places, they are probably sufficiently strict to offer good protection to the gas users under ordinary conditions. They should be considered in connection with the discussion of the earlier part.

The ordinance as given below is intended to meet normal conditions in a city of 25 000 or more population. For smaller cities the ordinance may better 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; and prescribing penalties for the violation of such rules and regulations.

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

SECTION 1. *Definitions.*—In this ordinance and the various sections and parts thereof 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 "customer" shall include any person, company, corporation, or other party to whom said gas 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 opinions to a maker or vender of such articles 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 ten days in which to answer such charges. All such charges and the inspector's defence against them shall be made a matter of public record: *Provided, however*, That at the time when first appointed, the inspector shall serve for a probationary period of six months; and he may be removed by the mayor during said six 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 two 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 and pressure of the gas and 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, calibrations, and formal complaints, which shall be preserved complete and correct. He shall open said records to the company and, in his discretion, to any person who wishes to examine the records.

(d) He shall make a monthly report of the tests made as to candle-power, heating value, impurities, and pressure of the gas, and of the tests made of gas meters. One copy of said report shall be sent to the company, one to the city council, and one to the city clerk; and the whole or an abtract of said report shall be published by the city clerk in the official papers of the city. The inspector shall also render monthly an itemized statement of the amount due to the city from the company for penalties or fees required in section fourteen of this ordinance.

(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.[12]

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 a 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 or candlepower of the gas used in the determination of liability for penalty under section fourteen 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. Special tests may be made at places other than the regular testing station without notice to the company, and the results of such special tests may be communicated to the company at the discretion of the inspector.

The character of the apparatus and supplies used in all testing, the calibration of said apparatus, the testing of said 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, "Standard Methods for the Testing of Illuminating Gas," except in so far as said provisions may be contrary to any part of this ordinance.

Unless otherwise provided a cubic foot of gas shall mean that amount of gas which occupies the volume of one cubic foot at the temperature of sixty degrees Fahrenheit, when saturated with water, and at a pressure of —— inches of mercury, which is taken as the average condition as to temperature, humidity, and pressure of the gas as metered to customers in this city.[13]

SEC. 7. *Heating Value.*—The gas supplied by the company, when tested as herein provided, shall show a monthly average total heating value of not less than —— A —— British thermal units per cubic foot of gas; however, no daily average total heating value of the gas shall be less than —— B —— British thermal units per cubic foot of gas.[14] It is understood and agreed that a gas of the heating value as thus defined is equivalent to a

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

[13] Alternate for last paragraph of section 6: Unless otherwise provided a cubic foot of gas shall mean that amount of gas which occupies the volume of one cubic foot at the temperature of sixty degrees Fahrenheit, when saturated with water, and at a pressure of thirty inches of mercury, which conditions are taken as standard conditions for gas measurement in connection with the testing of gas. However, in the sale of gas no reduction of gas volumes shall be made to standard conditions, but the meter readings shall be used as taken.

[14] If the company is permitted to reduce the heating value of the gas with a proportional reduction in price, the form given on page 32 may be substituted for the first sentence of section 7. The alternate form there proposed has much to recommend it.

gas having a heating value of —— C —— British thermal units per cubic foot of gas measured at thirty inches of mercury pressure.[15]

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 five 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 twenty daily averages shall be used to determine a monthly average heating value upon which penalty is demanded under section fourteen hereof.

SEC. 8. *Candlepower.*—The gas supplied by the company when tested as herein provided shall show a monthly average candlepower of not less than ——— International candles. It is understood and agreed that a gas of the candlepower thus defined is equivalent to a gas of approximately ——— candlepower when measured and burned at a barometric pressure of thirty inches of mercury.[16]

The candlepower of the gas shall, if possible, be determined by the inspector at least once each working day, and the average of all of the results thus obtained during any one calendar month shall constitute the monthly average candlepower for that month: *Provided, however,* That results obtained on not less than twenty days shall be used to determine a monthly average candlepower upon which penalty is demanded under section fourteen hereof.

The candlepower observation shall be made upon the gas burning at approximately five cubic feet per hour, measured under existing atmospheric conditions, from a ———— burner.[17] Subsequent correction of the observed candlepower shall be made so as to determine the candlepower that would have been observed if the gas had been burned at the rate of exactly five cubic feet per hour, measured as provided in section six hereof.

The standard lamp used for comparison shall be tested and certified by the National Bureau of Standards; and if a flame standard lamp is em-

[15] Alternate for second sentence of section 7: It is understood and agreed that the gas as thus rated has an actual heating value per cubic foot as metered to customers of approximately —— D —— British thermal units.

[16] Alternate for second sentence of section 8: It is understood and agreed that a gas of the candlepower thus defined will furnish a light of approximately ——— International candles when burned at five cubic feet per hour, measured under average local barometric conditions.

[17] The name of the burner, which should be one of the forms of lava-tipped, open-flame burners, should be inserted here. See circular on gas-testing methods for names of burners.

ployed, the value assigned by said certification as the candlepower of the lamp when burned at the mean barometric pressure of this city and in air containing eight-tenths of one per cent by volume of water vapor shall be used in the calculation of the measurement of the candlepower of the gas. If an electric standard is used correction of the measured candlepower shall be made to a humidity of eight-tenths of one per cent by volume of water vapor in the air, which is taken as a standard condition of humidity for photometry.

SEC. 9. *Impurities.*—The gas supplied by the company when tested as prescribed herein shall show the presence of not more than a trace of hydrogen sulphide and shall contain in one hundred cubic feet of gas not more than thirty grains of sulphur in any and all forms known as total sulphur and not more than five 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 one minute a strip of white filter paper freshly moistened with a solution containing six and one-half per cent by weight of lead acetate, the gas flowing at the rate of five 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 shall show no darkening perceptible by comparison with another similar strip of paper which is wet with the same solution but has not been exposed to the gas.

The determination of total sulphur and ammonia shall be made once each week at each testing station: *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. 10. *Pressure of Gas.*[18]—The company may divide its distributing system into as many districts as it shall consider desirable, and it shall fix for each such district or for the whole distribution system a normal pressure which it proposes to maintain; and the company shall file with the inspector a statement of the normal pressure thus fixed. Gas shall be supplied by the company to each district at a pressure never varying by an amount

[18] Two alternate forms of pressure rules are given on p. 59.

more than two inches of water pressure above or below the normal pressure thus fixed, as measured at the outlet of the company's service pipe to any customer: *Provided, however,* That the maximum pressure on any day at any such outlet shall never exceed twice the minimum pressure on that day at that outlet.

The company may change the normal pressure in any district, provided it shall first give written notice to the gas inspector and to each customer in the district affected, and shall without charge to the customers readjust all appliances in use in the district and shall replace any burner which is not suitable for use with gas supplied at the new normal pressure with a burner which shall be suitable for use at the new normal pressure.

The pressure as measured at the outlet of the company's service pipe to any customer shall never be less than two inches of water pressure, nor shall it be greater than —— inches of water pressure without the written permission of the inspector or the written request of a customer for gas at higher pressure to supply high pressure appliances.

Each testing station shall be equipped with a continuously recording pressure gauge by means of which a record shall be made of the gas pressure at said station. Additional gauges 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 equivalent to two inches of water pressure, then the company shall promptly and permanently correct this deficiency within three months of the time when it is first reported to the company, if possible: *Provided, however,* That if this deficiency of pressure be first reported to the company between November first and April first, then the company shall be allowed until the first of the following July to make such correction.[19] But if at any time a pressure shall be discovered by or reported to the company as less than one and one-half inches, then correction of this deficiency shall be made at once.

Sec. 11. *Meters and Meter Testing.*—Every meter which shall be used by the company for the measurement of gas supplied to any customer shall be tested by the company, and if found correct within one per cent, shall be sealed before installation for use. Meters shall be tested as follows:

(a) During each period of one year after the passage of this ordinance, until all such meters have been tested, the company shall remove not less than twenty per cent of the meters now in service. Said meters shall be

[19] In cities where the ground does not freeze enough to seriously interfere 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.

tested and sealed, as required of meters described in paragraph (c) of this section. The removal of said meters now in service shall be made as nearly as possible in the order of the length of time since they were last tested, those longest in service being removed first.

(b) All new meters purchased by the company and all old meters which have been repaired, adjusted, or removed from service for any cause shall be tested and sealed before being placed in service.

(*c*) No meter shall be allowed to remain in service longer than ——— years after being once tested and sealed before being again tested and sealed.

(d) Any customer's meter shall be tested free of charge by the company, upon application of said customer, unless in special cases the company is given permission by the inspector to make a charge for such test 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 one year of said application; and, second, that the customer shall agree to accept the result of such test by the company as a basis for settlement of the difference claimed.

(e) Upon application of any customer and after deposit with the inspector by said customer of the sum of one dollar, the inspector shall test said customer's meter. If the meter proves to be slow or correct within three 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 three per cent fast the company shall pay into the city treasury fifty cents as the fee for said test, and the deposit of one dollar shall be returned to said customer by the inspector; and, further, the company shall refund to the complaining customer 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 at the time of said test. If the meter proves more than three per cent slow the company may charge to the complaining customer such percentage of the amount of the bills for the six months just previous to said complaint, or during the time said meter was in use not exceeding six months, as the meter shall have been shown to be in error at the time of said test.

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

If on removal of any meter from service for any cause it shall be found more than three per cent fast, the company shall refund to the customer for whose use said meter had been installed such percentage of the amount

of the bills of said customer for the period of six months just previous to the removal of said meter from service, or for the time said meter was in use by said customer not exceeding six months, as the meter shall have been shown to be in error at the time of said test.

For purposes of supervision of 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 or calibrate 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 supervision 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. 12. *Company Records.*—The company shall maintain complete and correct 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 customers purchasing gas from the company and the number of the meter or meters in use by each.

Second. A record of all the 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 testing 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.

SEC. 13. *Complaints.*—The company shall make a reasonable investigation of all complaints made to it by the inspector or by any customer and shall promptly make all such changes, alterations, or additions to its methods or apparatus and equipment as may be necessary in order that the quality and the pressure of the gas shall be such as is required by the provisions of this ordinance. When requested by any complainant, the company shall inform said complainant as to the results of the investigation of his complaint, stating the cause of the difficulty and the approximate time when it will be corrected.

SEC. 14. *Penalties.*—The company shall be subject to and shall pay to the city a penalty of the amount herein stated whenever and as often as it

shall violate this ordinance and shall be convicted thereof in the manner hereinafter provided in each of the following cases, viz:

(1) In case that the daily average total heating value of the gas shall be less than ——— British thermal units per cubic foot of gas for any day, ——— dollars ($Y) for each such day.

(2) In case that the monthly average total heating value of the gas shall be less than ——— British thermal units per cubic foot of gas for any month, ——— dollars ($X) for each such month for each ten British thermal units or major fraction thereof by which said average is less than ——— British thermal units.

(3) In case that the monthly average candlepower of the gas shall be less than ——— International candles for any month, ——— dollars ($Y) for each such month.

(4) In case that more than a trace of hydrogen sulphide is shown by the specific test provided therefor to be present in the gas on three or more successive days, ——— dollars ($Y) for each day within such period of three or more working days.

(5) In case that the total sulphur in the gas for any week is found to be in excess of thirty grains per one hundred cubic feet of gas, ——— dollars ($Y) for each such week.

(6) In case that the ammonia in the gas for any week is found to be in excess of five grains per one hundred cubic feet of gas, ——— dollars ($Y) for each such week.

(7) In case that the pressure of the gas at the outlet of the company's service pipe to any customer is at any time found to be less than equivalent to one inch of water pressure, ——— dollars ($X) for each day when such pressure shall be found; or in case that said pressure of the gas thus measured is found at any time to be less than equivalent to one and one-half inches of water pressure, but during the same day never less than equivalent to one inch of water pressure, ——— dollars ($Y) for each day when such pressure shall be found: *Provided, however*, That if the deficiency of pressure noted is due to a stoppage of the single service pipe to the point of test, then the company shall not be held liable for the penalty of this paragraph unless such stoppage is not removed by the company within three days from the time when such pressure deficiency is reported to the company.

(8) In case that the pressure of the gas at the outlet of the company's service pipe to any customer is on any day greater than equivalent to

——— inches of water pressure, or in case that the variation in the pressure of the gas during any one day is greater than the variation allowed by section ten hereof, ——— dollars ($Y) for each such day.

(9) In case that any meter is installed or used by the company contrary to the provisions of section eleven without the written permission of the inspector for such use or installation, ——— dollars ($Y) for each meter so used or installed.

(10) In case that after one month's notice in writing by the inspector the company shall fail or refuse to prepare, maintain, or disclose such records as they are required to do by provisions of this ordinance, ——— dollars ($X) for each week or fraction thereof during which they so fail or refuse to carry out said requirements.

Provided, however, That the company shall not be liable for penalty as hereinbefore specified: First, if the inspector shall not have given to the company such report as is required by paragraph (e) of section four hereof regarding the test on which said penalty is claimed; or, second, if the tests upon which said penalty is claimed were not made as required in section six hereof; or, third, if the conditions which caused the gas or gas service to be other than those which are required herein were conditions clearly beyond the control or prevention of the company by reasonable care and forethought on its part.

No Sunday or holiday on which no tests are made shall be considered in the determination of the number of successive working days which are necessary before penalty can be required, but said Sunday or holiday shall be counted in calculating the number of days for which penalty must be paid when said Sunday or holiday shall intervene between the first and last days of any one period for which such penalty may be demanded.

The city clerk shall prepare monthly from the reports of the inspector an itemized statement of the fees, fines, charges, and other indebtedness which is due from the company to the city according to the provisions of this ordinance. Said statement shall be verified and sworn to by the inspector and shall be filed with the city treasurer, and a copy of said statement shall be sent to the company. The company, within thirty days of the delivery to it of the copy of said statement, shall pay to the city treasurer the amount shown by said statement to be due; and if the company shall fail to pay said amount as herein required within said thirty days, then the city, by its proper officials, shall take action, as provided in section fifteen hereof or, if necessary, in some court of competent jurisdiction to compel the payment of said amount.

SEC. 15. *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. 16. *Repeal.*—All ordinances of the city and parts thereof controvening or inconsistent with the terms of this ordinance are hereby repealed.

SEC. 17. *Time of Becoming Effective.*—This ordinance shall take effect and be in force from and after ———.

B. STATE REGULATIONS

RULES PROPOSED FOR THE USE OF STATE COMMISSIONS

The following rules are proposed as representing the conclusions of the previous sections. They should be considered in connection with the preceding discussion. The form which was first adopted by the Wisconsin Railroad Commission, and which has been subsequently followed by several other State commissions, has been followed. When set forth in a formal order of the commission they may be accompanied by a statement as to the classes of companies to which they apply, e. g., as follows:

It is hereby ordered that the following rules shall be observed and followed by each company in the State of ———— operating as a public utility, municipal or private, for the distribution or sale of coal gas, water gas, oil gas, or their mixtures.

