DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 32

STANDARDS FOR GAS SERVICE

[3d Edition]
Issued March 10, 1915

Superseding Circular No. 32, second edition, issued October 1, 1913, entitled "STANDARD REGULATIONS FOR MANUFACTURED GAS AND GAS SERVICE" and first edition, issued April 1, 1912, entitled "STATE AND MUNICIPAL REGULATIONS FOR THE QUALITY DISTRIBUTION AND TESTING OF ILLUMINATING GAS"

WASHINGTON
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1915

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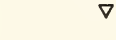

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STANDARDS FOR GAS SERVICE

INTRODUCTION

The necessity for a third edition of this circular and the information and experience which have been accumulating since the preparation of the second edition made it appear desirable at this time to revise the circular thoroughly both as to arrangement and material. The very large demand for the second edition and the favorable comments from many sources as to the character of the work indicate that there is a real need for a publication of this kind, one that is prepared by an agency that is unhampered by the necessity of enforcing rules and yet is in position to obtain not only the experience of State and city officials who are responsible for the enforcement of such rules, but also the experience and suggestions of the companies who must conform to the rules, and, in addition, the most trustworthy technical information on the various scientific and engineering questions involved.

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. 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. The standard methods for gas testing are described in Circular 48 of this Bureau.

In this third edition very few changes have been made in the recommendations except such verbal corrections or such additions as were needed to amplify the text or to make it more easily understood by readers without technical experience. However, the proposed ordinance form and the set of rules suggested for adoption by State authorities have been materially improved by many verbal modifications. The compilation of rules now in force under State authorities has been carefully revised. No attempt was

made to get complete information as to new city legislation; the summary of municipal requirements is, therefore, changed only in the few cases where corrections have happened to come to the attention of the Bureau.

The careful consideration of these existing regulations and the results of their enforcement have 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. 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.

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.

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.

The discussion contained in the following sections applies alike to coal gas, carburetted water gas, by-product gas, oil gas as made 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.

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 this Circular, and different forms of regulations are suggested for the two cases.

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 both from the scientific and technical standpoint, and 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.

It should be borne in mind 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; that is, so that the public gets the best service possible at a reasonable cost, the plant meanwhile being kept up to a high state of efficiency and the stockholders receiving reasonable dividends.

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.

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. The fact that 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.

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. It may be well, however, in small cities or towns where no regular inspection is practicable 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.

A. CANDLEPOWER AND HEATING VALUE

1. RELATIVE VALUE OF SPECIFICATIONS

The earliest specific requirements made as to gas quality were as to the candlepower of the gas supplied. Even at the present time this form of regulation is frequently in force. However, it has been estimated that except in the larger cities, 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. 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. In the last few years the increased number of companies which have been operating on the basis of the heating value of the gas, and the general satisfaction which this method of control has given, have so changed the former situation that prominent gas engineers are 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 operations, are some of the practical advantages to the manufacturer which may be expected from a control based on heating value.

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. Moreover, the best forms of apparatus used for heating-value determinations are readily portable and are therefore suitable for use in State gas inspection, while most portable gas photometers are not suited for accurate work. The relative expense and the comparative skill required for the two kinds of work show 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. In either case careful and properly supervised work should be required.

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 open-flame lighting, for mantle lighting, for heating and cooking, and for producing power. For the first of these uses the candlepower represents the desired measure of usefulness; but for the other uses the heating value is of chief importance. The usefulness of the gas for incandescent mantles and for gas engines 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. 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 tendency is decidedly toward the adoption of heating-value regulations only. Candlepower measurements are more and more being made to test the efficiency of mantles, appliances, and lighting installations rather than to test the quality of the gas itself.

2. SINGLE OR "DOUBLE" STANDARD

At the present time the methods employed in gas making are such that all coal gas and carbureted water gas made on a heating-value basis will also have a reasonable candlepower; but it is uncertain what will be the result as considerable modifications in the manufacturing processes are developed. 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, if one be in force, can be readjusted or eliminated.

The time has not yet come in all places 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. It may be desired, therefore, to retain 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 should always be so low that the manufacture of gas is not thereby complicated and its cost is not increased. It is not essential that the State rules include such candlepower provision, since a State commission can from time to time amend its rules; and thus, 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 may be considered 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. If it is desired to include in the rules adopted by a State commission a provision as to candlepower, a form similar to that given on page 109 may be incorporated.

In cities where a candlepower requirement is now in force, it may be desired to substitute a heating-value requirement; but if this is done, the requirement should be fixed so that the customers will receive the same amount of heat under the new condition or consideration should be given to the fairness of a lower price for the new (poorer) quality of gas.

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 embarrass the manufacturer. A nominal candlepower gas will be sufficient for use in the few places where an open-flame burner is preferable to a mantle light, 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 600 Btu or higher.

B. HEATING-VALUE REGULATIONS

1. NET AND TOTAL HEATING-VALUE STANDARDS

Definitions.—Either the total or the net heating value of a gas may be used as a standard for specifications. The following definitions of these terms are sufficiently precise for purposes of industrial and engineering tests.

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

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

In addition to the terms "total heating value" and "net heating value," the term *observed heating value* may be used as a matter of convenience in discussing experimental data. The observed heating value for a flow calorimeter may be understood to be the value obtained by multiplying the mass of water which flowed through the calorimeter during the test, by the corrected rise in temperature of the water, and dividing by the volume of gas burned, the latter being referred to the standard conditions of 60° F and 30 inches pressure.

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. It has been the general practice to regard the observed heating value as identical with the total (often called "gross") heating value. This practice is not permissible if an accuracy greater than 2 or 3 per cent is required, since, even with a perfect flow calorimeter, these two heating values would necessarily differ by 2 per cent or more under certain atmospheric conditions (e. g., 10 per cent humidity and 90° F), while for some of the calorimeters which have been tested by the Bureau, the difference might amount to about 4 per cent.

By the application of a correction, which can be taken from a table of corrections when the atmospheric humidity and the room temperature are known, it is practicable to correct this 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 cor-

rection will be negligible. At the worst it will be much less uncertain than the uncorrected value.

The net heating value, according to the above definitions, is less than the total heating value by an amount of heat equal to the heat of vaporization, at the initial temperature of the gas and air, of the water formed in the combustion of the gas. From the observed heating value, as above defined, one may also obtain the net heating value by making a correction depending upon the amount of water condensed in the calorimeter.

Recommendation.—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, only a few cities specify the "total" heating value. A majority of these cities do not state precisely what is intended; some specify "gross" value and one or two require "net."

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 is recommended by the Bureau as the most suitable for use in technical specifications.

Briefly stating 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 heating value of coal gas, water gas, or mixed gas is within 2 per cent of the total heating 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 Circular 48 of this Bureau.

In view of the fact that the term "gross heating value" was intended to mean total heating value, but has generally been applied to the observed

heating value as well, it seems desirable to discontinue the use of the term "gross heating value." [1]

2. METHODS OF TESTING

The instruments generally used for the determination of the heating value of gases are of the flow calorimeter type, of which the Junkers is a well-known example. Various makes of this type of calorimeter have found wide use in the gas industries in this country, and practically all of these will meet the present-day requirements of industrial testing. The different instruments give results in 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 (Circular No. 48 of this Bureau). 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 cubic foot paid for by the customer is the "standard cubic foot" and the customer gets 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 some other pressure or temperature, the number of heat units available for use by the customer per cubic foot paid for, is different from 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 according to the number which it would have under some conditions, called the "standard conditions."

[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. Technologic Paper No. 36 and Circular No. 48 of this Bureau discuss the measurement of the heating value of a gas.

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 the gas is metered to the customers at about 60°. Many meters may be in 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. The barometric pressure is nearly uniform throughout any one city and is constant for any altitude if the day-to-day variations due to changing atmospheric conditions are disregarded. These latter are of no more significance than the corresponding variations in temperature and may, therefore, be disregarded in the same way. The average pressure is or can usually be accurately known for any city over any period. Therefore, two possible methods of rating of gas are available, viz:

1. The volume of the gas may be reduced to the pressure which is usually taken as standard, 30 inches of mercury, for purpose of rating the heating value.

2. The volume of the gas may be 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; 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. In other words, the actual amount of heat which the

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

customer can get from a cubic foot of the gas as metered to him is given by the second method, but not by the first unless the city be near sea level. It is also true that customers in two cities, even at different altitudes, when supplied with gas of the same heat value (rated 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. On the other hand, gas of given composition is always rated the same, irrespective of local conditions, if the first basis of measurement is employed.

The first of the 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 in cases where the facts are not understood, an uncertainty or misunderstanding of the significance of tests may result. For example, in a city at high altitude, where the customer does not get the number of heat units per cubic foot of gas 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. It should be clearly understood, however, 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 critics of the customary system would not claim that it is unjust; it may, however, be misleading. In order to compare the cost of gas with the cost of other fuels, the customer must know the heat actually available per cubic foot of gas registered by his meter, and comparisons of prices in two or more cities must take account of the barometric pressure of the several places as well as the rated gas quality.

The criticism of 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. To prevent such misunderstandings, the Bureau of Standards has urged *either* that the cubic foot used for purposes of rating the quality of the gas be made the same as the cubic foot used in measure-

ment of gas to the customers, *or* that the difference between the cubic foot used for the one purpose and that used for the other be made clear in the regulation itself in any case where there is material difference between the two. In the latter case the principal chance for uncertainty has been cared for, but it would also be desirable that the reports of tests make clear this relation. The proposed forms for regulations indicate a simple method of accomplishing this.

If it is desired to follow the customary method of rating the gas on the basis of the cubic foot measured under "standard conditions," the rules given on page 100 will serve. If it seems better to rate the gas upon the basis of a cubic foot measured under local average gas pressure conditions, the following alternate form for rule 1 can be used:

Alternate Form for Rule 1.—For the testing required by these rules, one cubic foot of gas shall be taken to be the amount of gas which occupies a volume of one cubic foot when saturated with water vapor and at sixty degrees Fahrenheit and under a pressure equal to the average gas pressure in the customers' meters in the city in which the test is to be made. The average gas pressure in the customers' meters in the various cities of this State is assumed to be as follows:[3]

The engineering significance of rating a gas on the basis of the cubic foot measured under local average gas pressure has frequently been misunderstood. 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 5.2 feet per pound in another, this does not necessarily 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 also corrected to the basis of 30 inches 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 the operating results or the service conditions in such different

[3] The gas pressure which prevails on the average in each of the several cities in which therei s a gas company should be listed as a part of this rule. To determine this average, the annual average barometric pressure for the city should be increased by the amount of the excess of gas pressure above atmospheric and the value for each city expressed to the nearest one-tenth of an inch.

cities is no more difficult on the second basis than on the first. However the rating of gas quality may be made, the basis of a company's operating records need not be changed unless the company wishes to make such modification. The basis for official rating of gas quality, a matter of public relations, is the only question referred to in the recommendations of the Bureau.

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 average heating value of the gas for each month is, therefore, often used as the basis of specifications; and usually the minimum heating value to be supplied is also prescribed. Such monthly averages with a suitable minimum limit have been used with success for several years in a number of States, and the Bureau recommends their adoption generally for candlepower and heating values.

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.

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 quality of the gas should not be permitted to fluctuate unduly. 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 the average may be very good in quality or pressure; but when suitable minimum allowable values are specified, such irregularities are controlled.

A tolerance for a single day of 50 Btu below the required average 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 restric-

tion 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 paragraphs are included. The Bureau does not, of course, 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.

The present 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. Ever since the invention of the first processes for the manufacture of artificial gas the price of this product has been gradually reduced. This has been possible because of improvements in manufacturing processes, increase in size of plants, and many developments in the industry. 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. Furthermore, as the processes of making and distributing gas have been improved the risk of the business has been made smaller; this with the closer 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 everywhere 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.