This order shall become effective the ——— day of ———, nineteen ———; and any company or corporation affected hereby which can not observe and follow any rule or rules of this order on and after that date, shall previous to said date make application to this commission for extension of time for compliance with said rule or rules, and such company or corporation shall in such application show cause why it can not comply fully with said rule or rules.

RULE 1. *Definition of a Cubic Foot of Gas.*—For purposes of testing, one cubic foot of gas shall be taken to be the amount of gas in a volume of one cubic foot when saturated with water and at sixty degrees Fahrenheit

and under a pressure equal to the average gas pressure at the customers' meters in the city in question. Said average gas pressure at the customers' meters shall be taken as having the following values in the various cities of this State:[20]

RULE 2. *Heating Value.*—The monthly average total heating value of all gas distributed in this State shall be at any point not less than one-half nor more than one mile from a manufacturing plant, not less than ——A—— British thermal units per cubic foot; and at no time shall the heating value of the gas at such point be less than ——B—— British thermal units per cubic foot: *Provided, however,* That in cities where the gas sold is manufactured in another city the tests may be made at or near the center of consumption in the city where the gas is sold. It is understood that gas of the heating value thus defined, if measured under standard conditions of pressure (thirty inches of mercury), would have a heating value greater than said ——A—— British thermal units per cubic foot in proportion as the standard barometric pressure is greater than the average local gas pressure in each city.[21]

Each company selling more than twenty million cubic feet of gas per year shall provide and maintain a calorimeter and all necessary accessories therefor; and each such company shall make determinations of the heating value of the gas on at least three days of each week.

RULE 3. *Candlepower.*—The actual candlepower of all gas distributed in this State shall be not less than ——— international candles when burned in an open flame burner at five cubic feet per hour measured as defined in rule one.[22]

RULE 4. *Hydrogen Sulphide.*—All 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 six and one-half per cent by weight of lead acetate, shows no darkening perceptible on comparison with a second paper freshly moistened with the same solution after the first paper has been for one minute exposed to a stream of the gas flowing at the rate of approximately five cubic feet per hour, the gas not impinging directly from a jet upon the test paper.

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[20] All cities where gas companies exist should be listed here with the pressure taken as normal for each, given to the nearest tenth of an inch. See p. 18 for a discussion of this rule; and see also the alternate form for rules 1 and 2 on p. 114.

[21] See alternate forms on p. 114.

[22] It is assumed that no regular inspection of candlepower will be required, but a rule fixing a lower limit of candlepower is a guide to the companies. Special inspection service can be instituted when it appears that the service furnished is not satisfactory in this particular. For completeness of specification this rule may be included in the rules adopted for any State; its relative importance has been discussed on p. 11.

Each company distributing gas shall daily test the gas leaving its holders for the presence of hydrogen sulphide, in the manner specified.

RULE 5. *Sulphur and Ammonia.*—All gas distributed in this State shall contain, in each one hundred cubic feet not more than thirty grains of total sulphur and not more than five grains of ammonia.

Each company selling more than one hundred million cubic feet of gas per year shall provide and maintain such apparatus as is necessary for the determination of the total sulphur and ammonia in the gas, and each such company shall regularly determine the amount of total sulphur and ammonia in the gas distributed by it.

RULE 6. *Pressure of Gas.*—Subject to the approval of the commission each company may divide its distributing system 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 a normal pressure which it proposes to maintain. Gas shall be supplied at a pressure never varying by an amount more than two inches of water pressure above or below the normal pressure thus fixed as measured at the outlet of the company's service pipe to any customer: *Provided, however,* That the maximum pressure on any day at any such outlet shall never exceed twice the minimum pressure on that day at that outlet; and the pressure shall never be less than two inches of water pressure at any such outlet.[23]

The normal pressures thus fixed by each company and any proposed changes in these normal pressures shall be reported to the commission and shall be approved by the commission before going into effect.

Each company distributing gas shall regularly take one or more continuous records of the gas pressure in each pressure district fixed under the provisions of this rule.

RULE 7. *Meter Testing.*—No gas meter shall be placed in service until it has been tested and found correct within one per cent, when passing gas at the rate of six cubic feet per hour per rated light capacity. Each such meter shall be sealed by the company testing it with a seal showing the date of such test. Whenever a meter is found to be more than one per cent in error or to be otherwise not in good condition, it shall be repaired and adjusted before being put in service. Meters shall be tested as follows:

(a) During each period of twelve months, until all such meters have been tested, each company shall remove for test not less than twenty per cent of the meters now in service, those longest in service being removed first.

[23] Two alternate forms for the first paragraph in rule 6 are suggested on p. 59 of the discussion.

(b) All new meters and all old meters which have been repaired, adjusted, or removed from service for any cause shall be tested and sealed before installation.

(c) No meter shall be allowed to remain in service longer than ——— years since it was last tested and sealed.

RULE 8. *Request Meter Testing.*—Each gas company, upon request of any customer shall test the accuracy of the meter used by him: *Provided,* First, that the meter in question has not been tested within one year previous to such request, either by said company or by the commission; and second, that the customer will agree to accept the result of the test made by the company as determining the basis for settlement of the difference claimed. No charge shall be made to the customer for any such test. A report giving the result of each such test shall be made to the customer requesting it.

RULE 9. *Meter Testing by Commission.*—On formal application of any customer to the commission a test shall be made upon the customer's meter as soon as practicable by an inspector employed by the commission. For such test the estimated amount of the required fee shall be forwarded by the customer when making application; this fee shall be refunded to the customer by the company if the meter is found to be more than three per cent fast. The amount of the fee to be paid for each test so made shall be as follows: For each gas meter having a rated capacity not exceeding ten lights the test fee shall be two dollars. For all other gas meters the test fee shall be the actual cost to the commission of the test.

RULE 10. *Refunds.*—Whenever a meter removed from service for any cause is found to be more than three per cent fast, the company shall refund to the customer such percentage of the amount of the bills for the previous six months, or for the time the meter was in service not exceeding six months, as the meter was found to be in error at time of removal.

RULE 11. *Testing Station, Records, etc.*—Each company distributing gas in this State shall provide, equip, and maintain a station for the testing of gas and gas meters, and the equipment therefor, such as may be necessary for the testing required in any of these rules; and such station, with its equipment, shall at all reasonable hours be open to the inspection and use of any authorized representative of the commission.

Unless otherwise provided by the orders of this commission the methods of testing prescribed by the National Bureau of Standards shall be used in the testing work done by all companies under these rules.

The original record of every test of gas quality or pressure or of meter accuracy shall be preserved, including all data taken at the time of the test, which data must be sufficient to permit checking of the methods employed and the calculations. The record of each meter test shall show the reason for making the test, the reading of the meter on removal from service and the result of the test.

A record of all tests of heating value, purity or pressure of the gas supply shall be kept open for public inspection.

RULE 12. *Bill Forms.*—Bills rendered periodically for metered gas service shall give the registration of the meter at the beginning and end of the interval for which the bill is rendered and shall give the dates of the readings of the meter.

RULE 13. *Complaints.*—Each company shall make a reasonable investigation of all complaints made to it by its customers; and it shall keep a record of each complaint showing the name and address of the complainant, the nature of the complaint, with a statement of the method and date of its settlement.

RULE 14. *Records and Reports.*—Each company distributing gas shall keep a record of the names and addresses of all customers and the number of the meter or meters in use by each, and a record of all meters owned or used by the company, stating date of purchase, record of use, repairs, and tests to which each meter has been subjected and the present location of each.

Each company shall, on or before the tenth day of each month, report to the commission, for the period of the previous month, as follows:[24] First, the result of all tests made of heating value, purity and pressure of the gas; second, a summarized statement of all complaints received; and third, a statement as to the number of meters purchased, installed, removed from service, adjusted, repaired, etc.

ALTERNATE FORM FOR RULES 1 AND 2

The preceding rules provide for the rating of the gas on the basis of the gas actually delivered to the customer. In many cities this would be a considerably different basis than is now used. In States where it is desired to continue the practice of rating the gas on the basis of its sea-level value the following form for rules one and two may be used:

[24] The form and frequency of reports will, of course, be varied to suit the needs of the commission.

RULE 1. *Definition of a cubic foot of gas.*—For purposes of testing, one cubic foot of gas shall be taken to be the amount of gas in a volume of one cubic foot when saturated with water and at sixty degrees Fahrenheit and under a pressure of thirty inches of mercury.

RULE 2. *Heating Value.*—The monthly average total heating value of all gas distributed in this State shall be at any point not less than one-half nor more than one mile from a manufacturing plant, not less than ——A—— British thermal units per cubic foot, and at no time shall the heating value of the gas at such point be less than ——B—— British thermal units per cubic foot: *Provided, however,* That in cities where the gas sold is manufactured in another city the tests may be made at or near the center of consumption in the city where the gas is sold. It is understood that gas of the heating value thus defined has a heating value per cubic foot metered to each customer proportionately as much less than said ——A—— British thermal units per cubic foot as the gas pressure in said customer's meter is less than equivalent to thirty inches of mercury pressure, which is taken as the standard pressure for gas measurement.

Each company distributing more than twenty million cubic feet of gas per year shall provide and maintain a calorimeter and all necessary accessories therefor, and each such company shall make determinations of the heating value of the gas on at least three days of each week.

When conditions are such that the heating value to be required is different for different cities within any State, the following form for the first paragraph of rule 2 may be used:

RULE 2. *Heating Value.*—The monthly average total heating value of all gas distributed in this State shall be at any point not less than one-half nor more than one mile from a manufacturing plant not less than the values indicated in the following tabulation, and at no time shall the heating value of the gas at such point be more than fifty British thermal units below this average value: *Provided, however,* That in cities where the gas sold is manufactured in another city the tests may be made at or near the center of consumption in the city where the gas is sold. It is understood that gas of the heating value thus defined if measured under standard conditions of pressure (thirty inches of mercury), would have a heating value greater than the average above specified in proportion as the standard pressure is greater than the average local gas pressure in each city.

PART IV.—SUMMARY OF LAWS NOW IN FORCE

A. REGULATION BY STATES OR STATE COMMISSIONS

The present tendency toward State control of the public utilities has led to the enactment of a considerable number of State laws regulating the operation of gas companies. The Bureau of Standards has attempted to make a complete compilation of all such legislation as relates to the candlepower, heating value, purity, and pressure of the gas and the testing of gas meters. The facts given in this section represent practically complete data (to January, 1913, or later) regarding the particular subjects to which they refer. These data are compiled from the information as to the inspection practice of the various commissions which has been furnished in each case by the commission itself.

The following 21 States report that they have no laws upon the subjects discussed in this circular:

Alabama	Michigan	South Carolina
Arkansas	Minnesota	South Dakota
Delaware	Mississippi	Tennessee
Florida	Montana	Texas
Iowa	Nebraska	Utah
Kentucky	New Mexico	Virginia
Louisiana	North Dakota	Wyoming

The following 27 States have more or less complete provisions for regulation of the quality of gas and gas service, but the commissions which are provided for carrying on this work have in some cases not yet prescribed general rules nor taken up actively the inspection of gas:

Arizona	Maine	Ohio
California	Maryland	Oklahoma
Colorado	Massachusetts	Oregon
Connecticut	Missouri	Pennsylvania
Georgia	Nevada	Rhode Island
Idaho	New Hampshire	Vermont
Illinois	New Jersey	Washington
Indiana	New York	West Virginia
Kansas	North Carolina	Wisconsin

The authority given and the extent to which it is exercised in each of this latter group of States is indicated briefly in the following paragraphs. Where all of the municipal regulations are not superseded by the State law establishing the commission, these city rules are included under the list of municipal requirements in force.

1. ARIZONA

The Arizona Corporation Commission has full authority for the regulation of gas quality and service to the exclusion of municipal regulations, but no general rules have been promulgated. "At the present time (Jan. 28, 1913) there are pending for decision two cases in which gas service is involved."

2. CALIFORNIA

The Railroad Commission of California has authority to regulate the quality of gas and gas service; but its territory of jurisdiction is restricted to the cities which are not incorporated unless the cities surrender to the commission their right of regulation under the general State laws. A majority of the larger cities still retain their full power in this particular and no rules for gas or gas service have yet been established by the commission.

3. COLORADO

A public utilities commission was created by an act of the 1913 legislature, but as yet has not been organized. Full authority is given for the regulation of service.

4. CONNECTICUT

The Public Utilities Commission of this State has full authority in the establishing of standards for gas and gas service, but it has not yet (February, 1913) adopted any regulations on this subject. Municipal regulations are superseded by the authority of the State commission.

5. GEORGIA

The Railroad Commission of Georgia has been given authority over gas companies, but has made no regulations as to the quality of service. Some city ordinances are still operative; and it has not been determined whether or not these regulations would be superseded if the commission adopted general provisions.

6. IDAHO

A public utilities commission has been established this year but is not yet organized (May, 1913).

7. ILLINOIS

A public service commission was established by an act passed June, 1913, the commission to have full authority over utility service matters.

8. INDIANA

A public service commission with full authority was organized in May, 1913, and is now considering standards for gas service.

9. KANSAS

The Public Utilities Commission of this State has full authority over gas companies except those operating wholly or principally in a single city, and in the case of these latter, the commission may review municipal regulations or contracts upon appeal either by the utility or the public.

10. MAINE

A public utilities commission has just been established, but as yet has not been organized (May, 1913).

11. MARYLAND

The Public Service Commission of this State is authorized to supervise all utilities, and it is empowered to fix standards of service, with the limitation only that standards so fixed may not be less severe than those in force previous to the establishing of the commission.

12. MASSACHUSETTS

Massachusetts was the first State to provide for gas inspection. The office of State inspector of gas meters and illuminating gas was established in 1861. Gas inspection has continued without interruption since that time. Since 1902 the matter has been under the control of the board of gas and electric light commissioners.

Some of the more important provisions, now in force, as to the powers and duties of this board are as follows:

Said board shall have the general supervision of all corporations and companies which are engaged in the manufacture and sale of gas or electricity for light or heat, and shall make all neces-

sary examinations and inquiries and keep themselves informed as to the compliance of the several corporations and companies with the provisions of the law.

The board shall, from time to time, ascertain what degree of purity can reasonably be required in gas made and supplied by corporations and companies engaged in the manufacture and sale of gas for light or heat, and shall report to the general court when, in its opinion, any change in the law relative thereto is desirable.

Upon the complaint * * *, either of the quality or price of the gas or electric light sold and delivered, the board * * * shall give a public hearing * * *, and after said hearing may order any reduction in the price of gas or electric light or improvement in quality thereof * * *.