In any city with given facilities for fuel supply, labor supply, outlet for by-products, and other factors fixed, and with a given type of manufacturing plant already installed, 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 in the city in question to produce gas of the quality determined upon as most desirable. Obviously in some cities the price for gas may properly be more than in other cities, even though the quality be the same.

Heating Value Required.—In the past, heating values have usually been rated on the basis of reduction to 30 inches pressure. 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 fixing of heating-value requirements in the past has been more or less accidental or arbitrary. In most cases the selection has been made to correspond either with the figure required elsewhere or with the figure representing the quality delivered by the companies to be regulated previous to the time of the regulation. Either of these two methods taken alone is not a proper one, the first, because rules which are applicable under one condition may not be applicable under another, and the second, because there is no means of knowing without other investigations whether or not the previous practice of a company is the best, either for itself or for the customers concerned.

In two States investigations have been made to gather data bearing upon the question of the proper heating value for gas in those States.

The first of these investigations was carried on by Wisconsin during 1907 and 1908, and consisted of an investigation of the quality of gas which was furnished that time by the companies of that State and a study of conditions attending the operation of these companies. The conclusion reached

was that a majority of the companies were furnishing gas of 600 Btu per cubic foot or higher and that, where this condition existed, reasonable satisfaction to the customer was to be found. A requirement of 600 Btu was therefore prescribed by the commission. Indeed, at that time no other basis than the previous practice could have been chosen, since practically no data were then available as to the relative cost or the relative usefulness of gases of different heating values.

A committee made up of the representatives of the gas companies and the Public Service Commission of the second district of New York has also carried out an extended investigation. In this work the operation of 15 companies was studied by the committee and information was collected as to the operating practice and probable result of changes in this practice. Although a very large amount of data was collected by the committee and an extended report made, it does not appear that full consideration has yet been given to the exact technical significance of the data. Certainly the report does not make clear the connection between the fundamental principle upon which the committee states that it bases its conclusions and the conclusions themselves; nor why a lower heating value is recommended than is now supplied, when no change in price or other benefits to the customer to compensate for the decrease in heating value were recommended.

The correct basis for a heating-value standard, namely, the delivery of the most heat to the customer for $1, has sometimes apparently been misapplied. In the case referred to above a decrease in heating-value standard was recommended in order presumably to meet certain economic conditions, but it was not made clear either that greater economies would result or that the customer would benefit by this lower heating value. The companies would of course benefit by such a lower standard, but it was not shown that a larger rate of return was necessary to the companies.

Another misapplication of the principle has been found in the case of those companies which argue that the condition which will permit manufacture at the least net holder cost per heat unit is the best condition. However, the minimum net holder cost per heat unit is only a part of the total cost, and it is the total which should be a minimum.

Still another way in which the fundamental principle has been modified is on the basis of "conservation of materials." Those using this argument state that the heating value which enables one to get the largest number of heat units from each pound of coal or gallon of oil is the best one. This argument is of course sound if it does not make the realization of the main principle

impossible. If, however, in order to save a small amount of fuel we deliver a poorer gas at the same price, or give considerably less service for each dollar, the principle of conservation of materials can not control.

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.[3a] The correct application of this principle requires a consideration not only of the cost of manufacture, which is directly affected by changes in quality, but also a consideration of the changes in sales with changes in heating value of the gas and their effect on all operating costs. Moreover, it is necessary to consider what changes in fixed charges, both per thousand cubic feet and in the aggregate, will result from changing quality. In other words, it is necessary first to determine approximately for each of several qualities of gas what would be the proper price to charge the customer in order that all operating expenses be paid, proper allowance made for depreciation, and a proper return upon the investment assured. It is then easy to determine which of the several qualities of gas will give to the customer the most heat for each dollar paid. 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 the company, and it is assumed 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

[3a] The Joint Calorimeter Committee of New York State in the report of its investigation as to a proper heating-value standard, states the guiding principle of its 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."

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. 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 charge per 1000 cubic feet 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 substantially 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. Under one or more of the following conditions the lower figure named may be the more economical: 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. On the other hand, other conditions may make 625 Btu or even higher values the most economical; however, this is not the usual case.

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 may be more efficient for certain appliances, in that the service rendered by each heat unit is slightly greater. Thus, when used in mantle burners and certain other appliances the service obtained may be 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 oil-washed, 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. Gas of 575 to 600 Btu when properly made and condensed 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 as an argument against maintainance of a high standard of quality usually occur with 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 gas made to meet a 600 Btu requirement 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
Carbureted 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 (carbureted 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)	550–650	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 inexperienced 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 increase in price necessary 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 total cost per heat unit is higher than would be the case if the plant were operating to a lower heating value standard. Even in such cases a reduction in the quality without a reduction in the price would not be desirable, unless the inconvenience which results from the seasonal irregularity in supply was very great. 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 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.

There are many factors which in particular cases have an important bearing upon the question of the proper heating-value standard; it is, of course, impossible to discuss these at any length here.

Alternate for Heating-Value Section of Proposed Ordinance.—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. (See original form on p. 109.)

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 propor-

tionately. 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:

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.

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; but the customer is apt to believe such gas to be less satisfactory than a

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

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 statement 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.

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.

In a State where considerable differences of altitude exist between the various gas plants, the numerical 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.

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Summary of Recommendation.[8]—Gas of 600 Btu per cubic foot or higher is being furnished by practically all of the larger companies and a considerable number of smaller ones 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 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 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

[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 show 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.

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 "heat of combustion" of a gas of given composition is a definite amount of heat which 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 conditions 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; 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 lamp is rated at 10 candles and the gas when tested is found to give one and one-half times as much light, the candlepower of the gas is said to be 15. 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 is maintained by the cooperative effort of several national standardizing institutions and is checked from time to time by means of all the best primary standards in use. Such a unit can be kept 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 1, 1909, a common unit and to cooperate in maintaining the common value constant. The unit adopted was called the "international candle." In this agreement the value of the international candle was accepted as being the same as the pentane (or English) candle, the bougie décimale, and the American candle.

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. The Hefner unit is nine-tenths of an international candle, and the Carcel is 9.6 international candles.

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 sperm candle, the 10-candle 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 pentane and other photometric standards in use in America are now standardized by the Bureau of Standards in terms of the international candle. *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 composition) burned in the same burner on a day of average humidity and average barometer. 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 more nearly independent of the weather, the gas flame is usually compared with another flame, such as that of the pentane lamp, Hefner lamp, or a 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.

If we call a pentane lamp a "10-candle standard" at all times, because it will give 10 candles under certain conditions taken as normal, then a gas

flame which, when compared with it, is twice as intense will always be called a 20-candle flame, even though at the particular time of test the gas light may be only 18 or as much as 22 candles. When the value of the standard is properly chosen to correspond with the average conditions under which it is to be used, this procedure is perfectly fair both to 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.

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 10 candles might have on the average through the year in these cities an actual candlepower of 9 to 9.9. By using the value 10 candles the gas is rated from 1 to 10 per cent higher than its actual value, and if the further correction for the effect of barometric pressure on gas density is made the rated candlepower of the gas may in some cities at high altitude be as much as 40 per cent greater than the actual candlepower. 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).

Recent experiments at the Bureau of Standards, not yet published, show that the luminous efficiency of a gas flame (defined as the intensity of light per unit mass of gas burned per hour) decreases very considerably as the atmospheric pressure decreases. The quantity of gas burned at 25 inches pressure is one-sixth less than at sea-level, and hence if the luminous efficiency were unchanged only $16\frac{2}{3}$ candles would be obtained from a gas

which at sea-level gives 20 candles. But the luminous efficiency is smaller at the lower pressure, so that the actual candlepower, when using a very common type of burner, is 14 instead of 16⅔ candles.

The pentane standard lamp burning at constant flame height at 25 inches barometric pressure gives 9 candles instead of 10, so that the value observed for the gas is 15.5 candles instead of 14. Correcting for reduced pressure in the customary way, by adding 20 per cent, 18.6 is obtained as the rated value of the gas. We may tabulate these results as follows:

	Candles.
Candlepower of a given gas, burning at 5 cubic feet per hour, at sea level (30 inches barometric pressure) assumed to be	20.0
Candlepower the same gas would give at 25 inches pressure if the luminous efficiency were constant at all pressures	16.7
Candlepower actually found at 25 inches pressure (using Bray No. 7 slit union burner)	14.0
Candlepower observed against a pentane lamp, assuming its candlepower to be 10	15.5
Rated candlepower (corrected to sea level) based on pentane standard	18.6
Rated candlepower (corrected to sea level) based on Hefner standard	17.6
Rated candlepower (corrected to sea level) based on electric or other unvarying standard	16.8

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 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 greater than its actual value, but usually somewhat less than the sea-level value for gas of the same composition.[9] As a quantitative illustration, consider the following example: If a gas has an actual candlepower of 20 when burned at the rate of 5 cubic feet per hour at 30 inches barometric pressure

[9] In the earlier edition of this circular it was stated that the rated value according to current methods was higher when the test was made under lower barometric pressure conditions; however, our own tests on this point, which have been made since the previous issue, have shown the reverse to be the fact. Where the present statements are contrary to previous ones on this point, the change has been made on the basis of these newly obtained results.

and at normal humidity, then the rated candlepower at sea level would also be 20. The same gas burned from a Bray No. 7 Slit Union burner at the rate of 5 cubic feet per hour under 25 inches pressure would have an actual candlepower of about 14 and a rated candlepower (by current methods of calculation) of about 18.6, provided the test were made with a pentane lamp. If a Hefner lamp were used as the standard, the rated value would be about 17.6.

The use of another type of test burner would not only change the actual and rated candlepowers, but it would give values which would be a different percentage of the sea-level candlepower. For example, the same gas would give with a Sugg F Argand burner about 21.5 candles at sea level, and would have an actual candlepower of about 17.1 at 25 inches, but the candlepower when test is made with a pentane lamp would be rated by customary methods as about 22.8 candles.

The conclusion would seem to be inevitable 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 flame, 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 under the conditions of use of the gas should, if possible, be the basis of rating for the same reason that the actual heat delivered should be the basis of the heating value to be specified. Although there is some justification for specifying the candlepower, as well as the heating value, in terms of a cubic foot under standard pressure, as is now done, the only reason for overrating the candlepower of the standard lamp, as has been done in the past, is the lack of precise information as to the variations of candlepower with atmospheric pressure. This information will shortly be supplied, and then it will be possible to rate pentane and other flame standards according to their actual candlepower under different average atmospheric conditions. Then candlepower and heating value would be put on the same basis, in that both would represent the value to the consumer of a definite amount of the gas. And the fact that the cubic foot of gas as delivered under low pressures to the consumer contains

less gas than the standard cubic foot could be taken into account when necessary in the manner suggested on page 19.

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. 17–20), 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 for the gas, there is no reason evident why the use of the actual candlepower of the standard instead of a larger nominal value will be any embarrassment to the gasmaker. When the altitude is considerably above sea level, a lower value for the gas candlepower would need to be specified to allow for the decreased efficiency of the gas burner.

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 rating regardless of the conditions at the time of test. As far as the effect of humidity is concerned, this assumption is not far from

correct; but in the case of difference of pressure whether or not this be true depends upon what burner is used, as has been pointed out in the preceding section. Heating values as given in different places are directly comparable; candlepower values can be made comparable only by considering the change in efficiency of the particular type of test burner used. 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 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 might be 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 necessarily been taken into account where operating costs have been the basis of rate-making legislation.