The work of this board now includes (*a*) testing of the candlepower and chemical quality of the gas for total sulphur, ammonia and hydrogen sulphide, and (*b*) proving and sealing of all gas meters. In this inspection the State law allows the board some freedom in establishing the standard which shall be required of the companies, but makes the following definite provisions, which are not subject to the decision of the board:

SEC. 9. Every gas light company with a capital paid in of one hundred thousand dollars or more, and every other gas light company if required by the board of gas and electric light commissioners, and all makers and vendors of meters shall set up at some convenient place upon their premises one or more meter provers of a size and type approved by the board and tested and calibrated by the board, by means of which meters may be tested. A meter shall not be stamped correct if it varies more than two per cent from the standard measure. The board shall keep a correct record of all meters examined by its inspectors with their proof at the time of inspection, which shall be open at all times for examination by the officers of any gas light company in the commonwealth.

SEC. 10. A gas company providing a meter for measuring gas supplied to a customer which has not been duly sealed and stamped shall be punished by a fine of five dollars for every such meter in use, payable to the city or town in which the meter is situated.

SEC. 11. Meters in use shall be tested by the inspector or by one of his assistants or a deputy on the request of the consumer or of the gas light company, in the presence of the consumer if desired, and with sealed apparatus. If he finds that the meter is correct, the person requesting the inspection shall pay the fees for such inspection and the expense of removing the meter for the purpose of being tested, and the re-inspection shall be stamped on the meter. If he finds that the meter is incorrect, the gas light company shall pay such expenses and shall furnish a new meter without charge to the consumer.

SEC. 12. Meters for measuring gas supplied to consumers shall register the quantity of gas passing through them in cubic feet so that the number of cubic feet of gas consumed can be easily ascertained by the consumer thereof. No meter shall be used which may confuse or deceive the consumer in ascertaining the price he pays per thousand cubic feet or the number of cubic feet consumed. No charge for the use of a meter during any portion of twelve consecutive months shall be made if the consumer during said time uses gas to the value of seven dollars.

SEC. 13. Every gas light company which annually manufactures or sells more than fifteen million cubic feet of gas shall, when required by the board of gas and electric light commissioners, provide and maintain a suitable room at least a quarter of a mile from the gas works with a disc photometer and its appurtenances of a construction approved by the board, which shall be open to the inspector and assistant inspectors on every working day from eight o'clock in the morning until six o'clock in the afternoon.

SEC. 14. The gas of every company which supplies more than fifty consumers, except gas made and used exclusively for heating, cooking, chemical and mechanical purposes, shall be inspected at least twice a year and as much oftener as the board of gas and electric light commissioners may determine. The gas shall be tested for illuminating power by means of a disc photometer and during such test, shall be burned from the burner best adapted to it, which is at the same time suitable for domestic use, and at as near the rate of five feet an hour as is practicable. The board of gas and electric light commissioners shall, for the purpose of establishing a standard of purity for gas, and after a public hearing, determine how many grains of sulphur and ammonia per hundred cubic feet of gas may be permitted, and the board shall have power to change such standards from time to time, after a public hearing; but not more than thirty grains of sulphur per hundred cubic feet and no sulphuretted hydrogen shall be allowed.

If the gas of any gas company or of any city or town supplying gas is found on three consecutive inspections, or on three inspections made within a period of thirty consecutive days, to give less light than sixteen standard English candles, or upon such averaging of inspections as the board may prescribe, to be below the standard of purity fixed under this act, unless such defect is in the opinion of the board due to unavoidable cause or accident, a fine of one hundred dollars shall be paid by such company, city or town into the treasury of the commonwealth.

If during the test the consumption of gas varies from five feet an hour, or the candle from one hundred and twenty grains an hour, a proportionate correction shall be made for the candlepower. Upon such complaint and after such notice and hearing as are provided for by section thirty-four of chapter one hundred and twenty-one of the Revised Laws the board may require a company to supply such gas as will give, when tested in the manner prescribed in this section, a light equivalent to such number of standard English candles, not less than sixteen, as said board may determine.

The work of inspection, as carried out by the Massachusetts commission, is described on pages 90 to 93.

13. MISSOURI

The State of Missouri has recently provided for the creation of a State commission which will have full authority to regulate public service corporations, including gas companies. This commission has not yet been appointed (March, 1913). The commission is required by the law to test all meters in use in the State.

14. NEVADA

The Public Service Commission of Nevada has complete authority to regulate the gas service in that State. The following rules have been adopted by the commission:

RULE 1. A meter may be considered as correct if, when passing gas at the rate of six cubic feet per hour per light capacity, it shows, in comparison with a standard gas-prover, an error which is not greater than two per cent.

RULE 2. No gas company shall allow a gas meter to remain in service for a period longer than three years without checking it for accuracy and readjusting it if found to be inaccurate.

RULE 3. Each company shall keep a record of all tests made on meters, both before installation and while in service.

RULE 4. Each gas company shall provide itself with equipment necessary for testing meters, such equipment to consist of a standard meter prover with suitable accessories.

RULE 5. Each gas company shall make a test of the accuracy of a meter upon request of a consumer, provided such consumer does not make a request for tests more frequently than once in six months. A report giving the results of such tests shall be made to the consumer, and a complete record of such tests shall be forwarded to the Public Service Commission.

RULE 6. Upon formal application of any consumer to the Public Service Commission a test shall be made upon the consumer's meter by an inspector employed by the Commission, such test to be made as soon as practicable after receipt of the application. For such test a fee of one dollar and fifty cents (1.50) shall be paid by the consumer making the application for the test if the meter is found to be slow or correct within the allowable limits, and by the company owning the meter if the meter is found to be fast beyond the allowable limit.

RULE 7. Meter dials shall read directly in cubic feet of gas, and bills rendered periodically by the company shall designate the readings of the meter at the beginning and end of the time for which the bill is rendered, and give the dates at which the readings were taken.

RULE 8. The company furnishing gas, which, within a one-mile radius from the distribution center, gives a monthly average total heating value of not less than 550 B. T. U., with a minimum which shall never fall below 500 B. T. U., may be considered as giving adequate service as far as the heating value of the gas is concerned.

RULE 9. Each gas company, whose output exceeds five million cubic feet a year, shall equip itself with a standard calorimeter outfit, with which periodic tests upon the gas shall be made. A record of these tests shall be kept open for public inspection.

RULE 10. Gas pressure, as measured at meter inlets, shall never be less than 1½ inches nor more than 6 inches of water pressure; and the daily variation of pressure at the inlet of any one meter on the system shall never be greater than 100 per cent of the minimum pressure.

RULE 11. Each company shall make frequent measurements of the pressure and pressure variations, and these shall be kept on record and open for public inspection.

RULE 12. In no case shall the gas contain more than thirty grains of total sulphur per 100 cubic feet, and not more than a trace of sulphur as sulphuretted hydrogen.

RULE 13. Each company shall keep a record of complaints which shall include the name and address of the consumer, the date, the nature of the complaint, and the remedy. A classified summary of these records shall be submitted to the commission on or before the thirtieth day of each month for the preceding month.

15. NEW HAMPSHIRE

The Public Service Commission of New Hampshire, which has full authority to establish standards for gas and gas service, has not yet made any rules in regard to this subject.

16. NEW JERSEY

The rules of the Board of Public Utility Commissioners of New Jersey have, in effect, superseded all local regulations of the gas companies of that State. The following rules are now in force:

RULE I. A meter may be considered correct if, when passing gas at the rate of six cubic feet per hour, per light capacity, it shows, in comparison with a standard gas prover, an error which is not greater than two per cent.

RULE II. No gas company shall allow a gas meter to remain in service for a period longer than six years without checking it for accuracy and readjusting it if found to be inaccurate.

RULE III. Each company shall keep a record of tests made on meters before installation and upon receiving them from the services. The original of such record shall be kept in the meter shop, and available for examination at any time by the inspectors of the Board. A report shall be made up from such record book, giving a summary of records and sent to the office of the Board at stated periods. Each company having over 500 meters shall report monthly; each company having less than 500 meters shall report quarterly. Blank forms will be furnished by the Board on which reports are to be made.

RULE IV. Each gas company shall provide itself with equipment necessary for testing meters, such equipment to consist of a standard meter prover with suitable accessories. Each prover will be inspected by the Board and furnished with an inspection tag or plate. After January 1st, 1912, tests made with an uncertified prover shall not be deemed authoritative. Provers will be set up permanently in the location where they are to be used, and will be tested by an Inspector of the Board, using a standard cubic foot bottle which has been previously calibrated and certified by the National Bureau of Standards at Washington.

RULE V. Each gas company shall, without charge, make a test of the accuracy of a meter upon request of a consumer, provided such consumer does not make a request for test more frequently than once in six months. A report giving the results of such tests shall be made to the consumer, and a complete record of such tests shall be kept on file in the office of the company.

RULE VI. Upon formal application by any consumer to the Board of Public Utility Commissioners, a test shall be made of the consumer's meter by an inspector employed by the Board, such test to be made as soon as practicable after receipt of the application. For such test a fee of one dollar ($1.00) shall be paid by the consumer, at the time application is made for the test, this fee to be retained if the meter is found to be slow or correct, within the allowable limits. If the meter is found to be fast beyond the allowable limits the fee of one dollar ($1.00) will be returned to the consumer and collected from the company owning the meter. Each meter to be so tested is to be removed and will be tested by an inspector of the Board using the nearest certified prover. In certain cases tests will be made with a portable test meter. In cases of dispute, however, as to the accuracy of such meter, the test made with the prover shall be considered the correct one.

RULE VII. Meter dials shall read directly in cubic feet of gas, and bills rendered periodically by the company shall designate the readings of the meter at the beginning and end of the time for which the bill is rendered, and give the dates at which the readings were taken; bills shall also show the gross amount charged and the net amount after deducting any rebate, if any, allowed for prompt payment. Where prepayment meters are in use, the meter reader, at the time of reading same, shall leave with the customer a slip showing the reading as well as the amount of money which has been collected from the meter.

RULE VIII. No company shall make any charge for changing a meter found defective or where test is to be made; and no charge shall be made for changing a meter of one type for a meter of another type unless the first meter referred to has been in use less than one year, in which case a charge, which in no case shall exceed $1.00, may be made to cover the actual expense of making the change.

RULE IX. The company furnishing gas which, within a one-mile radius from the distribution center, gives a monthly average total heating value of not less than 600 B. T. U., with a minimum which shall never fall below 550 B. T. U., may be considered as giving adequate service as far as the heating value of the gas is concerned.

RULE X. Each gas company whose output exceeds twenty million cubic feet a year shall equip itself with a standard calorimeter outfit, constructed and calibrated as approved by the National Bureau of Standards, with which periodic tests upon the gas shall be made. A record of these tests shall be made and kept on file in the office of the company.

RULE XI. Gas pressure, as measured at meter inlets, shall never be less than one and one-half (1½) inches nor more than six (6) inches of water pressure; and the daily variation of pressure at

the inlet of any one meter on the system shall never be greater than one hundred per cent. of the minimum pressure.

RULE XII. Each company shall make frequent measurements of the pressure and pressure variations, and these shall be kept on file in the office of the company.

RULE XIII. In no case shall the gas contain more than thirty grains of total sulphur per 100 cubic feet, and not more than a trace of sulphur as sulphuretted hydrogen.

RULE XIV. Each company shall keep a record of complaints, in regard to service, which shall include the name and address of the consumer, the date, the nature of the complaint and the remedy.

RULE XV. Each company supplying gas shall inform each of its customers where peculiar or unusual conditions prevail, as to the conditions under which efficient and satisfactory service may be secured from its system.

RULE XVI. Each company supplying gas shall adopt some method to inform its customers as to the reading of meters, either by printing on bills a description of the method of reading meters, or a notice to the effect that the methods will be readily explained on application. It is recommended that an exhibition meter be kept on display in each commercial office maintained by a gas company.

17. NEW YORK

The public service commissions law enacted in 1907 by New York provides for two commissions of five members each, the one for the first district having jurisdiction in New York City, the other board covering all of the rest of the State. The work of the two commissions is kept distinct.

That in the first district will be included under New York City in the compilation of city laws.

The second district commission has a well-organized system for inspection of candlepower, purity, and pressure of the gas and the testing of meters, and has undertaken extended investigations of the heating-value determination, with a view to fixing a requirement as to this quality. In the study of this last question the commission has decided that a heating-value requirement is desirable, but that it is without power to fix any such regulation.

A more extended statement of the inspection work of the commission is made on pages 90 to 93. The following extracts from the State law indicate the special provisions which the commission is required to enforce:

SEC. 67. *Inspection of Gas and Electric Meters.*—1. Each commission shall appoint inspectors of gas and electric meters whose duty it shall be when required, to inspect, examine, prove and ascertain the accuracy of any and all gas meters used or intended to be used for measuring or ascertaining the quantity of illuminating or fuel gas or natural gas furnished by any gas corporation to or for the use of any person and any and all electric meters used or intended to be used for measuring and ascertaining the quantity of electric current furnished for light, heat and power by any electrical corporation to or for the use of any person or persons and when found to be or made to be correct, the inspector shall stamp or mark all such meters and each of them with some suitable device, which device shall be recorded in the office of the secretary of state.

2. No corporation or person shall furnish or put in use any gas meter which shall not have been inspected, proved and sealed, or any electric meter which shall not have been inspected,

approved, stamped or marked by an inspector of the commission. Every gas and electrical corporation shall provide or keep in and upon its premises a suitable and proper apparatus, to be approved and stamped or marked by the commission, for testing and proving the accuracy of gas and electric meters furnished for use by it, and by which apparatus every meter may and shall be tested, on the written request of the consumer to whom the same shall be furnished, and in his presence if he desires it.

If any consumer to whom a meter has been furnished, shall request the commission in writing to inspect such meter, the commission shall have the same inspected and tested; if the same on being so tested shall be found to be, four per cent. if an electric meter, or two per cent. if a gas meter, defective or incorrect to the prejudice of the consumer, the inspector shall order the gas or electrical corporation forthwith to remove the same and to place instead thereof a correct meter, and the expense of such inspection and test shall be borne by the corporation; if the same on being so tested shall be found to be correct the expense of such inspection and test shall be borne by the consumer. A uniform reasonable charge shall be fixed by the commission for this service.

CHAPTER 557, LAWS 1907

AN ACT Fixing standards of purity, illuminating power and pressure of gas in cities of the second class.

SECTION 1. The gas furnished or supplied by any corporation, association, co-partnership or person in any city of the second class shall be free from sulphuretted hydrogen, to be determined by exposing for thirty seconds a slip of white paper saturated with acetate of lead to a jet of gas flowing about five feet per hour, and each one hundred cubic feet shall not contain more than ten grains of ammonia nor twenty grains of sulphur.

SEC. 2. The maximum illuminating power required and minimum illuminating power permitted of gas so furnished or supplied in any such city shall be as follows: if a coal gas, sixteen candles; if a mixed coal and water gas, eighteen candles; if a carburetted water gas, twenty candles. A candle shall mean a sperm candle, six to a pound, burning at the rate of one hundred and twenty grains of spermaceti per hour. The test for illuminating power shall be made with gas obtained from a service pipe or main located at a distance of not less than one mile nor more than one and one-half miles from any distributing holder, using for coal gas and mixed coal and water gas containing more than fifty per centum of coal gas an F Argand burner, and for mixed coal and water gas containing fifty per centum and less of coal gas and for carburetted water gas a No. 7 slit union Bray burner, on a basis of consumption of five cubic feet of gas per hour.