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 in an efficient open-flame burner at 5 cubic feet per hour under the average atmospheric conditions of the city. This can be done very simply by rating the standard lamp for these conditions; and the gas volume could be corrected to the average local gas pressure or to the standard condition of pressure on the same basis as the heating value. The results of tests are then not only simply obtained, but they are of real significance. The proposed ordinance given in Part III shows the manner in which this can be fixed simply and clearly in the law.

2. METHODS SPECIFIED FOR TESTS

Only a few points concerning the methods of candlepower testing which need be taken into account in the ordinance itself are included in the discussion of this section. Other points are discussed in Circular 48, "Standard methods of gas testing."

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. 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. 38), and the corresponding ordinance forms are given on page 110. Whether a flame or an electric standard should be used need not be stated in the ordinance.

The Test Burner.—As the 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 selection of a test burner and of the candlepower value to be specified should be considered together. If the burner selected gives a lower or a higher candlepower than some other burner which might be used, then the required candlepower should be made lower or higher, accordingly. That is, the 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 18 to 22 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. Indeed this higher rating is misleading, 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 110, 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.

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. The monthly average is generally better as the principal requirement; but this may be supplemented by a minimum, as is recommended for heating-value regulations. 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. However, if the candlepower regulation is supplementary to a heating-value requirement, as will usually be the case, it will not be necessary to pre-

scribe 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.

As may be noted in the tabulation of candlepower requirements now in force on page 162, 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, in some measure to misunderstandings of the proper function of a candlepower requirement, and in some cases to retention of old regulations which have not yet been brought up to date.

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 10 to 15 open-flame candlepower gas without undue difficulty or expense;[10] 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 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 12 to 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 these cases a candlepower requirement of 12 or 16 in the open flame would not be severe and yet would afford to the open-flame user ample protection.

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 may be greater than it would be for a gas averaging 18 candles. 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

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

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 the 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 the legal limit for candlepower is fairly low.

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 quality appear somewhat lower than if rated by the Argand candlepower. This is perfectly fair, as it gives more nearly the real value of the gas for use in open-flame burners; but of course the nominal value specified should be lower than it otherwise would be.

5. Moderately low-candlepower gas will 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 believes that those larger cities which need a full regulatory gas ordinance may fairly specify, in connection with a calorific standard, that the gas supplied be of 14 to 16 candle-

power measured on the open flame. However, if, 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 if the gas supplied is of especially low heating value to permit use of by-product or unenriched coal gas, 10 to 14 candlepower may be prescribed. 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 is reasonably uniform, 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 of controlling 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. 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.

Second. As *favoring* a hydrogen sulphide restriction:

The hydrogen sulphide will increase the sulphur dioxide in the products of combustion, and hence should be removed, since this can be done with comparative ease and with very small expense. 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, and hence hydrogen sulphide may be somewhat more objectionable than other sulphur-containing compounds. It is also claimed by some that because of its unpleasant odor the presence of hydrogen sulphide in the gas is conducive to unfriendly relations between company and consumer.

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

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*) The information which is now available as to the exact sensitiveness of the tests with lead acetate paper indicates that this test when carefully defined has practically a quantitative significance. There is no advantage, therefore, in a numerical value fixing a limit on the amount of this impurity, and the benefit of past experience would be lost by the use of a new test which had not previously had wide application. (*b*) The determination by quantitative methods 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.

The test proposed is somewhat more severe than some used in this country, but it is much less severe than others. It probably conforms to average practice very closely in its commercial significance, and is for ordinary conditions wholly practical and sufficient to permit good control of operating conditions.[11]

[11] A full discussion of the comparative as well as the absolute sensitiveness of the various methods of detection of hydrogen sulphide is included in Technologic Paper 41 of the Bureau, which has just been issued.

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 cause of such trouble. As specified in section 14 (p. 114), "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.

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

2. TOTAL SULPHUR

The amount of total sulphur present in a purified gas is not wholly within the control of the company, since 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 gas manufacture is in effect a limitation upon the quality of fuel purchased. It is desirable, therefore, that the limits set be not unduly severe, lest a coal or an oil 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 inferior grades, and the resulting gas is thus higher in sulphur. With the fuel supplies which are available at present, coal gas can not be made as low in sulphur compounds, other than hydrogen sulphide, as can water gas. There is no difficulty in maintaining the sulphur in water gas below 20 grains per 100 cubic feet, and 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. The allowance of 30 grains per 100 cubic feet will be desirable in some cases; this will give relief in certain localities where high sulphur coals are used and 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.

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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. However, some leeway is necessary in interpreting such rules. For example, 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.

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.

Practically no ammonia is produced in the water-gas and oil-gas processes; no limit need be prescribed for ammonia when these processes are employed exclusively. In the case of coal-gas plants some limit should be placed for ammonia; a 5-grain limit would usually 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 which is not deserved, and the limits recommended are enough higher than otherwise necessary to cover errors in the determination.

4. CARBON MONOXIDE

There has been some agitation for a limitation of the carbon monoxide content of gas based upon the fact that this substance is the only constituent of illuminating gas which, in the amounts ordinarily found, is poisonous; but a review of existing legislation shows no tendency to establish such a limit by law.

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, might operate to limit the amount of water gas made. It is apparent that such regulations as would prevent the operation of water-gas plants would be very radical. Although 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. 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 considering such a restriction.

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 the use of 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, as in a faulty appliance or in 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.

There are three values of the gas pressure commonly specified, viz, the maximum pressure, the minimum pressure, and the variation in pressure allowable. 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.

In this circular 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.

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, feeding mains with 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. In discussing this question it should be borne in mind that a regulatory measure usually has to do only with the pressure of gas in the consumers' premises; the gas-main pressures are not affected by any limitation of the sort proposed in this circular.

The tendency toward maintainance of higher distribution pressures 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. And when a pressure of 1 pound or more is necessary the ordinary type of low-pressure distributing system will usually, if not always, have to be replaced by one designed for such higher pressure.

There are even more serious objections to the use of higher pressures on the consumers' premises; and although there is no doubt that these objections will gradually be overcome, yet for a number of years, at least, it is probable that pressures below 6 to 8 inches will be used in practically all cities. Some question has been raised as to the desirability of legal limitation of the maximum pressure to be maintained in the consumers' piping; but after very careful consideration of all the facts presented to it, the Bureau has come to the conclusion that it will usually, if not always, be best to set some upper pressure limit 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. Ordinary gas burners for both stoves and mantle lights are designed for use at a pressure of 2 to 6 inches. If pressures higher that these are used, readjustment or replacement of the gas outlets with those of smaller size is necessary; and unless some one is required to supervise this adjustment and determine 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.

2. 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. Although 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.

3. The average gas consumer can not be trusted to regulate his appliances when the pressure goes above 6 to 8 inches, and, furthermore, he is 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.

4. 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 might thus

be impossible for any dealer to sell appliances suitable for all parts of the city, and the public might not be able to purchase fittings capable of proper adjustment. 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.

5. By the use of high-pressure lines, a booster system, or 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 doubtful 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.

6. Six to eight 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 specify this distinctly, as suggested in the proposed regulations.

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 the gas, being larger with coal gas than water gas. The differences actually occurring depend not only on the 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 officials in authority should permit the higher pressures as the needs of the companies might demand, and no supplementary legislation would be required to bring about changes under the rule which is proposed.

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 at 1 inch. It is generally true, however, that reasonable 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 whenever 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 prevents 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 because of 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;

this shows 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.

With proportionate change of pressure the increasing amount of gas entering an appliance is no greater at high pressures than at low pressures, 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 with a higher normal pressure smaller variations can in practice be economically maintained, it is only fair to assure the customer that the company will prevent any variation greater than necessary. 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.

The plan of leaving it largely to the company to determine what normal pressures shall be maintained in different districts of a 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.

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 regulations, 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 gradually to 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 applicances 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 change will not result in any serious inconvenience to the customers affected.

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 presssure 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 146 of this circular.

Since there is still 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.

F. METERS AND METER TESTING

Since the records 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

A meter can 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. The tolerance of 1, or at the most 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.

After having been in service for some time 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 highest commercial accuracy at time of installation, but allowing reasonable variation after use. Under this new scheme meters will start in service adjusted as accurately as it is practicable to have them, 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 can 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 or labeling of the meters can be done in several ways, which are described under methods of testing. Even when the regular inspection is done by the company, the meters should be marked 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 regulations arrange 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 inpsectors 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.

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.

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 has usually been considered undesirable. 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.

When a five-year removal rule is in force it can be assumed that each year about 25 per cent of the total number of meters installed must be tested. This includes removals due to change of consumer, complaints, 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 system used by some companies by which clerks are constantly going over the ledgers to pick out and to investigate cases in which the consumption of gas is falling off 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.

3. TESTS ON REQUEST OF CUSTOMER

A number of State commissions require that the companies shall test any service 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. 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 or State inspector and the company be given no previous opportunity to adjust them. A rule of this sort has been in force in Wisconsin for several years requiring the companies 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.

Testing oftener than once a year is rarely necessary, and few cases will be met where this frequency of test is demanded. A second test within a year should be made when demanded, but the charges should then fall on the customer, unless the meter shall prove to be fast.

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 thay 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.

4. FEES FOR TESTING AND REFUNDS

If a 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 this fee 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) of the proposed ordinance 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 approximately equal to 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.

The proposed refund to customers is so arranged that the customer recovers only the probable excess in charge during the previous six months. It should not be assumed 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.

Refunds to customers for overcharges which are discovered by a routine test of a meter should also be made when a sufficiently large sum is involved to make the expense for payment not an unduly large part of the refund itself, e. g., if an error of more than 5 per cent is detected by such test.

In cases where undercharges are detected by a test, the loss usually can fairly fall upon the company; but in unusual cases where a large undercharge has accumulated, apparently through no fault of the company, a bill for this amount may properly be rendered. In any case where refunds are made for fast meters, the company should probably have the option of charging for slow meters. Most companies would probably not wish to exercise this option; but if they make every reasonable effort to keep the meters in good order, they should be allowed to collect for losses when discovered as well as required to refund overcharges detected.

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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. It is an advantage to bear in mind the three essential parts of the enforcement procedure, since 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-service 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 that, through its larger resources, a State legislature or State commission should be able to 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 experi-

ence 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 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. 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 under municipal regulations; in fact, a State gas law appears to be little more than a municipal regulation applied over larger territory.

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 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. In this connection the

Bureau wishes to 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.

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.

B. REGULATION BY STATE AUTHORITIES

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 the work done by each State 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 what might be termed limited legislative powers to all the State commissions thus far established has been attended by considerable advantage, and in some respects such authority is essential to the success of any State gas inspection. Some States have, however, fixed the maximum or minimum requirement which may be made of any company in respect to certain of the more important technical matters. The supposed 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 which has a staff 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.

The object of a gas law is to insure the public a gas supply of good quality, properly delivered, and 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. However, 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; but 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

Before establishing a set of regulations fixing standards for gas service it is advisable to take certain preliminary steps. Assuming that it is known approximately what technical subjects should be included in the rules, an investigation of the quality and purity of gas supplied and of the gas-pressure conditions existent, and a study of the meter-testing practice of the companies should first be made. When information on these subjects is available, the rules proposed by the Bureau of Standards or other State rules which appear to apply to the particular conditions found may be used as a basis for a preliminary set of regulations. It is then desirable to submit this preliminary draft to the companies affected and to hold one or more conferences with their representatives, giving the companies full opportunity to suggest changes or additions to the rules proposed before the final form of the rules is determined.

The Bureau of Standards has been in touch with work preliminary to the adoption of regulations in the majority of States where such rules are now in force, and it appears to the Bureau that a careful procedure along the lines above outlined is almost certain to lead to the adoption of rules satisfactory to the utilities and the public.

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 gas inspectors and seven gas-meter inspectors are required to make the regular tests, and even with this large force the companies are, on the average, visited for a gas inspection only about once each month. It does not appear that this plan would be a desirable one to apply in general, particularly in the States having only a few gas companies.