SEC. 3. The minimum pressure of gas so furnished or supplied which shall be permitted in any service main in any such city shall be sufficient to balance a column of water one and one-half inches in height. The maximum pressure therein allowed shall be an amount sufficient to balance a column of water three and three-fourths inches in height, plus an allowance at the rate of one inch for variation of each one hundred feet of increase in altitude in the distributing system between the holder and the point of consumption, except that 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.

There are also several State acts which affect only the gas companies in some individual cities. In so far as they are known we have included them in the compilation of the city ordinances.

The commission of the second district has continued the following requirements made by an official order of the commission which preceded it in this work for all of the State under its jurisdiction; i. e., all except the city of New York.

IN THE Matter of fixing and establishing a standard of illuminating power and purity of gas manufactured and sold by persons, corporations and municipalities for lighting purposes.

Order entered June 15, 1907, by the Commission of Gas and Electricity.

Pursuant to the provisions of section 9, subdivision 3 of chapter 737 of the Laws of 1905, and on reading and filing the notice of hearing herein, dated February 6, 1907, and the same having been duly served upon the companies and corporations affected thereby, and a public hearing having been had thereon, pursuant to such notice, at the Capitol, in the city of Albany, on the 21st day of February, 1907, it is

Ordered, That the Commission of Gas and Electricity does hereby fix and establish the standard of illuminating power and purity of coal gas, mixed coal and water gas and water gas, respectively, manufactured and sold in the State of New York, as follows, viz: Except as otherwise prescribed by law, the gas sold, or manufactured and sold, by any person, corporation or municipality in the State of New York for lighting purposes, except to lighting companies, shall have an illuminating power, if the same be coal gas, of at least sixteen candle power; if mixed coal and water gas, of at least eighteen candle power; and if water gas, of at least twenty candle power. A candle shall mean a standard English sperm candle weighing six to the pound, burning at the rate of one hundred twenty grains of spermaceti per hour, and correction shall be made for any variation from this rate of consumption. The test for illuminating power of gas shall be made with gas taken from a service at a distance of not less than one mile from the nearest distributing holder where possible, and where not possible by reason of limited distribution system, said test shall be made from farthest available service; and it is further

Ordered, That tests of candle power shall be made on a basis of consumption of five cubic feet of gas per hour, corrections being made for temperature and pressure above or below the normal, to wit: sixty degrees Fahrenheit and thirty inches barometer; and it is further

Ordered, That such tests of said gas for illuminating power shall be made with a standard bar photometer of an approved make, equipped with either a New Style F Argand burner, Old Style D Argand burner or Number 7 Slit Union Bray burner, as may be best suited to the gas tested; and it is further

Ordered, That each one hundred cubic feet of said gas shall not contain more than ten grains of ammonia, nor more than twenty grains of sulphur compounds; and it is further

Ordered, That the gas sold, or manufactured and sold, shall exhibit no trace of hydrogen sulphide when tested as follows: If a strip of white paper moistened with a solution of acetate of lead and exposed to a current of gas flowing at the rate of about five cubic feet per hour, does not after thirty seconds of such exposure become discolored, the gas shall be considered to contain no hydrogen sulphide; and it is further

Ordered, That this order shall take effect on the fifteenth day of June, 1907.

IN THE Matter of the installation of stationary photometers by corporations supplying and distributing 15,000,000 cubic feet or more per annum of coal, water or mixed gas.

Order entered June 15, 1907, by the Commission of Gas and Electricity.

On reading and filing the notice of hearing herein, dated January 8, 1907, and the same having been duly served by mail upon the companies and corporations affected thereby; and a public hearing having been had thereon, pursuant to said notice, at the Capitol in the city of Albany on the sixteenth day of January, 1907; now, due deliberation having been had, it is

Ordered, That each and every corporation manufacturing and supplying or distributing fifteen million (15,000,000) cubic feet or more of either coal gas, water gas or mixed coal and water gas per annum, or a total amount of fifteen million (15,000,000) cubic feet of any or all of them shall on or before September 1, 1907, properly install and maintain a stationary bar photometer of an approved make for testing the candle power of the gas manufactured and supplied or distributed

by said company in order to ascertain the candle power of gas furnished to the consumer; and it is further

Ordered, That such photometers shall be supplied with suitable burners for testing the various kinds of gas manufactured, supplied or distributed by the company; and it is further

Ordered, That in case the gas distributed or supplied be manufactured by or purchased from another company, said approved photometer may be installed at or near the main distributing holder of the purchasing company, or the installation of said approved photometer by the purchasing company may be dispensed with in the discretion of the Commission, provided the gas has been tested by an approved photometer from the mains of the company manufacturing the same; and it is further

Ordered, That each company affected by this order and already supplied with a photometer or hereafter installing a photometer in pursuance of this order, shall report to this Commission immediately for approval, the style and make of such photometer now installed, or the style and make of the photometer which it is proposed to install in accordance with this order.

The 1913 legislature has recently (May, 1913) amended the public service commissions law for New York so that the commissions now "have power by order to fix from time to time standards for the measurement of the purity of gas and for the measurement of the illuminating power of gas and for the measurement of the heating power of gas to be manufactured, distributed, or sold by persons, corporations, or municipalities for lighting, heating, or power purposes, notwithstanding that another standard for the measurement of any thereof may have been fixed by statute, and to prescribe from time to time the efficiency of the electric supply system, of the current supplied and of the lamps furnished by the persons, corporations or municipalities generating and selling electric current, and by order to require the gas so manufactured, distributed or sold to equal the standards so fixed by it, and to prescribe from time to time the reasonable minimum and maximum pressure at which gas shall be delivered by said persons, corporations or municipalities."

This authority has not yet been exercised but as soon as the commission takes action under it, the regulations above quoted will be superseded by the orders which they may issue.

18. NORTH CAROLINA

The Corporation Commission of North Carolina has just been given authority over gas, electric, and other utilities (1913).

19. OHIO

The State laws of Ohio fix a minimum limit of 12 candlepower for artificial gas and prohibit the use of meters more than 3 per cent in error. The State public service commission has some regulatory authority concerning these matters, but the cities of the State still retain the power to regulate

their own utilities, subject to appeal to the State commission. The commission has made no general rules on the subject, having but recently (January, 1913) established a division of gas.

20. OKLAHOMA

The Corporation Commission of Oklahoma has authority to regulate gas service in that State, but the exact extent of this authority has not been determined. No general rules relating to this subject have been enacted.

21. OREGON

The Railroad Commission of Oregon has complete authority in regard to gas service. The commission now has under consideration a tentative set of rules, but these have not yet been adopted. (March 7, 1913).

22. PENNSYLVANIA

The 1913 legislature passed a public service commission law establishing a commission with full authority over the service rendered by utilities.

23. RHODE ISLAND

The Public Utilities Commission of Rhode Island has authority to regulate the quality of gas and gas service, and the adoption of rules covering these subjects is under consideration at this time. Only the following order (dated February 26, 1913) has been issued up to May, 1913:

(1) That a meter will be considered correct, if when passing gas at the rate of six cubic feet per hour, per light capacity, under a pressure of two inches of water, it shows, in comparison with a standard gas prover, an error which is not greater than two per cent.

(2) That the fees for testing gas meters shall be as follows:

3-light to 30-light meter, inclusive	$1.00
45-light to 50-light meter, inclusive	1.50
60-light to 80-light meter, inclusive	2.00
100-light to 150-light meter, inclusive	2.50
200-light to 250-light meter, inclusive	3.00

24. VERMONT

No rules with regard to gas service have been made by the Public Service Commission of Vermont, although the commission has had authority to make regulations for several years.

25. WASHINGTON

On May 1, 1912, the Public Service Commission of Washington, which has complete authority to regulate public utilities in that State adopted a set of rules regulating gas, electric, and water service. The following rules apply to gas service:

RULE 1. The following rules shall apply to any person, firm, or corporation now or hereafter engaged in the business of furnishing gas or electricity for light, heat, or power or supplying water for domestic or commercial uses within the State of Washington. The word "company" used in these rules shall be construed to mean any person, firm, or corporation engaged in the business designated. The word "commission" used in these rules shall be construed to mean the Public Service Commission of Washington.

RULE 2. The commission shall designate two or more laboratories where the tests called for by these rules, other than those tests to be made by the companies, shall be made, and will appoint inspectors under whose direction the tests shall be made at the several laboratories so designated or elsewhere as near as practicable to the locality where the test is desired.

RULE 3. Every meter for measuring gas, electric current, or water which has been tested for, accuracy by the company furnishing the substance measured, or by any inspector appointed by the commission, shall have firmly attached thereto a tag or label giving the number, size (or capacity) of the meter, the date and result of such test, and by whom made. No such card or label shall be defaced or removed until a subsequent test shall be made and a later test record attached. Each of such tags or labels shall have printed thereon the substance of this provision. This rule shall not apply to water meters when set outside of a building, underground, and in such position as to make them liable to become submerged. Whenever any test has been made at the request of a consumer the latter shall be notified in writing within ten days thereafter by the company, such written notification to contain all the information hereinbefore mentioned.

RULE 4. Each company supplying gas, electric current, or water shall make a test of the accuracy of a meter upon request of a consumer and within ten days thereafter free of charge, provided such consumer does not make a request for a test more frequently than once in twelve months.

RULE 5. If any consumer of gas, electric current, or water desires any meter test other than that provided for in the preceding rule, said consumer shall first make application to the company, who shall have ten days within which to make said test and report the result thereof to the consumer, or to refuse altogether to make said test. Should the company refuse to make said test or should the consumer not be satisfied with the accuracy of any test made by the company the consumer may then make formal application to the commission, who shall cause such test to be made by an inspector appointed by the commission as soon as practicable after the receipt of the application. For such tests made by the commission a fee of three dollars shall be paid by the consumer making the application if the meter is found to be slow or correct within the allowable limit and by the company owning the meter if the meter is found to be fast beyond the allowable limit.

RULE 6. A complete record of all the meter tests made under these rules shall be kept by each gas, electric, and water company, accessible to the public during business hours at its principal office in the town or city where the service is furnished or at such other place as the commission may designate. The records so kept shall contain complete information concerning the result of each test, showing the date and hour upon which the test was made, the name of the inspector conducting the test, the capacity and number of the meter, and the percentage of accuracy obtained by the test, and such other data as the company may deem desirable.

RULE 7. Each company supplying gas, electric current, or water within the State shall, upon written request of any consumer, cause the meter reader reading the meter installed upon the

premises of such consumer to leave upon such meter a card showing the date and time such reading was taken, and either the total reading expressed in cubic feet, kilowatt-hours, gallons, or other unit of service recorded by the meter read, or showing the position of the hands upon the dial of such meter at the time the reading is taken.

RULE 8. All bills rendered to consumers by any company for gas, electric current, or water shall show the reading of the consumer's meter at the beginning and end of the period of time for which the bill is rendered and shall give the dates at which the readings were taken, the number of units of service supplied, and the price per unit; and said bills shall be made out in such a way as to be readily understood by the consumers.

RULE 9. Each company supplying gas, electric current, or water may require a deposit or advance payment or other security from the consumer before service is supplied, providing that the amount so required shall not exceed the estimated monthly bill from such consumer. Interest at the rate of eight per cent per annum payable annually (or upon the returning of any deposit covering the time of the deposit) shall be paid by every company to its consumers upon every deposit so required, provided said deposit remains for a period of at least six months, and provided further, that interest shall cease when the consumption of the product used ceases. If the reasonableness of any rule, regulation, or practice of any company with reference to deposits and advance payments is challenged, the commission shall, upon investigation, prescribe the proper rule, regulation, or practice which shall thereafter be followed.

RULE 10. Each company supplying gas, electric current, or water shall keep a record of all interruptions of service upon its entire system, or major divisions of its system, and include in such record the time, duration, and cause of such interruptions, and such record shall be open at all times to public inspection, and the commission may at any time require from such company a copy of such record.

RULE 11. No rental shall be charged by any company supplying gas, electric current, or water for any meter installed by it.

RULE 12. Each company furnishing gas, electric current, or water shall keep a record of all complaints made to it by its consumers which record shall include the name and address of the consumer, the date, a statement of the complaint, and a statement of what the company did in reference thereto; and such information shall be furnished to the commission upon request.

RULE 13. Every gas company selling more than fifteen million cubic feet of gas per annum shall, when required by the commission, provide itself with equipment necessary for testing meters, such equipment to consist of a standard meter prover with suitable accessories, to be approved by the commission.

RULE 14. Each gas meter shall be tested and accurately adjusted previous to its initial installation, and a gas meter shall not be allowed to remain in service longer than five years without a test being made. If found to be inaccurate, when compared with the standards adopted in these rules, such meter shall be immediately readjusted and corrected.

RULE 15. A meter may be considered as correct if, when passing gas at the rate of six cubic feet per hour per light capacity it shows, in comparison with a standard gas prover, an error which is not greater than two per cent (2 per cent) either fast or slow. Meters must not leak and must deliver gas without any noticeable fluctuation in the light caused by the mechanical operation of the meter. Meter dials shall read directly in cubic feet of gas.

RULE 16. Each gas company whose output exceeds ten million cubic feet per year shall equip itself with a standard calorimeter outfit with which periodic tests upon the gas shall be made not less frequently than once each week. A record of these tests shall be made and kept open for public inspection.

RULE 17. All gas furnished to consumers for lighting or heating purposes shall show a monthly average total heating value of not less than six hundred British thermal units (600 Btu) per cubic foot, with a minimum which shall never fall below five hundred fifty British thermal units (550 Btu) per cubic foot.

RULE 18. Each gas company shall make daily measurements of the pressure and pressure variations, and these shall be kept on record and open to public inspection.

RULE 19. Each gas company whose output exceeds ten million cubic feet per year shall maintain at different points on its mains one mile or more from any distributing station two or more recording pressure gauges, by which means a record of pressure at all times shall be made, and these records shall be kept on file and open for public inspection at the principal offices of the company in the city where the service is rendered.

RULE 20. Gas pressure, as measured at meter inlets, shall never be less than two inches nor more than five inches of water pressure for a period of more than an hour: *Provided*, That in localities where there is a difference of elevation of more than one hundred and twenty-five (125) feet between different sections of a city or town served by any gas company, the maximum limit of pressure allowed by this rule may be increased to an amount above five inches, not exceeding one inch for each one hundred and twenty-five (125) feet of elevation of the consumer's outlet above the gas holder supplying that section.

RULE 21. In no case shall gas sold for lighting or heating purposes contain more than thirty grains of total sulphur per one hundred cubic feet, nor more than a trace of sulphur as sulphuretted hydrogen.

RULE 22. In no case shall gas sold for lighting or heating purposes contain more than five grains of ammonia per one hundred cubic feet.