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 the gas supplied for hydrogen sulphide; further determinations of purity and heating value would be made by the larger companies as indicated in the proposed rules. The number of records and frequency of tests to be made by the companies can usually be left to the companies themselves. If any company does not make as many or as frequent tests as may seem to the commission to be desirable, an informal request by the latter that the frequency or number be increased would usually be sufficient to bring satisfactory results.

The records of these tests and the complaint files would be open to the State inspectors at all times, and by visits at irregular intervals the tests of the company could be supervised so that, even 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 proposed requirement of tests of heating value is very similar to that made in a number of States. Companies making less than 20 000 000 cubic feet of gas annually might also be required to purchase and use a calorimeter, since the expense of such purchase and use would rarely be excessive for any company if it were sure that the company could and would afford the time of a competent man to use the instrument properly. The saving accomplished by the closer works control, which is possible when making regular calorimetric tests, makes the purchase of a calorimeter a profitable investment even in the case of many small companies.

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

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.

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 necessary portion of the traveling inspection work is the calibration or standardization of the companies' testing apparatus and instruments which are used for all of the company tests and for many of those by the inspectors. 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, 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 regularity of the periodical testing, the use of suitable equipment and methods, and the keeping of full records of such tests. The inspectors should examine these records whenever a regular inspection is made; and summaries of meter tests may be collected and filed with the commission.

The proposed rules provide that a consumer may have his meter tested by the company at any time he may desire (provided this is not oftener than once 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. The rules also provide for the test of service meters by inspectors of the commission on formal complaint of consumer, and a few meters will be tested under this provision.

In addition to prescribing methods and checking prover equipment, it is well to send inspectors to the various cities occasionally, and to choose at random and remove from service a number of meters for test. 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.

Regular Testing Work by State Inspectors.—In some States it has been thought best to have official tests made regularly in all cities, rather than only to supervise the routine work as done by the companies. 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.

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

	1908	1909	1910	1911	1912
Number of inspections	1018	929	890	899	876
Number of companies subject to inspection	68	68	68	68	68
Number of meters tested	58 875	73 994	82 643	86 730	90 791
Number of complaint meters tested	438	415	328	457	446

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 1912 the testing of meters gave an income of over $23 000, and the operating expenses, including salaries of gas and gas-meter inspectors, were only about $15 000. The board thus had a surplus of $8 000 for that year from its gas-inspection department.

Second District of New York State.—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 941 tests for the supervision of the 89 companies visited in 1913. For convenience of operation the State is subdivided into three gas-inspection districts with headquarters as follows: Albany, two gas inspectors; Mount Vernon, one gas inspector; and Rochester, one gas inspector.

Every Saturday each inspector receives 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, who look after the territories contiguous to their headquarters, aided occasionally by the gas inspectors; the work 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 1913, 105 451 meters were tested by the commission. Of this number less than 100 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.

General Recommendations.—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 pr pared 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 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 caring for some 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 must be tested before installation. The work could, however, be planned by the chief inspector from week to week, according to the requests received from the companies for meter inspection. This plan has met with some success in the New York inspection work.

If we assume that because of 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 indicated 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 has been verified by the chief inspector. This follows the New York system of reports closely.

The gas-service 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 the commission should be very familiar are usually in question. The immediate reference of all such disputes to a court of law would make their

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

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.

C. 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, DEFUTIES, ETC.

The advantage derived from examining the inspector before appointment leaves no doubt as to its advisability (see p. 105). 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. 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 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. 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

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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. 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.

No pains should be spared to make the tests on gas representative of that delivered in the district in which such tests are made. 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.

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 adopted for small plants as well as large the distance is better placed at one-half to 1 mile.

In small cities the location of the testing equipment in the office of the gas company or of some city official can advantageously be made. 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 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. Geographic considerations are also 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. In any city where two companies distribute gas over the same district a single station may easily be equipped for testing the gas from both.

After a laboratory is properly located the 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. 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.: Heating-value determinations, candlepower measurements, tests of purity, pressure record taking, and tests of meters.

Heating-Value Determinations.—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.

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 various points in the city. These tests would not be used as basis for 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.

Candlepower Tests.—In order to maintain a reasonable supervision of the candlepower of 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.

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 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.

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

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 gages. 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, gages must be so located that no consumer will be more than 3800 feet from a gage station. For many cities such concentration will not be needed; but it is important that all parts of the district supplied with gas be carefully watched, as changes from year to year may develop serious deficiencies in one part or another. It is not practicable to give any general rule as determining the number of gages for use in a city.

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

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 shall 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 customary 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. 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, there-

fore, 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 gage 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 portable gages 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 gages are located upon private property. The removal 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; but unless any particular location seems specially suited as a pressure testing station for a neighborhood, it would be well to move all portable gages 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 gages 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 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 gages will be desirable, so that the main pressures will be recorded.

In setting test gages 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 gage. If leakage results under these circumstances, the company and not the city is responsible for the work.

The surprising percentage of the complaints of "poor gas," which on investigation resolve themselves into poor pressure, is sufficient reason for the uses of gages 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 usually will, do as good work as is possible under official testing. 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. For State work this plan is unquestionably the better; for cities it seems also preferable. Some city or State official would be expected to make the complaint-meter tests, when the company did the routine work.

Although some of the meter inspection work which 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. But for small cities,

where there is neither city nor State gas-inspection service, the complaint tests may be made by the city engineer or some other official.

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 any event, the company should be held responsible for the condition of its meters.

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 even for smaller cities, since the duties defined are, in general, only such as would naturally accompany the office of inspector, whether this officer be specially appointed for this work or one of the other regular city officials to whom the gas testing has been assigned. 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, because of 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. The Bureau believes that, generally speaking, the inspector can best serve the public by the fullest cooperation with the company in the examination of the quality of the gas and the character of

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.—Records similar to those proposed in section 12 should be kept by all progressive companies without requirement. This section, then, becomes, in effect, a requirement that the company shall allow access to these records. The necessity for this use of company records by the inspector arises 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.

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. These two records combined give full information of the meter-testing work.

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 file by the company's "complaint department" will amply repay the time and expense of 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 the prosecution of the company in the city courts, 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; but because of the different conditions in the manufacturing and testing methods of the two countries the American cities have found this reference to English practice somewhat unsatisfactory.

In order to furnish to the American gas inspectors a source of information on standard testing methods, the Bureau of Standards has issued a circular on this subject which represents not only a summary of work done at the Bureau but also a review of the experience of some of the well-known gas chemists and municipal inspectors. This circular will be revised from time to time in order to have it at all times represent the latest available information. It seems certain that the recommendations of this circular can be used as a basis for settlement 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.

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, as suggested in proposed section 15, 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 regarding 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 requirement is needed except that provided 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 the public, more or less completely, 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.

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.

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 pur-

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

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, the following are suggested:

Companies of class 1,[12] $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 cases of exemption from penalty described in the proposed ordinance section 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 satisfcatory 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. Since the city clerk receives a copy of the inspector's report, he should be responsible for bringing it to the notice of the officer who takes the legal action whenever the company should 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.

[12] 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.

Part III.—PROPOSED FORMS FOR REGULATIONS

In order to give in convenient form a summary of the recommendations of the Bureau on State and municipal gas regulations, a set of rules suitable for enforcement by a State commission and an ordinance suitable for adoption by a city have been prepared. These proposed forms may not be adopted as a whole; but they can be followed closely in most places, since the forms have been carefully arranged so that they will be generally applicable. 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. Every effort has been made to simplify the proposed regulations and further abbreviation might result in omitting an essential part. The numerical values specified must, of course, be modified to meet local needs, and the ordinance and rules proposed must be considered in the light of the discussion of the preceding sections of this circular, any necessary changes being made to meet special conditions.

A. RULES PROPOSED FOR THE USE OF STATE COMMISSIONS

In a number of States the regulations for gas service are combined with similar regulations for electric, water, and other utility service. It is sometimes necessary, therefore, to draft certain rules of general application for all these utilities, since in any State where several sets of regulations are adopted it is, of course, desirable that the general provisions for the several utilities should be in harmony.

The following rules which are proposed for use of State commissions have been divided into two parts, general rules and special rules for gas service. Most of the general rules require no discussion; however, some regulations affecting public-relations questions must be carefully considered. It is not possible at this time to include a full discussion of these general rules, and it should be understood that the form in which they are drafted is only a preliminary one. The proposals will be given further consideration in future editions of this circular and in our publications on standards for electric service. The Bureau will appreciate any suggestion bearing upon

these questions of standard regulations affecting public relations of utility companies.

1. GENERAL RULES

Rule 1. Application of Rules.—(a) The following rules shall apply to any person, firm, or corporation now or hereafter engaged as a public utility in the business of furnishing gas, electricity, or water for domestic or commercial customers within the State of ———.[13]

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

Rule 2. Definitions.[13]—(a) The word "utility" as used in these rules shall be construed to mean any person, firm, or corporation engaged as a public utility, either municipal or private, in furnishing gas, electricity, or water for domestic or commercial customers within the State of ———.

(b) The word "commission" used in these rules shall be construed to mean the Public Service Commission of the State of ———.

(c) The word "customer" used in these rules shall be construed to mean any person, firm, or corporation supplied by any utility with gas, electricity, or water.

Rule 3. Operating Schedules and Interruptions of Service.—(a) Each utility shall adopt an operating schedule and shall report the same or any changes therein to the commission, indicating, in any case where service is not rendered continuously, the time at which service is commenced and the time at which it is cut off. Any changes in such operating schedule shall be made only with the approval of the commission.[14]

(b) Each utility shall keep a record of all interruptions of service upon its entire system or major divisions thereof, including a statement of the time, duration, and cause of any such interruption. The company shall also keep a record of the time of starting up or shutting down the central station or substation generating, transforming, or pumping equipment, and the

[13] The first rule would, of course, be changed to suit the particular set proposed. The definitions of rule 2 should correspond with any similar definitions occurring in the public service commission law under which such rules as these may be adopted.

[14] The "operating schedule" refers to electric companies furnishing service only part of the time: it would not apply to gas companies which, of course, furnish gas 24 hours each day.

period of operation of all regulators used for the maintenance of constant gas or water pressure or constant voltage of electricity. This record shall include the readings taken periodically of station meters and switchboard instruments, which readings shall be taken with such frequency as the utility or commission may from time to time require.

(c) The record of interruptions of service and a statement of the operating schedule of the utility shall be open at all times to the inspection of any one authorized by the commission.

Rule 4. Inspection of Plant and Equipment.—Each utility shall inspect its plant and distributing equipment and facilities in such manner and with such frequency as is in accord with good practice, in order that the same may be maintained in proper condition for use in rendering safe and adequate service.

Rule 5. Testing Facilities.—(a) Each utility shall, unless specifically excused by the commission, provide such laboratory, meter-testing shop, and other equipment and facilities as may be necessary to make the tests required of it by these rules or other orders of the commission.[15] The apparatus and equipment so provided shall be of a form approved by the commission, and it shall be available at all times for the inspection or use of any member or authorized representative of the commission.

(b) Each utility shall make such tests as are prescribed under these rules with such frequency and in such manner and at such places as may be approved by the commission.

Rule 6. Records of Tests and of Meters.—(a) A complete record of the tests made under these rules of the quality and condition of service shall be kept by each utility. The record so kept shall contain complete information concerning each test, including the date and hour when and the place where the test was made, the name of the inspector conducting the test, the result of the test, and such other information as may be required by these rules or as the commission may from time to time direct or as the utility making the test may deem desirable.

(b) Whenever any service meter is tested the original test record shall be preserved, including the information necessary for identifying the meter, the reason for making the test, the reading of the meter upon removal from service, and the result of the test, together with all data

[15] See "Special rules—gas" for provisions as to what would be required of any company.

taken at the time of the test in sufficiently complete form to permit the convenient checking of the methods employed and the calculations.

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

Rule 7. Reports to the Commission.—Each utility shall at such times and in such forms as the commission shall prescribe report to the commission the results of all tests required to be made or the information contained in any records required to be kept by the utility.

Rule 8. Accidents.—Each utility shall as soon as possible report to the commission each accident happening in connection with the operation of its property, facilities, or service, wherein any person shall have been killed or seriously injured or whereby any serious property damage shall have been caused.[16] Such first report shall later be supplemented by as full a statement as is possible of the cause and details of the accident and the precautions, if any, which have been taken to prevent similar accidents. And, furthermore, each utility shall give all reasonable assistance to the commission in the investigation of the cause or suitable means for prevention of any such accidents.

Rule 9. Complaints.—Each utility shall make a full and prompt investigation of all complaints made to it by its customers, either directly or through the commission, and it shall keep a record of all complaints received, which shall show the name and address of the complainant, the date and character of the complaint, and the adjustment or disposal made thereof. This record shall be open at all times to inspection by any one authorized by the commission.

Rule 10. Information for Customers.—(a) Each utility shall at any time on request give its customers such information and assistance as is reasonably possible, in order that customers may secure safe and efficient service and may secure lamps and appliances properly adapted to the service furnished. Each utility shall inform each customer of any such change made or proposed to be made in any condition as to its service as would affect the efficiency or safety of operation of the appliances or equipment which may be in use by said customer.

(b) Each utility supplying metered service shall adopt some means of informing its customers as to the method of reading meters, either by

[16] Where a State industrial commission is receiving accident reports, the public-service commission may not need to do this work also.

printing on its bills a description of the method of reading meters or a notice to the effect that the method will be explained upon application. It is recommended that an exhibition meter be kept on display in each commercial office maintained by a utility.

Rule 11. Meter Readings and Bill Forms.—(a) Each service meter shall indicate clearly the cubic feet, kilowatt-hours, gallons, or other units of service for which charge is made to the customer. In cases where the dial reading of a meter must be multiplied by a constant to obtain the units consumed, the proper constant to be applied shall be clearly marked on the meter.

(b) Upon written request of any customer each utility shall cause the meter reader at the time the customer's meter is read to leave on such meter or with the customer a statement showing the date and the time when such reading was made, and the reading of the meter expressed either in cubic feet, gallons, kilowatt-hours, or other units of service upon which the charge is made, or the position of the hands on the meter dials.

(c) Bills rendered to customers for metered service shall show the readings of the meter at the beginning and end of the period for which the bill is rendered, the number and kinds of units of service supplied, the date of the meter readings, and the price per unit of service. On all bills which are computed on any other basis than a definite charge per unit of service the other factors used in computing the bill shall be clearly stated, so that the amount may be readily recomputed from the information appearing upon the bill.

Rule 12. Deposits from Customers.—(a) No utility shall require from any customer or prospective customer a deposit intended to pay for all or any part of the cost of extension or installation of service, except under rules and regulations approved by the commission and set down in the published schedules of the utility.

(b) Any utility may require from any customer or prospective customer a deposit intended to guarantee payment of current bills. Such required deposit shall not exceed the amount of an estimated sixty days' bill of such customer; or, in the case of a customer whose bills are payable in advance, it shall not exceed an estimated thirty days' bill for such customer. In any case the minimum deposit shall be two dollars. Interest shall be paid by the utility upon such deposits at the rate of —— per cent per annum, payable upon the return of the deposit, or annually upon request of the customer or at the option of the utility, for the time such deposit was held by the utility and the customer was served by the utility unless such period be less than six months.

2. SPECIAL RULES—GAS

Rule 1. Definition of a Cubic Foot of Gas.—When the gas itself is to be tested under these rules, a cubic foot of gas shall be taken to be that amount of gas which occupies the volume of one cubic foot when saturated with water vapor and at sixty degrees Fahrenheit and under a pressure of thirty inches of mercury. For purpose of measurement of gas to a customer a cubic foot of gas shall be taken to be the amount of gas which occupies a volume of one cubic foot under the conditions existing in such customer's meter as and where installed.[17]

Rule 2. Heating Value.—Each utility supplying manufactured gas shall supply gas which at any point within one mile of the manufacturing plant shall have a monthly average total heating value of 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 any city where the gas sold is manufactured in another city, the tests of heating value may be made at or near the center of consumption in the city where the gas is sold.[17a]

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

It is understood that gas of the heating value thus defined has a heating value per cubic foot as registered by the customer's meter proportionately as much less than said ——A—— British thermal units per cubic foot as the total pressure of the gas in the customer's meter is less than equivalent to thirty inches of mercury pressure.[18]

In any city where the total pressure of the gas in the customer's meters, defined as the sum of the average local barometric pressure and the average pressure of the gas above atmospheric pressure, is less than equivalent to twenty-nine inches of mercury pressure, any statement published by the utility as to the average heating value of the gas supplied shall indicate both the heating value per cubic foot measured under standard pressure conditions and the heating value per cubic foot measured under the total pressure

[17] See also alternate form for Rule 1 on page 20.

[17a] Exception to the requirement of testing "near the center of consumption" may be desirable for suburban or small communities supplied from large systems, in order to allow for loss in heating value occurring before the gas reaches the smaller city.

[18] This and next paragraph following should be omitted if the alternate form of Rule 1 (given on p. 20) is used, since in this case the basis of measurement is the same for testing as for sale.

of gas in the meters of the customers of that city, in order that the heat available per cubic foot of gas paid for may be made clear.[19]

[*Alternate Form for First Paragraph of Rule 2. Heating Value.*[20]—Each utility supplying manufactured gas shall supply gas which at any point within one mile of the manufacturing plant shall have a monthly average total heating value of not less than the value indicated for such utility in the following tabulation; and at no time shall the heating value of gas at such point be more than fifty British thermal units per cubic foot below the average value required: *Provided, however*, That in any city where the gas sold is manufactured in another city, the tests of heating value may be made at or near the center of consumption in the city where the gas is sold.]

Rule 3. Calorimeter Equipment.—Each utility selling more than twenty million cubic feet of manufactured gas per year shall provide and maintain a calorimeter and all necessary accessories therefor; and each such utility shall determine the heating value of gas supplied by it on at least three days of each week.

Rule 4. Purity of Gas.—(a) *Hydrogen Sulphide.*—All manufactured gas distributed in this State shall not contain more than a trace of hydrogen sulphide. The gas shall be considered to contain not more than a trace of hydrogen sulphide if a strip of white filter paper moistened with a solution containing five per cent by weight of lead acetate is not distinctly darker than a second paper freshly moistened with the same solution after the first paper has been exposed to the gas for one minute in an apparatus of approved form through which the gas is flowing at the rate of approximately five cubic feet per hour, the gas not impinging directly from a jet upon the test paper.

(b) *Total Sulphur and Ammonia.*—All manufactured 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.

(c) *Tests of Gas Purity.*—Each utility supplying manufactured gas shall daily test the gas leaving its holders for the presence of hydrogen sulphide in the manner above specified. Each utility selling more than one hundred million cubic feet of manufactured gas per year shall provide and maintain such apparatus and facilities as are necessary for the

[19] This and the next preceding paragraph should be omitted if the alternate form of Rule 1 (given on p. 20) is used.

[20] The alternate form for the first paragraph of rule 2, which is indicated, may be used in any State when conditions are such that the heating value to be required of different utilities must be different. It would be especially desirable to use this form for States where different methods of manufacture demand different standards: for example, if unenriched coal or by-product gas was supplied, or where high-pressure distribution over wide territory makes a lower value desirable for the outlying districts or for the high-pressure system as a whole.

determination of total sulphur and ammonia in gas; and each such utility shall regularly determine the amount of total sulphur and ammonia in the gas distributed by it: *Provided, however,* That any such utility supplying only water gas or oil gas, or mixtures of these, shall not be required to provide apparatus or make determinations of the amount of ammonia in gas.

Rule 5. Pressure of Gas.—(a) Subject to the approval of the commission each gas utility 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 of gas 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 utility's service pipe to any customer: *Provided, however,* That the maximum pressure on any day at any service outlet shall never be greater than twice the minimum pressure on that day at that outlet. The normal pressures thus fixed by each utility 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.

(b) Any utility supplying natural gas shall not be deemed to have violated the preceding paragraph of this rule if it can be shown to the satisfaction of the commission that variations in gas pressure occurring are due to extraordinary demand in extreme weather or to inadequacy of supply which is clearly beyond the control of the utility.

(c) Each gas utility shall maintain on its distributing system at least one recording gas-pressure gage for each district fixed under the provisions of this rule, and no utility shall maintain less than two such recording-pressure gages.

[*First Alternate Form for Paragraph (a) of Rule 5. Pressure of Gas.*[21]—(a) The pressure of gas supplied by any utility, as measured at the outlet of the utility's service pipe to any customer, shall never be less than two inches nor more than —— inches of water pressure, except as the commission may give permission for the maintenance of some higher pressure. And the daily variation in the pressure of gas at any such service outlet shall never exceed the following amounts, viz: During the period of one year

[21] The two alternate forms for the first paragraph of rule 5 are included, since it is possible that these older forms of pressure rule may be preferred in some places; the newer form provides greater flexibility of regulation and equal protection and so may generally be better for adoption by a State commission.

after this rule shall take effect, not greater than three inches of water pressure; during the second period of one year after this rule shall take effect, not greater than 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 two inches of water pressure.]

[*Second Alternate Form for Paragraph (a) of Rule 5. Pressure of Gas.*—(a) The pressure of gas supplied by any utility, as measured at the outlet of the utility's service pipe to any customer, shall never be less than two inches nor more than —— inches of water pressure, except as the commission may give permission for the maintenance of some higher pressure: *Provided, however,* That the maximum pressure on any day at any service outlet shall never be greater than twice the minimum pressure on that day at that outlet.]

Rule 6. Gas Meter Accuracy and Testing.—(a) Every gas service meter, whether new, repaired, or removed from the service for any cause, shall be in good order and shall be adjusted to be correct to within one per cent when passing gas at six cubic feet per hour per rated light capacity before being installed for the use of any customer. Each such meter shall be marked by the utility testing it with the date of last test made on that meter.

(b) No gas service meter hereafter installed shall be allowed to remain in service more than —— years from the time when last tested without being retested and, if necessary, readjusted to be correct within one per cent.

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

Rule 7. Meter Testing on Request of Customers.—(a) Each gas utility shall, at any time when requested by a customer, test the accuracy of the meter in use by him: *Provided,* First, that the meter in question has not been tested either by the utility or by the commission within one year previous to such request; and, second, that the customer will agree to accept the result of the test made by the utility as determining the basis for settling the difference claimed. No charge shall be made to the customer

for any such test, except as may be allowed by the commission for a special case. A report giving the result of every such test shall be made to the customer requesting it.

(b) On formal application of the customer to the commission a test will be made upon the customer's meter as soon as practicable by an inspector employed by the commission. The application for such test shall be accompanied by a deposit of the amount fixed as the fee for such test. If the meter is found to be more than three per cent fast, the deposit will be returned to the customer by the commission and the amount thereof shall then be paid to the commission by the utility as the fee for the test.

(c) The amount of the fee to be paid for a meter test made by the commission shall be as follows:

For each gas service meter—

Not exceeding 10 lights capacity	$2.00
Exceeding 10 lights but not exceeding 45 lights capacity	4.00
Exceeding 45 lights capacity	8.00

For any meter rated other than by lights capacity, a fee of the same amount as is required for a meter of corresponding size rated by its lights capacity.