26. WEST VIRGINIA

The 1913 legislature of West Virginia passed a bill creating a public-service commission with full authority in service matters. This commission is not yet organized (May, 1913).

27. WISCONSIN

The public utilities law, passed in 1907 by Wisconsin, makes very broad provisions for the railroad commission of Wisconsin, granting it powers as follows:

SEC. 1797 m–2. The railroad commission of Wisconsin is vested with power and jurisdiction to supervise and regulate every public utility in this state and to do all things necessary and convenient in the exercise of such power and jurisdiction.

SEC. 1797 m–23. 1. The commission shall ascertain and fix adequate and serviceable standards for the measurement of quality, pressure, initial voltage or other condition pertaining to the supply of the product or service rendered by any public utility and prescribe regulations for examination and testing of such product or service and for the measurement thereof.

2. It shall establish reasonable rules, regulations, specifications and standards to secure the accuracy of all meters and appliances for measurements, and every public utility is required to carry into effect all orders issued by the commission relative thereto.

In exercise of this authority the commission has established and is enforcing the following set of rules:

RULES FOR GAS SERVICE

RULE 1. A meter may be considered as correct if, when passing gas at the rate of six cubic feet per hour per light capacity, it shows, in comparison with a standard gas prover, an error which is not greater than two per cent.

RULE 2. No gas company shall allow a gas meter to remain in service for a period longer than three years without checking it for accuracy and readjusting it if found to be inaccurate.

RULE 3. Each company shall keep a record of tests made on meters before installation and upon receiving them from the services.

RULE 4. Each gas company shall provide itself with equipment necessary for testing meters, such equipment to consist of a standard meter prover with suitable accessories.

RULE 5. Each gas company shall make a test of the accuracy of a meter upon request of a consumer, provided such consumer does not make a request for test more frequently than once in six months. A report giving the results of such tests shall be made to the consumer, and a complete record of such tests shall be kept on file in the office of the company.

RULE 6. Upon formal application of any consumer to the Railroad Commission a test shall be made upon the consumer's meter by an inspector employed by the Railroad Commission, such test to be made as soon as practicable after receipt of the application. For such test a fee of two dollars ($2.00) shall be paid by the consumer making application for the test if the meter is found to be slow or correct within the allowable limits, and by the company owning the meter if the meter is found to be fast beyond the allowable limit.

RULE 7. Meter dials shall read directly in cubic feet of gas, and bills rendered periodically by the company shall designate the readings of the meter at the beginning and end of the time for which the bill is rendered, and give the dates at which the readings were taken.

RULE 8. The company furnishing gas which, within a one mile radius from the distribution center, gives a monthly average total heating value of not less than 600 B. T. U., with a minimum which shall never fall below 550 B. T. U., may be considered as giving adequate service as far as the heating value of the gas is concerned.

RULE 9. Each gas company, whose output exceeds twenty million cubic feet a year, shall equip itself with a standard calorimeter outfit, with which periodic tests upon the gas shall be made. A record of these tests shall be made and kept open for public inspection.

RULE 10. Gas pressure, as measured at meter inlets, shall never be less than 1½ inches nor more than 6 inches of water pressure; and the daily variation of pressure at the inlet of any one meter on the system shall never be greater than 100 per cent of the minimum pressure.

RULE 11. Each company shall make frequent measurements of the pressure and pressure variations, and these shall be kept on record and open for public inspection.

RULE 12. In no case shall the gas contain more than thirty grains of total sulphur per 100 cubic feet, and not more than a trace of sulphur as sulphuretted hydrogen.

RULE 13. Each company shall keep a record of complaints which shall include the name and address of the consumer, the date, the nature of the complaint, and the remedy. A classified summary of these records shall be submitted to the Commission on or before the twenty-eighth day of each month for the preceding month.

The commission has adopted a new set of rules which are printed beginning on page 164. The change was made too late for the new rules to be incorporated at this place. For the enforcement of the commission's rules service inspections are made regularly about as proposed on pages 86 to 90 of this circular, the Wisconsin system being used as a basis of these recommendations.

B. MUNICIPAL REGULATIONS IN FORCE

The following compilation of gas-ordinance requirements is a practically complete tabulation of the provisions made previous to January, 1913, in the cities of this country larger than 25 000 population (census 1910) relative

to candlepower, heating value, purity and pressure of gas, the accuracy of gas meters, and the methods of enforcement or inspection provided. These cities may be grouped according to the rules in force as follows:

	Number of cities
State rules in force	76
State commission has authority (unexercised)	94
City ordinances in force	78
No artificial gas supplied	21
No rules in force and no State commission in authority	12
Ordinances pending	4
Municipal operation	3
Total, less duplicates	229

In the following list the form of rules or regulations is shown for each city over 25 000 population.

TABULATION OF GAS LAWS IN FORCE IN CITIES

NOTE.—"State" indicates that a State commission supervises the gas company operations; where marked thus (*) the commission has rules for service actually in force, and where thus (†) the State authority is limited (see State-law compilation). "None" indicates that no State or city rules are operative, and no State commission has authority. Where no artificial gas is supplied, this is indicated by the term "natural gas." Where an ordinance is pending and the previous rules still in force, the latter are shown as well as the fact that a new rule is pending. Where the city owns and operates the gas plant, this fact is shown. The numbers opposite the city names have reference to the six tables which follow this list, as follows: **1,** Heating value; **2,** candlepower; **3,** purity; **4,** gas pressure; **5,** meter accuracy; **6,** inspection provided.

Akron, Ohio.....State, natural gas
Albany, N. Y.....State *
Allentown, Pa.....State
Altoona, Pa.....State
Amsterdam, N. Y.....State *
Atlanta, Ga.....State 6
Atlantic City, N. J.....State *
Auburn, N. Y.....State *
Augusta, Ga.....State
Aurora, Ill.....State 1, 2, 5, 6
Austin, Tex.....None
Baltimore, Md.....State † 2
Battle Creek, Mich.....5, 6
Bay City, Mich.....1, 2, 4, 5, 6
Bayonne, N. J.....State *
Berkeley, Cal.....State †
Binghamton, N. Y.....State *
Birmingham, Ala.....1, 2, 3, 5
Bloomington, Ill.....State
Boston, Mass.....State *
Bridgeport, Conn.....State

Brockton, Mass.	State *
Brookline, Mass.	State *
Buffalo, N. Y.	State *
Butte, Mont.	2
Cambridge, Mass.	State *
Camden, N. J.	State *
Canton, Ohio.	State, natural gas
Cedar Rapids, Iowa.	Ordinance pending
Charleston, S. C.	1, 2, 3, 4, 5, 6
Charlotte, N. C.	State
Chattanooga, Tenn.	1, 2, 3, 4, 5
Chelsea, Mass.	State *
Chester, Pa.	State
Chicago, Ill.	State 1, 2, 3, 4, 5, 6
Chicopee, Mass.	State *
Cincinnati, Ohio.	State, natural gas
Cleveland, Ohio	State 1, 2, 3, 4, 5, 6
Clinton, Iowa.	1, 2, 3, 4
Columbia, S. C.	None
Columbus, Ohio.	State, natural gas
Colorado Springs, Colo.	State 1, 2
Council Bluffs, Iowa.	2, 4
Covington, Ky.	Natural gas
Danville, Ill.	State 5, 6
Dallas, Tex.	Natural gas
Davenport, Iowa.	2, 5, 6
Dayton, Ohio.	State
Decatur, Ill.	State 5
Denver, Colo.	State
Des Moines, Iowa.	Ordinance pending 2
Detroit, Mich.	1, 2, 3, 4, 5, 6
Dubuque, Iowa.	None
Duluth, Minn.	Municipal plant
Easton, Pa.	State 3, 4, 5
East Orange, N. J.	State *
East St. Louis, Ill.	State 2, 3, 5, 6
Elgin, Ill.	State 1, 2, 3, 4, 5, 6
Elizabeth, N. J.	State *
Elmira, N. Y.	State *
El Paso, Tex.	2, 3, 5, 6
Erie, Pa.	State 5, 6
Evansville, Ind.	State
Everett, Mass.	State *
Fall River, Mass.	State *
Fitchburg, Mass.	State *
Flint, Mich.	None
Fort Wayne, Ind.	State 1, 2, 4, 5, 6
Fort Worth, Tex.	None
Galveston, Tex.	None
Grand Rapids, Mich.	1, 2, 3, 4, 5, 6

Green Bay, Wis.	State *
Hamilton, Ohio	State
Harrisburg, Pa	State
Hartford, Conn	State
Haverhill, Mass	State *
Hazleton, Pa	State
Hoboken, N. J	State *
Holyoke, Mass	State *
Houston, Tex	5, 6
Huntington, W. Va	State, natural gas
Indianapolis, Ind	State 1, 3, 6
Jackson, Mich	1, 2, 4, 5, 6
Jacksonville, Fla	None
Jamestown, N. Y	State *
Jersey City, N. J	State *
Johnstown, Pa	State
Joliet, Ill	State 1, 2, 5, 6
Joplin, Mo	State, natural gas
Kalamazoo, Mich	1, 4, 5, 6
Kansas City, Kans	State, natural gas †
Kansas City, Mo. [25]	State, natural gas 2, 4, 5, 6
Kingston, N. Y	State *
Knoxville, Tenn	2, 5, 6
La Crosse, Wis	State *
Lancaster, Pa	State
Lansing, Mich	1, 2, 4, 5, 6
Lawrence, Mass	State *
Lewiston, Me	State
Lexington, Ky	Natural gas
Lima, Ohio	State 2
Lincoln, Nebr	1, 2, 3, 4, 5, 6
Little Rock, Ark	Natural gas
Lorain, Ohio	State, natural gas
Los Angeles, Cal	State † 1, 2, 3, 4, 5, 6
Louisville, Ky	2, 4, 5, 6
Lowell, Mass	State *
Lynchburg, Va	2, 3
Lynn, Mass	State *
McKeesport, Pa	State 2, 5, 6
Macon, Ga	State
Madison, Wis	State *
Malden, Mass	State *
Manchester, N. H	State
Memphis, Tenn	2, 4, 5, 6
Meriden, Conn	State
Milwaukee, Wis	State *
Minneapolis, Minn	1, 2, 3, 4, 5, 6

[25] Artificial gas is soon to be supplied in Kansas City; certain local regulations for artificial gas may then be considered in force pending investigation by the State authorities.

Mobile, Ala.	None
Montgomery, Ala.	None
Mount Vernon, N. Y.	State *
Muskogee, Okla.	State
Nashua, N. H.	State
Nashville, Tenn.	1, 2
Newark, N. J.	State * 6
Newark, Ohio.	State, natural gas
New Bedford, Mass.	State *
New Britain, Conn.	State
Newburgh, N. Y.	State *
New Castle, Pa.	State, natural gas
New Haven, Conn.	State
New Orelans, La.	None
Newport, Ky.	Natural gas
Newport, R. I.	State *
New Rochelle, N. Y.	State *
Newton, Mass.	State *
New York, N. Y.[26]	State and city inspection * 2, 3, 4, 5, 6
Niagara Falls, N. Y.	State *
Norfolk, Va.	5, 6
Norristown, Pa.	State
Norwich, Conn.	State
Oakland, Cal.	State † 6
Ogden, Utah.	1, 2
Oklahoma City, Okla.	State, natural gas
Omaha, Nebr.	1, 2, 3, 4, 5, 6
Orange, N. J.	State *
Oshkosh, Wis.	State *
Pasadena, Cal.	State † 2, 3, 4, 5, 6
Passaic, N. J.	State *
Paterson, N. J.	State *
Pawtucket, R. I.	State *
Peoria, Ill.	State 2, 5, 6
Perth Amboy, N. J.	State *
Philadelphia, Pa.	State 2, 5, 6
Pittsburgh, Pa.	State 2, 3, 5, 6
Pittsfield, Mass.	State *
Portland, Me.	State
Portland, Oreg.	State †
Portsmouth, Va.	None
Poughkeepsie, N. Y.	State *
Providence, R. I.	State *
Pueblo, Colo.	State 2, 4
Quincy, Ill.	State
Quincy, Mass.	State *
Racine, Wis.	State *
Reading, Pa.	State
Richmond, Va.	Municipal operation

[26] See page 122.

Roanoke, Va.	Ordinance pending
Rochester, N. Y.	State *
Rockford, Ill.	State 1, 5
Sacramento, Cal.	State †
Saginaw, Mich.	1, 2, 3, 4, 5, 6
St. Joseph, Mo.	State, natural gas
St. Louis, Mo.	State 2, 3, 5, 6
St. Paul, Minn.	1, 2, 3, 4, 6
Salem, Mass.	State *
Salt Lake City, Utah [27]	General
San Antonio, Tex.	None
San Diego, Cal.	State † 1, 3, 4, 5, 6
San Francisco, Cal.	State † 1, 2, 3, 4, 5, 6
San Jose, Cal.	State †
Savannah, Ga.	State 5, 6
Schenectady, N. Y.	State *
Scranton, Pa.	State 5, 6
Seattle, Wash.	State *
Sheboygan, Wis.	State *
Shenandoah, Pa.	State
Shreveport, La.	Natural gas
Sioux City, Iowa.	1, 2, 3, 4, 5, 6
Somerville, Mass.	State *
South Bend, Ind.	State 5, 6
South Omaha, Nebr.	2
Spokane, Wash.	State * 2
Springfield, Ill.	State 1, 2, 3, 4, 5, 6
Springfield, Mass.	State *
Springfield, Mo.	State 2
Springfield, Ohio.	State 2
Stamford, Conn.	State
Superior, Wis.	State *
Syracuse, N. Y.	State * 3, 6
Tacoma, Wash.	State *
Tampa, Fla.	2
Taunton, Mass.	State *
Terre Haute, Ind.	State 5
Toledo, Ohio	State 2
Topeka, Kans.	State, natural gas †
Trenton, N. J.	State *
Troy, N. Y.	State *
Utica, N. Y.	State *
Waco, Tex.	1, 5
Waltham, Mass.	State *
Warwick, R. I.	State *
Washington, D. C.	Rules pending 2, 3, 5, 6
Waterbury, Conn	State
Waterloo, Iowa	1, 2, 5, 6

[27] In Salt Lake City it is required that "the gas shall equal in efficiency the general standard of efficiency of gas in New York, Chicago, and Philadelphia."

Watertown, N. Y.	State *
West Hoboken, N. J.	State *
Wheeling, W. Va.	State, municipal operation
Wichita, Kans.	State †
Wilkes-Barre, Pa.	State
Williamsport, Pa.	State, natural gas
Wilmington, Del.	5, 6
Wilmington, N. C.	State
Woonsocket, R. I.	State *
Worcester, Mass.	State *
Yonkers, N. Y.	State *
York, Pa.	State
Youngstown, Ohio	State, mainly natural gas
Zanesville, Ohio	State, natural gas

TABLE 1

Municipal Heating Value Requirements now in Force. (See also State rules)

City	Heating value required (Btu per cubic foot)	Frequency of test specified	Remarks
Aurora, Ill	600 gross		
Bay City, Mich	570	Periodic by company. Results may be checked by city engineer.	Less than 1 mile from holder.
Birmingham, Ala	575 gross		Define conditions of test.
Charleston, S. C	600		
Chattanooga, Tenn	600		
Chicago, Ill	600 gross	Daily	
Cleveland, Ohio	600 gross		
Clinton, Iowa	600		
Colorado Springs, Colo	600		
Detroit, Mich	600 gross		
Elgin, Ill	600 net	"Time to time"	Under "Standard conditions."
Fort Wayne, Ind	550		
Grand Rapids, Mich	600	Daily	
Indianapolis, Ind	600		
Jackson, Mich	600		
Joliet, Ill	600	"Time to time"	
Kalamazoo, Mich	600 gross		
Lansing, Mich	600 (low value)	City tests on complaint.	
Lincoln, Nebr	625	15 tests per month	
Los Angeles, Cal	600 gross	Daily with 2 extra if less than 600.	Define conditions of test.
Minneapolis, Minn	600 gross monthly average, daily minimum 550.	Twice daily	Discount in gas price if less than 600 monthly average.
Nashville, Tenn	600 average, 550 minimum.		
Ogden, Utah	500		New company.
Omaha, Nebr	600 net	Weekly	Penalty on monthly average. Test at 1½ miles from works.
Rockford, Ill	Average, 600		
Saginaw, Mich	570	At option of board of public works.	
St. Paul, Minn	600 gross average, 550 minimum.		Test with Junker's calorimeter.
San Diego, Cal	500 gross	Daily with 2 additional tests if heating value is low.	
San Francisco, Cal	600 gross		
Sioux City, Iowa	600		
Springfield, Ill	Monthly average 590, minimum 550.	Daily	After Aug. 1, 1913, 600 Btu. Conditions of test prescribed.
Waco, Tex	633		
Waterloo, Iowa	Equal to that of cities of like size in Iowa.		

TABLE 2

Candlepower Requirements

[The data of the ensuing table are arranged as follows: (1) The nominal value of the candlepower required; (2) standard of reference, when such standard is stated in the law or is directly implied therein (in cases of uncertainty no standard is quoted in the table); (3) burner specified for use in testing gas; (4) frequency which is specified for the official test (the values given are minimum frequencies); (5) miscellaneous specifications of special interest relative to this test and a statement of the kind of gas distributed under this law. (The kind of gas is, of course, not indicated in the law.)]

City	Candlepower required	Standard specified	Burner specified	Frequency of test	Remarks
Aurora, Ill.	16			"Time to time"	Mixed gas
Baltimore, Md.	20				Old State law for Baltimore. Mixed gas
Bay City, Mich.	Coal 16; mixed 18; water 20	Standard sperm candles	Lava-tipped, Bunsen-argand	Periodically by company	Penalty only on monthly average. Coal gas
Birmingham, Ala.	15	Candles.	Self-luminous, best adapted	Daily and repeat twice if less than 15 cp.	Mixed gas
Butte, Mont.	16				Coal gas
Charleston, S. C.	20				Water gas
Chattanooga, Tenn.	16				Coal gas
Chicago, Ill.	22	Pentane lamp standardized with standard English sperm candles	Bray No. 7 slit-union.	Daily.	<0.12 per cent CO_2 in air of room at time of test. Mixed gas
Cleveland, Ohio	16		Bunsen-argand.		Mixed gas
Clinton, Iowa	16				Mixed gas
Colorado Springs, Colo.	20				Coal gas
Council Bluffs, Iowa	22				Water gas
Davenport, Iowa	20				Mixed gas
Des Moines, Iowa	22				Mixed gas
Detroit, Mich.	18	Sperm candles.	Lava-tipped, Bunsen-argand	Daily.	Mixed gas
East St. Louis, Ill.	20	Candles.			Water gas
Elgin, Ill.	16	Candles.	Best adapted.	"Time to time"	Mixed gas
El Paso, Tex.	16				Mixed gas
Fort Wayne, Ind.	18				Mixed gas
Grand Rapids, Mich.	16	Candles.	Argand.	Daily.	Mixed gas

Jackson, Mich.	Coal 16; water 20.			At request of council.	Mixed gas
Joliet, Ill.	16				Penalty after 24 hours' notice Mixed gas
Kansas City, Mo.	22	Standard sperm candles		Daily.	Mixed gas
Knoxville, Tenn.	15				Mixed gas
Lansing, Mich.	18	Usual.		City tests on complaint.	Mixed gas
Lima, Ohio.	22				Water gas
Lincoln, Nebr.	18	English sperm candles	Sugg's London argand No. 1		Water gas
Los Angeles, Cal.	18	Standard sperm candles	Self-luminous, best-adapted	Daily, but twice repeated if <15 cp.	Oil gas
Louisville, Ky.	18	Sperm candles.			Mixed gas
Lynchburg, Va.	16	Standard sperm candles			Mixed gas
McKeesport, Pa.	15				By-product gas
Memphis, Tenn.	20				Water gas
Minneapolis, Minn.	18	Pentane lamp with Bureau of Standards certificate	Open-flame, lava-tipped	Twice daily.	Mixed gas
Nashville, Tenn.	16 average; 15 minimum	Standard sperm candles			Mixed gas
New York City.	22	Sperm candles.		Daily.	Mixed gas
Ogden, Utah.	18				Coal gas. Old company
Omaha, Nebr.	23 at works; 21.2 at station; 18 if coal gas	Standard sperm candles	Lava-tipped, open-flame	Weekly.	Water gas
Pasadena, Cal.	16	Sperm candles.		Monthly.	Oil gas
Peoria, Ill.	16				Mixed gas
Philadelphia, Pa.	22			Daily.	Mixed gas
Pittsburgh, Pa.	15	Standard candles.	Argand, described.	Every 3 months.	State law for Allegheny County. Mixed gas
Pueblo, Colo.	16				Mixed gas
Saginaw, Mich.	Coal 16; water 20.				Mixed gas
St. Louis, Mo.	18	English sperm candles	Argand.	Daily.	Define conditions of test. Mixed gas
St. Paul, Minn.	14				At 1½ miles from holders. Mixed gas
San Francisco, Cal.	19	Candles.			Oil gas

TABLE 2—Continued

Candlepower Requirements—Continued

City	Candlepower required	Standard specified	Burner specified	Frequency of test	Remarks
Sioux City, Iowa	21	Pentane lamp			Mixed gas
South Omaha, Nebr	20				Water gas
Springfield, Ill	Coal 16; water 20; mixed 18, monthly average	Pentane lamp, certified by Bureau of Standards	Burner best suited to gas	Daily	Tested at a point ⅜ to 1 mile from works. Mixed gas
Springfield, Mo	Water 22; coal 18				Water gas
Springfield, Ohio	16				Water gas
Tampa, Fla	20				Water gas
Toledo, Ohio	18				Mixed gas
Washington, D. C	22		Bray No. 7 slit union		Mixed gas
Waterloo, Iowa	As great as that furnished in any cities in Iowa, but not less than 16	Sperm candles		Upon complaint	Test by expert. Cost of test by loser. Mixed gas

TABLE 3

Purity—Chemical Requirements

City	Hydrogen sulphide must be—	Sulphur limit (grains per 100 cu. ft.)—	Ammonia limit (grains per 100 cu. ft.)—	Carbon monoxide limit (per cent).	Miscellaneous.
Birmingham, Ala.	Absent.	25	5		Free from all noxious impurities.
Charleston, S. C.	Absent.	20	5		
Chattanooga, Tenn.	Absent.	20	10		
Chicago, Ill.	Absent.	20	5		Specify method for S and NH_3 determination.
Cleveland, Ohio.	Absent.	20	10		
Clinton, Iowa.	Absent.				
Detroit, Mich.	Absent.	30	10		Inspector required to make analysis of gas.
Easton, Pa.		30			
East St. Louis, Ill.	Absent.	20	5		
Elgin, Ill.		30	10	35	Free from noxious impurities.
El Paso, Tex.					Shall be of "best quality."
Grand Rapids, Mich.	Absent.	30	10		
Indianapolis, Ind.		20	2.5		"Merchantable gas of highest standard of purity."
Lincoln, Nebr.	Absent.	20	10		Shall have sufficient odor to be readily detected.
Los Angeles, Cal.	Absent.	25	5	25	Two extra tests if impurities exceed limit.
Lynchburg, Va.	Absent.	20	4		
Minneapolis, Minn.	Absent.	20 in summer, 30 in winter.	4		All methods of tests defined. Daily tests if impurities exceed limits.
New York City.	Trace.	20	5		
Omaha, Nebr.	Absent.	15	5		All tests monthly.
Pasadena, Cal.	Absent.	20	5	25	All tests monthly.
Pittsburgh, Pa.		Absent.	Absent.		Gas must be "free from sulphur, ammonia, and carbolic acid."
Saginaw, Mich.	Absent.	30			
St. Louis, Mo.	As free as practicable.				
St. Paul, Minn.					Free from all noxious impurities.
San Diego, Cal.	Absent.	25		25	Free from all noxious impurities.
San Francisco, Cal.	Absent.				
Sioux City, Iowa.	Absent.				
Springfield, Ill.	Trace.	30	5		
Syracuse, N. Y.	Absent.	20	10		
Washington, D. C.	Absent.	20	5		

TABLE 4
Pressure Regulations

City.	Gas pressure tested at—	Must not exceed (inches)—	Must not be less than (inches)—	Daily variation permitted (per cent of minimum).	Records of test specified.	Remarks.
Bay City, Mich.			2.2			Subject to ruling of board of public works.
Charleston, S. C.		4	1.5			
Chattanooga, Tenn.		5	1.5			
Chicago, Ill.	Meter inlet		1.5	100	Continuous	Tests at 3 times as many places as there are regular testing stations.
Cleveland, Ohio	1 mile from works	6	1.5	100		
Clinton, Iowa		6	2			
Council Bluffs, Iowa						Require "uniform pressure."
Detroit, Mich.	Meter inlet	4.5	1.5		Daily	Test at each station.
Easton, Pa.	1 mile from center of distribution.	6	1.5	100		
Elgin, Ill.	Meter inlet	6	1.5	100		
Fort Wayne, Ind.	Consumer's		2.5			
Grand Rapids, Mich.	Meter inlet	4.5	1.8			
Jackson, Mich.	Meter outlet	4.5	1.5			
Kalamazoo, Mich.	Meter inlet	4	2		Weekly	
Kansas City, Mo.		4	1.5			Company must put on check burner if >3 inches and regulator >4 inches.
Lansing, Mich.		4.5	1.5			
Lincoln, Nebr.		5	1.5		Continuous	
Los Angeles, Cal.		9	2		Continuous in each of specified districts	While any appliance is in operation. Change to 4 inches minimum is contemplated.
Louisville, Ky.	City hall laboratory.		2			
Memphis, Tenn.		3.5	2			
Minneapolis, Minn.	Meter inlet	4	2	100	10 continuous	An allowance is made in maximum pressure allowed, for elevation above gas holder.
New York, N. Y.	Service outlet	6	2	3 inches	Continuous 1 in each square mile.	See note.
Omaha, Nebr.		4.5	2			
Pasadena, Cal.			2			"At an even pressure."
Pueblo, Colo.	Any burner		2.3			
Saginaw, Mich.		4	1.8	100		
St. Paul, Minn.	Service outlet		2			
San Diego, Cal.	Any service pipe	9	2			"Uniform." Limits apply "while all appliances are in operation."
San Francisco, Cal.		9	2			
Sioux City, Iowa	At city hall	4	2	100		
Springfield, Ill.	Meter outlet	6	1.5	2 inches		

NOTE.—The following rules are in force in New York City; as they cover several features in a novel way, they are quoted in full. These rules applied originally to Manhattan, but are now in force for all boroughs in practically this form.

GAS PRESSURE REGULATIONS FOR THE BOROUGH OF MANHATTAN

1. Each gas corporation supplying gas for light, heat, or power in the borough of Manhattan, city of New York, shall provide and maintain recording pressure gauges of a type to be approved by the commission, so located that no gas consumer will be more than thirty-eight hundred (3,800) feet in an air line from the nearest gauge upon the distribution system by which he is supplied, and that there will be at least one (1) gauge in each square mile of territory supplied by each corporation. Each gauge shall be located as nearly as practicable to the point of minimum pressure in its district, and a separate service shall in each case be run from the gas main to the gauge, no gas consumption being taken from said service. Each chart taken from these gauges shall be marked with the company's name, location of gauge from which it was taken and the date it was placed and removed, and shall be filed and preserved by the corporation for not less than three (3) years. On or before November 1, 1912, each corporation shall notify the commission of the location of each gauge, and also of all changes in location and new locations of gauges within five (5) days from the date of such change or new location.

The provisions of this paragraph (1) shall take effect November 1, 1912.

2. On and after July 1, 1913, the minimum pressure of gas as measured at the consumer's end of the company's service pipe to any consumer, shall not be less than two inches (2″) water column on two (2) consecutive days. Where the company is or will be unable to maintain such minimum pressure on account of causes beyond its control, it shall immediately notify the commission and request an extension of time within which to comply with this provision, and said company shall comply with this provision within the time thus fixed.

3. On and after July 1, 1913, the maximum pressure of gas, as measured at the consumer's end of the company's service pipe to any consumer, shall not exceed six inches (6″) water column on two (2) consecutive days, unless the consumer or consumers supplied from such service pipe have made a specific request in writing for pressure of or in excess of six inches (6″) water column. This provision shall not be construed as imposing any obligation on the company to furnish gas at a pressure of six inches (6″) or more.

4. On and after July 1, 1913, the maximum daily pressure variation (independent of momentary and pulsating variations of pressure) as measured at the consumer's end of the company's service pipe to any consumer shall not exceed three inches (3″) water column on two (2) consecutive days. On and after July 1, 1914, said maximum daily pressure variation shall not exceed two and one-half inches ($2\frac{1}{2}$″) water column on two (2) consecutive days. On and after July 1, 1915, such maximum daily pressure variation shall not exceed two inches (2″) water column on two (2) consecutive days.

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 inches ($\frac{8}{10}$″) water column on two (2) 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 inches ($\frac{8}{10}$″) water column on two (2) consecutive days. On and after January 1,

1914, said maximum pulsating pressure variation shall not exceed a total range of five-tenths inches ($\frac{5}{10}''$) water column on two (2) consecutive days.

7. This order shall take effect immediately except as herein provided and shall remain in force until modified or abrogated by further order of the commission.

8. Each of the companies above named shall notify the Public Service Commission for the first district within ten days after service of this order upon them whether the terms of this order are accepted and will be obeyed.