Rule 8. Adjustment of Bills for Meter Error.—(a) If on test of any gas service meter on request of a customer it be found more than three per cent fast, or if on test for any other cause it be found more than five per cent fast, the utility shall refund to the customer such percentage of the amount of the bills of the customer for the period of six months just previous to the removal of such meter from the service—or for the time the meter was in service, not exceeding six months—as the meter shall have been shown to be in error by such test.

(b) If on test of any gas service meter on request of a customer it be found more than three per cent slow, or if on test for any other cause it be found more than five per cent slow, the utility may collect from the customer the amount estimated to be due from the customer for gas used but not charged for in bills rendered for not to exceed the six months previous to such test.

B. 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 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 customer in said city; the word "customer" shall include any person, company, or corporation to whom the company shall furnish gas for use within said city; and the words "mayor," "city clerk," "city treasurer," "inspector," and "city council" shall be understood to refer, respectively, to the mayor, the city clerk, the city treasurer, the gas inspector, and the city council of said city of ————.

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

—— A —— and —— B —— and —— C —— shall constitute a board for the examination of all persons who shall apply for the position of inspector or deputy inspector. Said board shall give public notice of the time and place of such examination at least one month before the same is to be held, and the notice shall be published in the official papers of the city at least twice each week during said month. At the time and place so fixed the board shall examine all applicants, in such a manner as it shall deem

necessary, to determine their technical knowledge and competency to perform all duties of inspector or deputy inspector, as called for in this ordinance. After such examination said board shall certify to the mayor and the city council the names of such persons as said board shall deem fully competent to perform such duties. Only persons whose names are so certified shall be eligible to be appointed inspector: *Provided, however*, That any person who shall previously have held the office of inspector under the provisions of this ordinance may be reappointed to said office without such certificate from the board: *Provided, also*, That a person who has once been certified as competent by said board shall be subsequently eligible for appointment, without again being examined, during a period of five years from such first examination.

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

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

The mayor may remove the inspector at any time for sufficient cause, but notice shall first be given to the inspector of the charges against him and he shall be given a period of 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 heating value, candlepower, 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 abstract of said report shall be published by the city clerk in the official papers of the city.[22] The inspector shall also render monthly an itemized statement of the amount due to the city from the company for penalties or fees required 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.

[22] For any city where the local gas pressure, defined as on p. 20, is less than 29 inches there should be added some such provision as to the form of publication as is suggested on p. 100 for use in State rules.

(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.[23]

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 and 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 apparatus, the testing of supplies, and the methods of making official tests shall be substantially as determined by the provisions of the current issue of the National Bureau of Standards' Circular, "Standard Methods of Gas Testing," except in so far as said provisions may be contrary to any part of this ordinance.

When the gas itself is to be tested, a cubic foot of gas shall be taken to be that amount of gas which occupies the volume of one cubic foot when saturated with water vapor and at sixty degrees Fahrenheit and under a pressure of 30 inches of mercury. For purpose of measurement of gas to a customer a cubic foot of gas shall be taken to be the amount of gas which occupies a volume of one cubic foot under the conditions existing in such customer's meter as and where installed.[24]

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

[24] An alternate form for the last paragraph of sec. 6 may be drafted in practically the form given for the State rules on p. 20.

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.[25]

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.[26]

The candlepower of the gas shall, if possible, be determined by the inspector at least once each working day, and the average of all daily averages 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.

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

If the average local gas pressure as defined on p. 20 is less than 29 inches, it is desirable to add to the first paragraph of sec. 7 one or the other of the following sentences:

(To be used if original sec. 6 is used.) *It is understood and agreed that the gas as thus rated has an actual heating value per cubic foot registered by the customers' meters of approximately —— D —— British thermal units.*

(To be used if alternate form of sec. 6 is used; see footnote 24.) *It is understood and agreed that a gas of the heating value thus defined is equivalent to a gas having a heating value of —— C —— British thermal units per cubic foot measured at 30 inches of mercury pressure.*

[26] If the local gas pressure as defined on p. 20 is less than 29 inches, it is desirable to add to the first paragraph of sec. 8 one or the other of the following sentences:

(To be used if original sec. 6 is used.) *It is understood and agreed that a gas of the candlepower thus defined will, when burned under average local conditions at 5 cubic feet per hour measured under the average pressure of gas in customers' meters of the city, furnish light of approximately ——— international candles.*

(To be used if alternate form of sec. 6 is used; see footnote 24.) *It is understood and agreed that a gas of the candlepower thus defined is equivalent to a gas approximately ——— candles when measured and burned at a pressure of 30 inches of mercury and under standard conditions of humidity.*

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.[27] 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 or other recognized standardizing laboratory; and if a flame standard lamp is employed, 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 ——— per cent by volume of water vapor (which is taken as the local average humidity) 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 said local average conditions of pressure and humidity.

Sec. 9. Impurities.—The gas supplied by the company when tested as prescribed herein shall not show the presence of more than a trace of hydrogen sulphide and shall contain in 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 in a standard apparatus a strip of white filter paper freshly moistened with a solution containing five per cent by weight of lead acetate, the gas flowing at the rate of approximately 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 is not distinctly darker than another similar strip of paper which is wet with the same solution but has not been exposed to the gas.

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

[27] 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.

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.[28]—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 distributing 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 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 service outlet shall never be greater than 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.

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 two inches of water pressure, then the company shall, if possible, permanently correct this deficiency within three months of the time when it is first reported to the company: *Provided, however,* That if this deficiency of pressure be first reported to the company between November first and April first, then the company shall be allowed until the first of the following July

[28] Two alternate forms of pressure rules are given on p. 102.

to make such correction.[29] 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 gas-service meter, whether new, repaired, or removed from service for any cause, shall be in good order and shall be adjusted to be correct to within one per cent when passing gas at six cubic feet per hour per rated light capacity before being installed for the use of any customer. Each such meter shall be marked with a label showing the date of the last test made on that meter. Meters shall be tested as follows:

(a) During each period of one year after the passage of this ordinance, until all meters now in service have been tested, the company shall remove not less than twenty per cent of the meters now in service. Said meters shall be tested as required of meters described in paragraph (c) of this section. The removal of these 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 before being again tested.

(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

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

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 for the period during which 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.

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 test of any meter for any cause except request of a customer it shall be found more than three per cent in error, the company shall refund to the customer for whose use said meter had been installed or may charge to the customer 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.

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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 gas at the outlet of the company's service pipe to any customer is at any time found to be less than one inch of water pressure, ——— dollars ($X) for each day when such pressure shall be found; or in case that said pressure of the gas thus measured is found at any time to be less than one and one-half inches of water pressure, but during the same day never less than one inch of water pressure, ——— dollars ($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 —— 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 ———.

Part IV.—SUMMARY OF LAWS NOW IN FORCE

A. REGULATION BY STATES OR STATE COMMISSIONS

The tendency in the past few years 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 March, 1914) 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 Bureau is informed that in the following eighteen States there are no laws in force upon the subjects discussed in this Circular:

Alabama	Kentucky	Nebraska	Texas
Arkansas	Louisiana	New Mexico	Utah
Delaware [30]	Michigan	North Dakota	Wyoming
Florida	Minnesota	South Dakota	
Iowa	Mississippi	Tennessee	

The following thirty States and the District of Columbia 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	Illinois	Nevada	Pennsylvania
California	Indiana	New Hampshire	Rhode Island
Colorado	Kansas	New Jersey	South Carolina
Connecticut	Maine	New York	Vermont
District of Columbia	Maryland	North Carolina	Virginia
	Massachusetts	Ohio	Washington
Georgia	Missouri	Oklahoma	West Virginia
Idaho	Montana	Oregon	Wisconsin

[30] The Public Service Commission for the city of Wilmington has authority over gas companies in that city similar to the general State control exercised elsewhere.

The following tabulations summarize the principal requirements of the rules which have been adopted by the various State commissions and the State laws which are in force. These rules and laws are also given in full, arranged by States.

Heating Value Required by State Rules or Laws.

State	Total heating value required (Btu per cu. ft.)		Calorimeter required if sales exceed (millions of cu. ft.)—	Frequency of test	Place of test	Records
	Monthly average	Minimum value				
District of Columbia	600	550 (daily av.)	Not required	Daily	Commission's testing station	
Illinois [31]	565	530	20	At least 3 days each week	At least 1 mile from plant or where consumed	
Indiana	600	550	20	Periodic	Within 1 mile of distribution center	Open to public
Montana [32]	475	450	10	Periodic	Within 1 mile of distribution center	Open to public
Nevada	550	500	5	Periodic	Within 1 mile of distribution center	Open to public
New Hampshire	600	550	20	At least 3 days each week	Within 1 mile of manufacturing plant	Open to public
New Jersey [33]	600	550	20	Periodic	Within 1 mile of distribution center	Records to be kept
Oregon [34]	[35] 600	550	10	At least 3 days each week	Within 1 mile of manufacturing plant, or, when made out of city, at or near center of consumption	Open to public
Pennsylvania [36]	[37] 570	[37] 520	20	At least 3 days each week	Within 1 mile of manufacturing plant	Records to be kept
Washington	600	550	10	At least once per week		Open to public
Wisconsin	600	550	20	At least 3 days each week	Within 1 mile of distribution center	Open to public

[31] The heating value at present supplied must not be lowered without permission. For gas carried at 5 pounds or higher the values specified are: Monthly average, 530 Btu; minimum value, 520 Btu.

[32] Basis of rating not stated, but probably is the cubic foot measured at local barometric pressure.

[33] Calorimeter of form and calibration as approved by Bureau of Standards.

[34] 550 Btu average and 525 minimum allowed for six months from adoption of rules. Define monthly average.

[35] Except for oil gas, which must have 570 Btu monthly average.

[36] When gas is delivered to mains at more than 5 pounds test is made before compression. Natural gas, 800 Btu minimum. All calorimeters to be certified.

[37] Except for by-product gas, which is 550 monthly average and 500 minimum.

Gas Purity Required by State Rules or Laws

State	Hydrogen sulphide limit	Total sulphur (grains per 100 cu. ft.)	Ammonia limit (grains per 100 cu. ft.)	Remarks
District of Columbia	Not show presence	30	5	H_2S test daily by method recommended by Bureau of Standards.
Illinois	One grain or if passes test specified.	30	.....	H_2S test daily by method specified.
Indiana	Trace	30	.....	
Maryland	.....	20	.....	Applies only to Easton.
Massachusetts	Must be absent	30	.....	Limits of S and NH_3 to be fixed by board.
Montana	Trace	30	.....	
Nevada	Trace	30	.....	
New Hampshire	Trace	30	10	H_2S test daily by method recommended by Bureau of Standards.
New Jersey	Trace	30	.....	
New York, second district.	Trace	20	10	H_2S test specified.
Oregon	Trace	25	5	H_2S test daily by method recommended by Bureau of Standards.
Pennsylvania	.....	30	.....	
Washington	Trace	30	5	
Wisconsin	Trace	30	.....	