TABLE 5

Meter Testing Requirements

The more important details of the provisions for the testing of gas meters are tabulated under the following subjects: (1) "All must be tested," referring to cities which require all meters to be inspected before being placed in service and those which specify under certain conditions that all must be so examined; (2) city makes arrangements for testing the meters complained of by the consumers or requires that such meters shall be tested by the company; (3) variation from exact registration which is allowed or which is considered in the region "correct"; (4) fee for test—where this fee is indicated as being paid by loser it indicates that the complainant pays unless the meter is fast beyond the allowable limit, in which latter case the fee is paid by the company—(in general, these fees refer to complaint testing, although where the city tests all new and repaired meters the company often is charged a fee for such service); (5) refund period or period on the gas bills of which the company is required to make refund for the overcharge due to a "fast" meter, i. e., the period during which the meter is assumed to have been in the same condition as at the time of tests; (6) miscellaneous requirements.

City	All must be tested by—	Complaint meters tested by—	Variation allowed (per cent)	Fee for complaint tests (paid by and amount)	Refund period	Remarks
Aurora, Ill		City		Loser	90 days	
Battle Creek, Mich	City					Not yet enforced.
Bay City, Mich		City		Loser, $1		
Birmingham, Ala	City		±2	Loser, $1	3 months	Not actively enforced at present.
Charleston, S. C		Company	±2	Loser, cost		
Chattanooga, Tenn			±2			
Chicago, Ill	City	City	±2	Loser, $1	6 months	Test at 1.5 inches pressure; 3 meters with Bureau of Standards certificates as standards.
Cleveland, Ohio	City	City	±3			Limit of error set by State law; council reserves right to make more stringent requirement.
Danville, Ill		City	±3	Loser, cost		"Compared with standard meter."
Davenport, Iowa		City				
Decatur, Ill			±2			
Detroit, Mich		City	±2	Loser, $1		One-half fee to company.
Cincinnati, Ohio		City	±2	25 cents and cost of removing meter.		

TABLE 5—Continued

Meter Testing Requirements—Continued

City	All must be tested by—	Complaint meters tested by—	Variation allowed (per cent)	Fee for complaint tests (paid by and amount)	Refund period	Remarks
Easton, Pa	Company	Company	±2	Loser, cost if tested oftener than once in 6 months.		
East St. Louis, Ill		City	±2			
Elgin, Ill		City	±2	Loser, $1 if tested by city; 50 cents if by company.	30 days	All must be tested every 5 years.
El Paso, Tex		City		Loser, cost		
Erie, Pa	City	City	±1	Loser, $1		Test every 2 years; 3 meters with Bureau of Standards certificate as standards.
Fort Wayne, Ind		City	±2	Loser, $1		Fee to company, as it pays fixed monthly fee toward expenses.
Grand Rapids, Mich.	City	City	±2	Loser, $1		
Houston, Tex		City	±2	Loser, cost		
Jackson, Mich		City	±2	Loser, cost	One-half bills since last test.	Ordinance not enforced.
Joliet, Ill		City		Loser, cost	30 days	
Kalamazoo, Mich		City	±2	Loser, cost	3 months	
Kansas City, Mo	City	City	±2	Loser, $1	3 months	Refund on half of bills for 3 months; fee to company unless fast.
Knoxville, Tenn		Company	±2			
Lansing, Mich	City	City	±2	Loser, $1	One-half period since last test.	Fee shared with company.
Lincoln, Nebr			+3 or −2	$1		
Los Angeles, Cal	City	City	−3 or +2		Loser, cost	Methods of test defined.
Louisville, Ky		City	+2 or −3			
McKeesport, Pa		County	±3	Loser, cost		
Memphis, Tenn	City	City	±2			Not oftener then 4 times a year.
Minneapolis, Minn	City	City	±2	Loser, $1	6 months	All tested every 3 years; fee for routine test, 25 cents from company.
New York, N. Y	State	State	±2			Under State rules.
Norfolk, Va	City	City	±2	Routine, 25 cents; complaint, $1 by loser.		

TABLE 5—Continued

Meter Testing Requirements—Continued

City	All must be tested by—	Complaint meters tested by—	Variation allowed (per cent)	Fee for complaint tests (paid by and amount)	Refund period	Remarks
Omaha, Nebr	City	City	±2	Loser, $1		
Pasadena, Cal		City	±2	Loser, $2.50, deposit; $1 fee.	3 months	Method of test defined.
Philadelphia, Pa	City	City		Complainant, if not fast, $1.		Company pays fixed sum toward expense of testing.
Pittsburgh, Pa		County				
Peoria, Ill		City	±2			
Rockford, Ill		City		Loser, cost		
Saginaw, Mich		Company; city may.				All meters tested every 3 years; complaint meters not oftener than every 6 months.
St. Louis, Mo	City	City	±1	Loser, cost	Last bill	Allowed, if 1½ per cent slow, at company's request.
San Diego, Cal	City	City	±2	Loser, $1		
San Francisco, Cal	City	City	±2			
Savannah, Ga		City	±3			
Scranton, Pa		City				
Sioux City, Iowa		City	±2	Loser		
South Bend, Ind		City	+2 or −3			
Springfield, Ill	City	City	±2	Complainant, $1, if accurate.		One-half fee to company.
Terre Haute, Ind			+2 or −3			
Waco, Tex			±2			
Washington, D. C	City	City	±2 at normal rate, ±3 at other rates.	Loser, 50 cents.		
Waterloo, Iowa		Company	+2	Loser, $1	3 months	
Wilmington, Del		City		Loser, 50 cents.		"United States Standard."

TABLE 6

Inspection Official

The officer in charge of inspection work in the following cities is indicated in the table:

Atlanta, Ga	Board of Gas and Smoke Inspectors make occasional tests of gas candlepower and meter accuracy.
Aurora, Ill	Official designation by Mayor.
Battle Creek, Mich	Inspector of Weights, Meters, and Measures.
Bay City, Mich	Board of Public Works.
Charleston, S. C	City Electrician.
Chicago, Ill	Inspector appointed by Mayor; but testers, who do active gas-inspection work, are appointed under municipal civil-service rules.
Cleveland, Ohio	Director of Public Service.
Danville, Ill	City Electrician, ex officio.
Davenport, Iowa	City Electrician, ex officio.
Detroit, Mich	Gas Analyst and Inspector appointed by the Commissioners of Public Works.
East St. Louis, Ill	City Electrician, ex officio.
Elgin, Ill	Gas Inspector and Meter Tester, both appointed by City Council.
El Paso, Tex	Plumbing Inspector, ex officio.
Erie, Pa	Gas-meter Inspector, appointed by the Mayor.
Fort Wayne, Ind	Board of Public Works.
Grand Rapids, Mich	Gas Inspector.
Houston, Tex	Public Service Commissioner.
Indianapolis, Ind	Under Board of Public Works, City Chemist.
Jackson, Mich	Board of Public Works.
Joliet, Ill	Plumbing Inspector.
Kalamazoo, Mich	City Engineer, ex officio.
Kansas City, Mo	Inspector, appointed by Mayor.
Knoxville, Tenn	Inspector of Weights, Measures, and Meters.
Lansing, Mich	City Gas Inspector.
Lincoln, Nebr	Inspector under Water Commissioner.
Los Angeles, Cal	Inspector, appointed by Mayor.
Louisville, Ky	City Gas Inspector.
McKeesport, Pa	Allegheny County Inspector.
Memphis, Tenn	City Gas Inspector.
Minneapolis, Minn	Gas Inspector, appointed by City Council, after examination.
New York, N. Y	Both city and State have inspectors, part of work being done by one office, balance by other.
Newark, N. J	City Gas Inspector, for local enforcement of regulations similar to State rules.
Norfolk, Va	Inspector of Meters.
Oakland, Cal	City electrical department makes some inspections of candlepower and heating value.
Omaha, Nebr	City Gas Commissioner.
Pasadena, Cal	City Health Officer.
Peoria, Ill	City Gas Inspector.
Philadelphia, Pa	Bureau of Gas.
Pittsburgh, Pa	Allegheny County Gas Inspector.
Saginaw, Mich	Board of Public Works, through City Engineer.
St. Louis, Mo	Supervisor of City Lighting.
St. Paul, Minn	City Chemist, ex officio.
San Diego, Cal	Inspector of Gas and Electricity, appointed by City Council.
San Francisco, Cal	Bureau of Light and Water.
Savannah, Ga	City Meter Inspector.
Scranton, Pa	City Meter Inspector.
Sioux City, Iowa	City Engineer, or deputies appointed by him.
South Bend, Ind	Board of Public Safety.
Springfield, Ill	City Gas Inspector, elected by City Council.
Syracuse, N. Y	Purity tests are made by City Chemist.
Washington, D. C	Inspector, appointed by Commissioners of the District of Columbia.
Waterloo, Iowa	Expert, called in by city on complaint.
Wilmington, Del	Plumbing Inspector, ex officio.

PART V.—MANUFACTURE AND DISTRIBUTION OF GAS

The following brief discussion of the kinds of gas supplied commercially is intended to aid those who are unfamiliar with the gas industry in better understanding the reasons for some of the recommendations made in this circular.

A. CONSTITUENTS OF GAS

All commercial gas consists of a mixture of certain chemical substances, the most important of which will be first 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 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 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 of the methane series have higher densities and higher heating values and candlepowers than methane, 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 in any case and actually produce a considerable loss of candlepower for open-flame lights; the amount present in the gas is kept as low as possible in all well-managed works.

The value of gases of different composition varies according to the use to which the gas is to be put. The heating value is the property upon which the usefulness most frequently depends. For cooking appliances, room heaters, and water heaters, the heating value is the principal consideration. The flame temperature as distinguished from the heating value is of far greater importance in the use of gas for power purposes, being nearly as important a consideration as heating value.

In mantle lighting, the flame temperature is of the greatest importance, but many other factors enter, among them the amount of air required for combustion, the size of the flame, and the rate of the explosion wave in the gas-air mixture. The relation of some of these factors has never been fully worked out. Open-flame candlepower is still more complicated. Here another factor enters; namely, the amount of carbon liberated in the flame in the early stages of combustion and later oxidized.

The carbon particles so formed are heated to incandescence and constitute the source of light, serving the same function as the mantle in incandescent lighting. If we think of the carbon particles as a mantle, it at once appears that the flame temperature and heating value of the mixture remaining after the separation of carbon, including the carbon itself, bear the same relation to the candlepower of this flame, as the flame temperature and heating value of the original gas do to the candlepower in mantle lighting. The special function of the so-called illuminants in the gas is to supply the incandescent carbon particles in the flame.

Taking up now the useful properties of various gas mixtures, it is easy to understand the well-known fact that there is no very definite relation between the heating value, the open-flame candlepower, and mantle 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 would always be of a low candlepower. On the other hand, a mixture of hydrogen with just the right amount of "illuminants" which would provide for the liberation of carbon particles from the latter and the high flame temperature of the former would make the gas of high candlepower although of relatively low heating value. But a gas of this same candle-

power composed of methane and the illuminant would have a very high heating value. A gas of low heating value composed principally of hydrogen or carbon monoxide would produce a high mantle candlepower because of the small volume of air consumed and high temperature reached in the flame, while a natural gas of the same heating value composed of methane and nitrogen would give a very poor mantle efficiency. Or, comparing open-flame and mantle candlepower, a mixture of hydrogen and methane which would give a maximum mantle candlepower would be nearly worthless if burned in the open flame, while an illuminating gas of average composition which gave good open-flame values might give much lower mantle candlepower than the former mixture.

Changes in methods of manufacture such as increase in oil used, or change in temperature of operation may produce effects which can be predicated with some success for both the heating and the lighting value of the product; to this extent the way in which heat and light change together can be said to be known approximately, but there are so many such factors that affect the two qualities or only one of them, that two gases of the same heating value may be of very different candlepower and vice versa.

B. METHODS OF MANUFACTURE

Coal Gas.—Coal gas is the gas resulting from the destructive distillation of a gas coal in externally heated clay retorts. The types of retort settings vary greatly, from the simple horizontal direct-fired bench to the elaborate installations of inclined ovens and vertical retorts, equipped with various kinds of economizers and labor-saving devices.

Only such coals as contain a high percentage of volatile matter and are reasonably free from sulphur are suitable for the production of commercial coal gas, the average yield of gas being from 4.5 to 5.5 cubic feet per pound of coal. The quality of this gas is dependent upon the coal selected and also upon the methods that are employed in manufacture. The gas is always a very complex mixture containing variable amounts of all the constituents mentioned above. Generally speaking, with a given coal, the greater the yield per pound the lower the quality of the gas both in heating value and candlepower. There is, however, no definite method whereby gas of a certain heating value or candlepower may be produced, as the conditions that affect the manufacture of gas from different grades of coal are variable. Among the important factors affecting the quality of the resultant gas are the temperatures of the distilling retorts and the length of time the gas is

exposed to these temperatures, which result in an increase or a decrease of the candlepower of the gas by changing the character of the heavy hydrocarbons, those constituents of the gas which produce illumination.

Moreover, the methods adopted in treating the gas after it has been manufactured greatly affect its illuminating quality. The candlepower of the gas obtained from a coal may be increased by limiting the yield per pound. The gas first driven off from the coal containing nearly all the illuminants is of a higher illuminating value than the average yield, and as the distillation proceeds the resultant gas gradually decreases in illuminating value until that produced at the end of the charge is practically nonluminous and of low heating value. Therefore to produce a coal gas of an illuminating value higher than the average, it is necessary to reject the gas coming off last. Such a practice, however, means a decrease in the yield and of course an increase in the cost of manufacture.

This practice prevails to-day in the manufacture of by-product gas in coke ovens where the ovens are fired with the gas coming off during the latter part of the charge and the richer portions that come off during the earlier parts of the charge are made available for distribution. But in this method of manufacture the ovens are primarily a coke-producing plant and are operated in a manner best suited for that purpose rather than with the primary object of producing an illuminating gas.

The average heating value of coal gas produced in this country to-day, assuming yields of 5 cubic feet of gas per pound of coal, ranges from 550 to 630 Btu gross. Heating value, like candlepower, is not uniformly produced in the generation of the gas, as the richer gases evolved during the earlier parts of the distillation are considerably higher in heating value than at the latter part; however, the range in heating value is not as great as the range in candlepower.

In the larger manufacturing plants, where greater yields of gas per pound of coal are obtained, due to more efficient operation, there is a tendency toward a slight reduction both in illuminating and heating value of the "raw" gas. However, this is more than compensated for by a more efficient handling of the gas during condensing, washing, and purification.

Coke-oven gas is a coal gas made in ovens designed primarily for production of a high grade of coke, the gas being considered the by-product. As is above indicated, only the richer portions of this gas are utilized for commercial distribution, and even then the product unless specially enriched is usually inferior in candlepower and heating value to coal gas made in the ordinary process.

Carburetted Water Gas.—Carburetted water gas is formed by action of steam on incandescent coke or anthracite coal, with enrichment by the addition of an oil gas simultaneously generated.

The manufacture of carburetted water gas in the United States has reached such proportions that from 60 to 70 per cent of the total quantity of illuminating gas is now made by this process. The reasons for this remarkable development will be apparent from the advantages explained below.