Gas Pressure Requirements of State Rules and Laws[38]

State	Gas pressure tested at—	Maximum allowed (inches)	Minimum allowed (inches)	Daily variation allowed at any point (% of minimum or inches of water)	Measurements required	Gages required
District of Columbia	Service outlet	6	2	100%	.....	
Illinois	Meter outlet	*8	2	100%*	Frequent	1 or more.
Indiana	Meter inlet	6	1.5	100%	Frequent	
Montana	Meter inlet	*5	1.5	100%	Frequent	
Nevada	Meter inlet	6	1.5	100%	Frequent	
New Hampshire	Service outlet	8	2	3 in	Frequent	1 or more.
New Jersey	Meter inlet	6	1.5	100%	Frequent	
New York, first district.[39]	Service outlet	*6	2	2.5 in. until July 1, 1915, then 2 in.	Continuous	1 per sq. mile.*
New York, second district.	.....	*3.75	1.5	.....	.....	
Oregon[40]	Service outlet	*6	2	2.5 in. until Jan. 1, 1915, then 2 in.	Continuous	1 per district (at least 2).
Pennsylvania	Meter outlet	*8 [41] 14	1.5 [41] 1.5	100%* 4 in.[41]	Frequent	1 or more calibrated.
Washington	Meter outlet	*5	*2	.....	.....	2 or more.*
West Virginia	Meter outlet	.....	(*)	.....	Continuous	At inlet of distributing system and elsewhere as required.
Wisconsin	Service outlet	6	2	100%	Frequent	1 or more.

[38] An asterisk (*) indicates that some special provision of the rule should be noted.
[39] Momentary pressure variation 0.8 inch, pulsating pressure variation 0.5 inch. All limits for 2 consecutive days.
[40] System divided into districts; normal pressure for each.
[41] For natural gas only.

Gas-Meter Regulations of State Rules and Laws [42]

State	Routine meter tests		Complaint meter tests		Tolerance in registration		Companies required to have prover	Test rate specified	Adjustment of bills prescribed			Remarks
	Made by—	Frequency (years)	Free by company if period greater than—	Fee for test by commission	At installation	To avoid refunds			Refunds	Additional charge allowed	Period for which adjustment is made	
Arizona	State and city sealers of weights and measures.	2		$1	±3			No	No	No		All under corporation commission.
District of Columbia.	Company	5	1 year	$0.50 to $1	±2		All	Yes	No	No		All meters sealed by commission after test by company under supervision.
Illinois	Company	5	6 months	$2 to $8	±1	±2	All	Yes	Yes	Yes	6 months	Tabulation of meter tests required,
Indiana	Companies	3	6 months	$2	±2		All	Yes	No	No		
Massachusetts	Board			Cost of moving and 25 cents or more fee.	±2		Large	No	No	No		Meters sealed after test.
Montana	Companies	5	1 year	Actual expense ($2 minimum).	±2	±2	All	Yes	Yes	No	Half period since last test.	Record of tests required both on installation and removal.
Nevada	Companies	3	6 months	$1.50	±2		All	Yes	No	No		
New Hampshire	Companies	5	1 year	$1 or estimated cost.	±2	±3	All	Yes	Yes	Yes*	6 months	Companies charged fees for routine tests made by commission.
New Jersey	Companies	6	6 months	$1	±2		All*	Yes	No	No		Reports to commission required monthly or quarterly.
New York, first district.	Commission	6 or 7	No limit	Expense	±2		All	No	No	No		Meters sealed after test.
New York, second district.	Commission		No limit	Expense	+2		All	No	No	No		Meters sealed after test.
Ohio					±3			No	No	No		
Oregon	Companies	5	1 year	$2 to $8	±1	+3 or −50	All	Yes	Yes	Yes*	3 months	Meters to be marked with date of test.
Pennsylvania	Companies	5	No limit	$2 to $10	±2	+2	All*	Yes*	Yes	No	Current bill.	All meters to be inspected within 60 days after installation.

Rhode Island				$1 to $3	±2			Yes*	No	No	
Washington	Companies	5	1 year	$3	±2		Sales >15 000 M per year.	Yes	No	No	Meters to be marked with date of test; must not leak or cause fluctuation in light.
West Virginia	Commission	5		$1 to $10	±2		All	Yes*	No	No	Must not leak; must register at rate of 3 cubic feet per hour; meters dated and sealed after test.
Wisconsin	Companies	4	6 months	$2 to $8	±2		All	Yes*	No	No	

[42] An asterisk (*) indicates that some special provision of the rule should be noted.

Miscellaneous Requirements of State Rules and Laws

The various States have rules on the following subjects as indicated:

Candlepower of gas: Maryland, Massachusetts, New York (second district), Ohio.

Inspection of plant and equipment: Pennsylvania.

Interruptions of service: Illinois, Oregon, Pennsylvania, Washington.

Meter reading and bill forms: Arizona, District of Columbia, Illinois, Indiana, Massachusetts, Montana, Nevada, New Hampshire, New Jersey, Oregon, Washington, West Virginia, Wisconsin.

Deposits, minimum bills, or meter rentals: Massachusetts, New Jersey, Oregon, Washington.

Information for customers: Montana, New Jersey, Oregon.

Complaints: Illinois, Indiana, Montana, Nevada, New Hampshire, New Jersey, Oregon, Pennsylvania, Washington, Wisconsin

Penalties: Arizona, Massachusetts.

Accidents: Pennsylvania.

Free extension of mains: Illinois.

1. ARIZONA

The Arizona Corporation Commission has full authority for the regulation of gas quality and service, to the exclusion of municipal regulations, but it has not yet prescribed rules on this subject. The weights and measures law of this State, which took effect October 1, 1913, also gives certain jurisdiction in the matter of gas-meter testing to the State inspector of weights and measures and to the city sealers of weights and measures. The authority is granted subject to the supervision of the State commission. Certain additional rules are also under consideration by the commission. No gas meter inspection had been done up to June, 1914. The following sections of weights and measures law are those of interest in this connection:

SECTION 2. There shall be a State Inspector of Weights and Measures, who shall be appointed by the Governor by and with the advice and consent of the Senate. * * *

SEC. 4. It shall be the duty of the State Inspector of Weights and Measures, in unincorporated or incorporated cities or towns with a population of not more than five thousand nor less than nine hundred inhabitants, according to the latest official State or United States census, at least once in every two years, and as much oftener as he may deem necessary, to test the accuracy of every meter used or to be used in the measuring of any water, electricity or gas furnished or to be furnished to the consumer through such meter. If the meter tested shall, upon test thereof by the Inspector, be found to measure too fast or too slow by as much as three per centum, such meter shall be condemned by him and shall not be again used or used at all until corrected and made to measure accurately. Unless any water, gas or electric meter is made to conform with the standard of such State Inspector within thirty days after the date of the condemnation by such Inspector, the said State Inspector is not required to re-test such condemned water, gas or electric meter for a period of one year thereafter.

The State Inspector shall keep in a book, together with a card index system to be furnished him by the State, a complete list of all meters inspected and tested by him, the name of the person, firm or corporation owning the same, the name of the furnisher of the water, gas or electricity, the name of the consumer thereof, and the date and result of all inspections, and shall at all times keep the same open to the inspection of the public.

SEC. 5. He shall, upon the written request of any citizen, firm or corporation or educational institution in the State, test any water, gas or electric meters used as standards in the State. He shall, at least once every year, test all water, gas and electric meters used in any institution for the maintenance of which moneys are appropriated by the Legislature, and he shall report in writing his findings to the supervisory board and to the executive officers of the institution concerned.

SEC. 7. There shall be a city sealer of weights and measures in unincorporated or incorporated towns or cities of not less than five thousand population. * * *

SEC. 8. It shall be the duty of the city sealer in unincorporated or incorporated cities of not less than five thousand population, according to the latest official State or United States census, at least once in every two years and as much oftener as may in his judgment be necessary, or whenever requested in writing by either the furnisher of water, electricity, or gas, or by the consumer of the same, to test the accuracy of any meter used or to be used in the measuring of any water,

electricity, or gas furnished or to be furnished to the consumer through such meter. If the meter tested shall, upon a test thereof by the sealer, be found to measure too fast or too slow by as much as three per cent. such meter shall be condemned by him, and the owner or owners of the same shall be notified of the condemnation at the time when such condemnation is made by the city sealer, and such meter shall not be again used or used at all until corrected and made to measure accurately.

The city sealer shall keep in a book, together with a card index system to be furnished him by the city, a complete list of all meters inspected and tested by him, the name of the person, firm or corporation owning the same, the name of the furnisher of the water, gas or electricity, the name of the consumer thereof, and the date and result of all inspections, and shall at all times keep the same open to the inspection of the public.

SEC. 13. It shall be unlawful for any person, firm or corporation, in any city having a city sealer of weights and measures, to install any water, electric or gas meter, for measuring water, electricity or gas for the purposes of lighting, heating or other commercial or domestic uses without first having had such meter tested by the city sealer of weights and measures.

SEC. 14. It shall be unlawful for any person, firm or corporation to sell and deliver, charge and collect for water, electrical energy or illuminating gas used or to be used for lighting, heating or other commercial or domestic purposes except by meter measurement, if the consumer shall request that the same be sold by meter measurement; or to charge and collect for, or pay for a greater amount of such water, electrical energy or illuminating gas than actually furnished during the period for which the charge was made; Provided, however, that an allowance of not exceeding three per centum may be made for inaccuracy in meter measurement. * * *

SEC. 15. It shall be unlawful for any person, firm or corporation to use any water, electric or gas meter which shall have been tested and condemned by the State Inspector or city sealer of weights and measures for the purpose of measuring water, electricity or gas without first having had the same corrected and made to record the measurement of the same accurately.

SEC. 16. In cities having a sealer of weights and measures where water, illuminating gas or electrical energy is or shall hereafter be sold every person, firm or corporation furnishing such water, gas or electricity shall file at the office of the city sealer a complete written list of the readings of all water, gas or electric meters, together with the individual meter numbers, and the address of the premises upon which such meter is located, upon the day such readings are made.

SEC. 17. The fee for making the test of any water, gas or electric meter shall be the sum of one dollar, and shall in all cases be advanced and paid by the party demanding the test, but in case the meter be one already in use and be found to be measuring too fast by as much as three per centum the inspector or sealer shall return the fee to the consumer if same was advanced by him, and the same shall be and become a lawful charge against the furnisher, and the inspector or sealer shall collect the fee from the said furnisher of water, gas or electricity.

SEC. 18. Any person, firm or corporation, or any agent, or employee thereof, violating any of the provisions of the five preceding sections shall, upon conviction thereof, be punished by a fine of not less than ten dollars nor more than two hundred and fifty dollars, or by imprisonment in the county jail for not less than one day nor more than ninety days, or by both such fine and imprisonment.

SEC. 19. The continuance of such violation from day to day shall be deemed a separate offense as to each day on which such violation is continued.

SEC. 20. Such State Inspector and city sealer of weights and measures shall be under the direction and control of the Corporation Commission in all functions connected with the inspection of water, gas and electric meters, as herein provided.

2. CALIFORNIA

The Railroad Commission of California has authority to regulate the quality of gas and gas service, except within a few of the larger cities which have this power under freeholders' charters. A procedure has been provided by which these cities can vote into the railroad commission all or any portion of their powers over public utilities, and the cities are rapidly conferring upon the railroad commission their public-utility powers. The railroad commission is at present working on rules for gas and gas service in territory over which it has jurisdiction with respect thereto.

The following cities have already voted their power over gas companies within their limits into the hands of the commission:

Antioch.	Daly City.	Ontario.	Salinas.
Bakersfield.	Eagle Rock.	Orange.	San Jose.
Belvedere.	Huntington B.	Oroville.	San Rafael.
Claremont.	Monterey.	Palo Alto.	Taft.
Covina.	Oakland.	Petaluma.	Willits.

3. COLORADO

The act passed by the 1913 legislature of this State, creating a Public Utilities Commission with full authority over utility-company operation, took effect August 15, 1914.

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 (March, 1914) adopted any regulations on this subject. Municipal regulations are superseded by the authority of the State commission.

The commission has established a well-equipped laboratory at Trinity College, Hartford, for both gas and electric inspection work and has the privilege of using the apparatus with which the college is equipped. The equipment of the laboratory is such as will enable it to do the necessary inspection work when standards are prescribed.