The generation of carburetted water gas takes place in cylindrical steel chambers, lined with fire brick, and internally heated by the partial combustion of the coal or coke. Straight water gas, or "blue gas," as it is sometimes called, is first made. This consists, theoretically, of equal volumes of hydrogen and carbon monoxide, but in practice the quantity of carbon monoxide is usually appreciably lower than this, depending upon the quantity of carbon dioxide formed. The enrichment of this straight water gas is necessary, as it is not suitable for commercial distribution, being a nonluminous, nonodorous gas of relatively low heating value, averaging about 300 British thermal units per cubic foot.

The illuminating and heating value are increased by enrichment with oil gas, and the gas is given a strong pungent odor. The illuminating and heating value of the enriched gas depend upon the quantity and grade of oil used and upon the degree of efficiency attained in gasifying this oil. The carburetting process, however, should be carried on only between certain limits, determined by the commercial practicability of manufacture. In the average operating conditions in the United States from 3½ to 5 gallons of oil are employed per 1000 feet of gas made, producing illuminating values, when measured on the distribution system, of from 15 to 24 candlepower. Such a gas should have a gross heating value ranging from 500 to 650 Btu per cubic foot. As the illuminating value of the gas is dependent on the efficiency obtained in gasifying the oil, it will be seen that, on the average, from 5 to 6 candlepower can be produced for each gallon of oil used per 1000 cubic feet of gas made. It is evident, therefore, that both the illuminating value and the heating value will be increased by increasing the quantity of oil used for carburetting.

The differences in oil efficiency are due to the methods and temperatures employed in gasifying the oil, which are not at all times controllable. High oil efficiencies seem to coincide with the formation of a relatively greater quantity of benzene vapors which give a higher candlepower to the gas than do corresponding percentages of other illuminants. As the benzene and its homologues thus formed are in the gas in the form of a vapor instead of in

the form of a fixed gas, they are rightly called "unfixed illuminants"; they represent a part of the gaseous mixture that is not permanent under all conditions and, to a greater or lesser extent, are deposited in the gas works and distribution system when unusually high pressure or low temperatures are encountered. The loss in candlepower experienced in distribution is due to the deposition of these unfixed illuminants.

The heating value of the gas is also raised as the quantity of oil used for enrichment is increased, but not in the same ratio as the illuminating value; and the deposition of the unfixed illuminant affects the heating value of the gas, but no definite figures are available to show just what is the extent of this loss. It is generally conceded that the loss in heating value is much less proportionately than the loss in illuminating value, especially when the gas contains any appreciable quantity of benzene and its homologues, as these vapors contribute considerably more to illuminating value than they do to heating value.

Mixed Gas.—Mixed gas is usually understood to be a mixture of carburetted water gas and coal or coke oven gas. It is supplied in many cities in the United States where the requirements permit of a mixed gas being supplied.

The manufacturing installation for mixed gas is practically two complete installations, one for coal gas and one for carburetted water gas, with their auxiliary scrubbing, condensing, purifying, and metering apparatus entirely independent and separate. The manufactured mixed gas, however, is stored in common holders and 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.

Coal gas finds its greatest advantage over water gas in the sale of its by-products, namely, coke, tar, ammonia, and occasionally cyanide. Under favorable conditions these return to the manufacturer a large percentage of the cost of the gas manufactured; and, indeed, unless the by-products are intelligently and economically handled, and unless a favorable market for them is available, coal gas can not be made at sufficiently low net cost to allow it to compete with water gas. The greatest difficulty in extension of large coal-gas works is the lack of a suitable outlet for the coke, as the coke produced is ordinarily not suitable for foundry or metallurgical purposes. The demand for coke for domestic consumption may often be

increased by active advertisement, but in some cases this automatically reduces the use of gas for heating and industrial work. This result is, of course, not desired by the gas maker.

Coal gas always contains considerable percentages of methane and its homologues, together with some ethylene, acetylene, and other illuminants, which are permanent gases, and relatively small amounts of benzene and other easily condensable vapors. A water gas of the same heating value is composed principally of hydrogen and carbon monoxide, the low heating value of which must be made up by the addition of oil gas, some of which is easily condensed in the service mains, causing losses in transmission, and, what is perhaps even worse, a gas supply of irregular quality, depending more or less upon weather conditions. When a very rich gas of this character and of uniform quality is sent out from the central station, during cold weather some of the illuminants are condensed throughout the distributing system. When the weather again becomes warm, the gas that is sent out not only carries with it all the vapors with which it starts, but it may take up some of the previously condensed illuminants from the mains, producing in all the burners properly adjusted for the poorer gas smoky flames and inefficient service. If the burners are now properly adjusted for the new gas quality and the weather again becomes cold, the burners are once more out of adjustment to the extent of causing inconvenience and inefficient service. It will be seen that a gas of very high heating value and especially of high candlepower is not always of advantage to the customer, particularly where it must be produced by the enrichment of a very poor gas with very large amounts of condensable vapors. The very high candlepower water gas formerly sold was of this sort, but a water gas up to 20 candlepower or more can give very satisfactory service except in extremely cold weather.

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. Many 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 small amounts of by-products formed.

The following advantages of mixed gas were also very influential in increasing the amount of water gas made: The coke made in the coal-gas works can be used to make water gas; the candlepower of the mixture can be readily raised by the use of high-candlepower water gas; the more stable character of the coal gas permits distribution of the mixed gas without undue loss of the illuminants and all the disadvantages to manufacturer and consumer which this involves; 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 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, but mixed gas of varying proportions is distributed to some extent in practically all 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 with it the demand for the high candlepowers which gave water gas a great advantage over 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 that its relative desirability is decreasing. 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 decreased appreciably.

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. The process of manufacture resembles that used for water gas. The gas is produced in cylindrical chambers filled with a checker work of fire brick which are heated by a blast of air and oil, the products being permitted to escape from the stack When the generator has reached the proper temperature the air blast is cut off and

oil and steam are forced into the apparatus. The reactions which take place result in the decomposition of both the oil and the steam and the formation of large quantities of hydrogen and methane with relatively smaller amounts of carbon monoxide and the heavy hydrocarbons. While the method of manufacture resembles that of water gas and possesses most of its advantages, the gas produced approximates coal gas in its composition.

C. DISTRIBUTION METHODS[28]

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 greater efficiency 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.

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 11 inches, or for a 3-inch pressure when a 2 to 4 inch variation would

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

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 it is 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 pressures at the burners are 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, since it may have to investigate any complaint which may result from such incorrect installations.

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, generally in the evening when gas is being used for both lighting and cooking. 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 many systems are used in large cities to supply gas to points remote from the works without raising the pressure at the plant. High-pressure belt lines or feeders, pumping mains with district holders or district governors, and various combinations of these are used for this purpose.

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 suddenly 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. Under the rules recommended it will be possible for any company to change its method of operation to one which will be more efficient, without injury to the consumer, and without the expensive and often unsatisfactory investigations frequently found necessary to insure the public that the service and rates proposed are fair.

APPENDIXES

The following tables have been prepared from the data most readily available in the hope that the information thus summarized will be of value to those interested in the manufacture and distribution of gas. Although no conclusions of the previous sections have been based upon these data, they offer, in general, a confirmation of the earlier conclusions. The source of the data from which the tables are compiled is indicated in each case. These sources have been used in preference to correspondence with all of the gas companies of this country, since they furnished the data desired in a form sufficiently trustworthy for the present purpose. The Bureau has not attempted to verify the figures in these tables, which are taken from Brown's directory, but as they are the only data of the kind available they are given as they are believed to be at least approximately correct.

TABLE 1

Gas Production and Value

Total sales (1910)	156.7 billion cubic feet (907 companies reporting)
Total miles of main	48 177 (947 companies reporting)
Total number of consumers	5 648 000 (930 companies reporting)
Value of gas	$150 000 000 (approximate)

TABLE 2

Kind of Gas Made by Companies of Various Size

(Data from Brown's " Directory of American Gas Companies," 1912)

Kind of gas	Gas companies (size, in million cubic feet of annual sales)								Total sales, million cubic feet (approximate).
	More than 1000	500–1000	200–500	100–200	50–100	20–50	Less than 20	Total of all sizes	
Coal	0	1	4	6	23	93	169	296	8 500
By-product	1	1	1	2	3	0	1	9	2 500
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	0	6	5	7	15	92	129	13 200
Character not stated	0	0	0	0	0	1	9	10	70
Total	30	31	64	65	87	206	519	1001	182 000

TABLE 3

Distribution Data for Companies of Various Size

(Data from Brown's "Directory of American Gas Companies," 1911)

	Size of company (annual sales in million cu. ft.)						
	Greater than 1000	1000–500	500–200	200–100	100–50	50–20	Less than 20
Annual sales per mile of main (million cu. ft.):							
Maximum	18.7	6.0	5.0	4.0	9.4	3.7	5.0
Minimum	2.3	1.3	.4	.6	.6	.3	.003
Average [29]	6.1	3.4	2.6	2.3	2.3	1.5	1.07
Number of consumers per mile of main.							
Maximum	600	240	190	300	164	160	210
Minimum	20	48	18	38	15	14	1
Average [30]	175	123	98	98	84	73	59
Annual sales per consumer (thousands cu. ft.):							
Maximum	50	50	50	70	47	80	65
Minimum	22	16	14	12	13	5	1
Average [31]	33	29	26	25	24	21	19

[29] General average, 2.65. [30] General average, 76.3. [31] General average, 21.3.

TABLE 4

Gas Main Pressures

(Data from Brown's "Directory of American Gas Companies," 1912)

Companies—[32]	Pressure stated (inches of water pressure)								Total number reporting
	Greater than 10	8–10	6–8	5–6	4–5	3–4	2–3	Less than 2	
Stating maximum	10	13	21	54	190	276	66	3	633
Stating minimum	0	0	1	11	33	172	316	51	584
Stating average only	0	1	1	1	3	20	9	2	37

[32] Number of companies reporting a pressure variation of less than 2 inches, 508. Companies reporting a high-pressure distribution only are not included.

TABLE 5

Heating Value

(Data from Brown's "Directory of American Gas Companies," 1912)

Companies reporting heating value of—	Kind of gas				Total number
	Coal or by-product gas	Water gas	Mixed coal and water gas	Oil gas	
700 or above	7	5	1	1	14
650–700	28	23	14	14	79
625–650	23	31	20	4	78
600–625	73	55	41	16	185
550–600	13	9	4	3	29
Less than 550	1	4	0	0	5
Total	145	127	80	38	390
Average heating value [33]	620	620	620	625	

[33] General average heating value, 620.

TABLE 6

Candlepower

(Data from Brown's "Directory of American Gas Companies," 1912)

Companies reporting candlepower of—	Kind of gas					Total number
	Coal or by-product gas	Water gas	Mixed coal and water gas	Oil gas (Lowe or Jones process)	Character not stated	
24 or above	0	33	1	6		40
22–24	3	111	14	20	1	149
20–22	13	129	24	36	2	204
18–20	115	61	65	40		281
16–18	147	13	25	3		188
14–16	10	1	2	1		14
Less than 14	1	1	0	0		2
Not reporting	16	45	32	23	7	123
Average candlepower [34]	17.5	21.0	19.0	20.5		

[34] General average, 19.5.

NEW RULES OF THE WISCONSIN RAILROAD COMMISSION.

(Ordered August 9, 1913.)

RULE 1. *Allowable error.*—No gas service meter shall be placed in service or allowed to remain in service which has an incorrect gear ratio or an error in measurement in excess of two per cent when passing gas at the standard test rate of flow.

RULE 2. *Periodic tests.*—Each gas service meter shall be tested before installation and shall be removed, tested, and overhauled at least once every forty-eight months, and adjusted whenever it is found to be incorrect. At least two consecutive test runs must be made which agree within one-half of one per cent.

RULE 3. *Meter test records.*—Whenever a gas service meter is tested the original test record shall be kept indicating the information necessary for identifying the meter, the reason for making the test, the reading of the meter before being disturbed, and the accuracy of measurement, together with all data taken at the time of the test. This record must be sufficiently complete to permit the convenient checking of the methods employed and the calculations. A record shall also be kept, numerically arranged, indicating approximately when the meter was purchased, its size, its identification, its various places of installation with dates of installation and removal, and the dates and general results of all tests.

RULE 4. *Meter testing equipment.*—Each utility furnishing metered gas service shall own a suitable meter prover and maintain the same in proper adjustment to register the condition of the meters within one-half of one per cent. The meter prover shall be so located as to be shielded from excessive temperature disturbances and shall be equipped with suitable thermometers and other necessary accessories.

RULE 5. *Request tests.*—Each utility furnishing metered gas service shall make a test of the accuracy of any gas service meter upon request of the consumer provided the consumer does not request such test more frequently than once in six months. A report giving the results of each request test shall be made to the consumer and the complete, original record kept on file in the office of the utility.

RULE 6. *Referee tests.*—Any gas service meter may be tested by an inspector employed by the commission, upon written application of the consumer. For such test a fee shall be forwarded to the commission by the consumer when making application; the amount of this fee shall be refunded to the consumer by the utility if the meter is found to be fast beyond the two per cent limit. The amount of fee to be collected for tests

so made shall be $2.00 for each gas service meter having a capacity not exceeding ten lights; for other gas service meters having a capacity not exceeding forty-five lights the test fee shall be $4.00 per meter; for all other gas service meters the test fee shall be $8.00.

RULE 7. *Meter readings on bills.*—Bills rendered periodically for metered gas service shall designate the reading of the meter at the beginning and end of the interval for which the bill is rendered and shall give the dates of the readings of the meter.

RULE 8. *Required heating value.*—Each utility furnishing gas service must supply gas giving a monthly average of not less than 600 British thermal units total heating value per cubic foot, as referred to standard conditions of temperature and pressure. The minimum heating value shall never fall below 550. The tests to determine the heating value of the gas shall be made anywhere within a one-mile radius of the center of distribution.

RULE 9. *Calorimeter equipment.*—Each utility whose gas output exceeds twenty million cubic feet per year shall equip itself with a complete standard calorimeter outfit and shall determine the heat value of the gas on at least three days each week. A record of all of these tests shall be made and kept open for public inspection.

RULE 10. *Pressure variation.*—Gas pressure, as measured at the outlet of the company's service to any consumer, shall never be less than two inches nor more than six inches of water pressure, and the maximum pressure at any such outlet on the system shall never be greater than double the minimum pressure at the outlet.

RULE 11. *Pressure surveys.*—Each gas utility shall provide itself with one or more portable graphic recording pressure gauges and shall make frequent measurements of the gas pressure and pressure variation throughout the system, and these shall all be kept on record and open for public inspection.

RULE 12. *Sulphur requirements.*—In no case shall the gas contain more than thirty grains of total sulphur per 100 cubic feet, and not more than a trace of sulphur as sulphuretted hydrogen.

RULE 13. *Complaint record.*—Each company shall keep a record of all complaints made, which shall include the name and address of the consumer, the date, the nature of the complaint, the remedy, and date of completing the work. This record shall be kept open for public inspection.

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