5. DISTRICT OF COLUMBIA

The Public Utilities Commission of the District of Columbia has full authority over the service and rates of utilities of the District. The following rules for gas service have been adopted by the commission, to take effect September 1, 1914:

SECTION 1. The testing done under these regulations shall be by the methods prescribed by the National Bureau of Standards, except as otherwise prescribed by law or by direction of the Commission.

SEC. 2. No gas meter shall be placed in service or allowed to remain in service which has an error in measurement in excess of two (2) per cent when passing gas at the standard test rate of flow, and which is not sealed with the seal of the Gas Inspection Bureau.

SEC. 3. The Gas Inspection Bureau shall seal with the prescribed seal those meters which, upon inspection and test, are found to have an error in measurement of not more than two (2) per cent when passing gas at the standard test rate of flow, to be of proper construction, and to be in good order.

SEC. 4. Each gas light company shall own a suitable meter prover and maintain the same in proper adjustment to register the condition of the meters within one-half (½) of one (1) per cent.

SEC. 5. Each company shall keep a complete record of each test of a meter made by it.

SEC. 6. New meters and meters which have been removed from service and repaired shall be tested by the gas light company under the supervision of the Gas Inspection Bureau.

SEC. 7. The prescribed fees for this supervision shall be ten cents (10¢) for each meter having a rated capacity not exceeding sixty (60) lights, and twenty cents (20¢) for each meter of greater capacity.

SEC. 8. At least once every five (5) years each meter shall be tested by the company for accuracy as prescribed in these regulations and readjusted if found to be incorrect.

SEC. 9. Each gas light company shall, without charge, make a test of the accuracy of a meter upon request of a consumer, provided that the meter in question has not been tested by either the company or the commission within one (1) year previous to such request. A report giving the results of the test shall be furnished to the consumer.

SEC. 10. Upon application of any consumer to the Gas Inspection Bureau, a test shall be made of the consumer's meter by the Bureau. The consumer shall be required to deposit the prescribed fee at the time of making his application. If, upon test, the meter is found to have an error in measurement not in excess of two (2) per cent or to read slow, the fee deposited by the consumer at the time of making application for the test will be kept. If, upon test, the meter is found to read fast in excess of two (2) per cent, the fee deposited by the consumer will be returned and the prescribed fee shall be paid by the gas company owning the meter.

SEC. 11. Upon application of a gas light company to the Gas Inspection Bureau, a meter shall be tested by the Bureau and the prescribed fee shall be paid therefor by the said company.

SEC. 12. The consumer and a representative of the company owning the meter may be present during the test of the meter, but such persons shall not interfere in the testing.

SEC. 13. The prescribed fees for referee tests of meters shall be as follows:

Upon application of a consumer or of a gas light company, fifty cents (50¢) for each meter having a rated capacity not exceeding sixty (60) lights; one dollar ($1.00) for each meter of greater capacity.

SEC. 14. The Gas Inspection Bureau shall keep a complete record of each test of a meter made by it, and of all fees due and received for such testing and for supervising the tests made by the gas light companies. All such fees shall be paid by the Bureau to the Collector of Taxes of the District of Columbia for payment into the Treasury of the United States, to be placed to the credit of the United States and the District of Columbia in equal parts.

SEC. 15. Each gas light company shall transport to the office of the Bureau all of its meters to be tested by the Bureau.

SEC. 16. When a meter is removed from a consumer's premises for referee test by the Bureau, the gas light company shall set in its place a meter which has been sealed by the Bureau within a period of one (1) year and which has not been in service since being sealed.

SEC. 17. No person other than an authorized representative of a gas company shall be allowed to remove and set meters.

SEC. 18. Each gas light company shall keep a record of the dates on which its meters are set in and removed from the service of consumers.

SEC. 19. Meter dials shall read directly in cubic feet of gas, and bills rendered periodically for metered gas service shall contain the readings of the meter at the beginning and end of the time for which the bills are rendered and the dates on which the readings were taken.

SEC. 20. The monthly average total heating value of gas for any calendar month supplied by any gas light company shall not be less than six hundred (600) British thermal units per cubic foot of gas nor shall the daily total heating value of the gas for any day fall below five hundred fifty (550) B. t. u. per cubic foot of gas.

SEC. 21. The tests for heating value shall be made at any of the Commission's testing stations, and may be made at any hour of the day or night. The daily total heating value for any day shall be the average of all tests made on that day; Provided, That if the test made at any station of the gas supplied by any gas light company shows a total heating value of less than six hundred (600) B. t. u., then at least one (1) other test of the gas supplied by that company shall be made on the same day and the average of the results of the tests thus obtained shall be taken as the daily total heating value of the gas for that day.

SEC. 22. The monthly average total heating value for any calendar month shall be the average of all the daily total heating values during the calendar month; Provided, That this value shall be the average of not less than twenty (20) daily total heating values during that calendar month.

SEC. 23. The gas supplied by any gas light company shall not show the presence of any hydrogen sulphide and shall contain not more than thirty (30) grains of total sulphur in one hundred (100) cubic feet of gas and not more than five (5) grains of ammonia in one hundred (100) cubic feet of gas.

SEC. 24. The gas supplied by each gas light company shall be tested for hydrogen sulphide at any of the Commission's testing stations by exposing a strip of white filter paper, freshly moistened with solution containing six and one-half (6½) per cent by weight of lead acetate, to a stream of the gas flowing at the rate of five (5) cubic feet per hour for one (1) minute. The gas shall not impinge directly from a jet upon the test paper. The gas shall be judged free from hydrogen sulphide if the paper thus exposed shall show no darkening perceptible when compared with another similar strip of paper which is wet with the same solution but has not been exposed to the gas.

SEC. 25. The determination of total sulphur and ammonia in the gas supplied by any gas light company shall be made at any of the Commission's testing stations.

SEC. 26. Volumes of gas specified in these regulations shall be understood to be at a temperature of sixty (60) dergrees Fahrenheit, under a pressure of thirty (30) inches of mercury, and saturated with water vapor.

SEC. 27. The gas supplied by any gas light company shall be maintained at a pressure of never less than two (2) inches nor more than six (6) inches of water pressure, measured at the outlet of the company's service pipe to any consumer or to any of the Commission's testing stations, and the daily variation in said pressure during any day at any such outlet shall never exceed one hundred (100) per cent of the minimum pressure at that outlet for that day.

6. GEORGIA.

The Railroad Commission of Georgia has 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.

7. IDAHO

The Public Utilities Commission was established in 1913 and has just been organized. No regulations for gas service have yet been adopted.

8. ILLINOIS

The Public Service Commission, established by an act of June, 1913, was organized in January, 1914. The commission has full authority over utility-service matters. It has just adopted (November, 1914) the following regulations for gas service·

PRELIMINARY

I. *Statutory.*—The Illinois Public Utilities Law, Act of 1913, contains the following provisions:

No. 10. Definitions: The term "service," when used in this Act, is used in its broadest and most inclusive sense, and includes not only the use or accommodation afforded consumers or patrons, but also any product or commodity furnished by any public utility and the plant, equipment, apparatus, appliances, property and facilities employed by, or in connection with, any public utility in performing any service or in furnishing any product or commodity and devoted to the purposes in which such public utility is engaged and to the use and accommodation of the public.

No. 54. Standards of Service: The commission shall have power to ascertain, determine and fix for each kind of public utility suitable and convenient standard commercial units of service, product or commodity, which units shall be lawful units for the purposes of this Act; to ascertain, determine and fix adequate and serviceable standards for the measurement of quantity, quality, pressure, initial voltage or other condition pertaining to the performing of its service or to the furnishing of its product or commodity by any public utility, and to prescribe reasonable regulations for examining, measuring and testing such service, product or commodity, and to establish reasonable rules, regulations, specifications and standards to secure the accuracy of all meters and appliances for examining, measuring, or testing such service, product or commodity.

II. *Authorization of Rules.*—In accordance with the statutory provisions in No. 54 above, the attached rules establishing standards for gas and electric service have been prepared and are approved by the commission this twenty-fifth day of September, 1914, to become effective on November 1, 1914.

III. *Application of Rules.*—These rules shall apply to any public utility defined as such by the Illinois Public Utilities Commission Law which is now or hereafter may be engaged in the production, sale or distribution of gas or electricity and which comes under the jurisdiction of the Commission.

IV. *Saving Clause.*—The adoption of these rules shall in no way preclude the commission from altering or amending the same in whole or in part or from requiring any other or additional service, equipment, facility or standard, either upon complaint or upon its own motion or upon the application of any utility and, furthermore, these rules shall in no way relieve any utility from any of its duties under the laws of this State.

If any utility has been supplying or is under contract to supply a quality of service of greater value to the consumer than that which these rules require, no reduction in such quality of service shall be made by the utility before a determination by the commission of the proper rate to be charged the consumer for the lower grade of service. Such a rate shall, in general, be based upon the cost of furnishing the grade of service required by these rules.

V. *Definitions.*—The word "utility" used in these rules shall be construed to mean public utility.

The word "commission" used in these rules shall be construed to mean the State Public Utilities Commission of Illinois.

The word "consumer" used in these rules shall be construed to mean any person, firm or corporation supplied by any utility with gas or electricity.

General Service Rules

Rule 1. *Records and Reports.*—All records required by these rules shall be preserved for at least three years after they are made. Such records shall be kept within the State at an office or offices of the utility located in the territory served by it and shall be open for examination by the commission or its representatives. Each utility shall notify the commission of the office or offices at which the various classes of records are kept and shall file with the commission such reports as the commission may from time to time require.

Rule 2. *Testing Facilities.*—(a) Each utility shall, unless specifically excused by the commission, provide such laboratory, meter-testing shop, and other equipment and facilities as may be necessary to make the tests required by these rules or other orders of the commission. The apparatus and equipment so provided shall be at all times available for the inspection or use of any member or authorized representative of the commission.

(b) Each utility shall make such tests as are prescribed under these rules with such frequency and in such manner and at such places as may be approved by the commission.

Rule 3. *Request Tests.*—Each utility furnishing metered service shall make a test of the accuracy of any meter upon written request by a consumer: *Provided,* first, that the meter in question has not been tested by the utility or by the commission within six months previous to such request; and second, that the consumer will agree to accept the result of the test made by the utility as determining the basis for settling the difference claimed. No charge shall be made to the consumer for any such test. A report giving the result of every such test shall be made to the consumer.

Rule 4. *Adjustment of Bills for Meter Error.*—If on any test of a service meter, either by the utility or by the commission, such meter shall be found to have a percentage of error greater than that allowed in Rule 11 (c) for gas meters, or Rule 22 (e) for watt-hour meters, the following provisions for the adjustment of bills shall be observed:

(a) *Fast Meters:* If the meter is faster than allowable, the utility shall refund to the consumer a percentage of the amount of his bills for the six months previous to the test or for the time the meter was installed, not exceeding six months, corresponding to the percentage of error of the meter. No part of a minimum, service, or demand charge need be refunded.

(b) *Slow Meters:* If the meter is found not to register or to run slow, the utility may render a bill to the consumer for the estimated consumption during the preceding six months, not covered by bills previously rendered, but such action shall be taken only in cases of substantial importance where the utility is not at fault for allowing the incorrect meter to be in service.

Rule 5. *Records of Tests and of Meters.*—(a) *Service Test Record:* A complete record of the quality and condition of service shall be kept by each utility. The record so kept shall contain complete information concerning each test, including the date and hour when and at the place where the test was made, the name of the inspector conducting the test, the result of the test and such other information as may be required by these rules, or as the commission may from time to time direct, or as the utility making the test may deem desirable.

(b) *Meter Test Record:* Whenever any service meter is tested, the original test record shall be preserved containing the information necessary for identifying the meter, the reason for

making the test, the reading of the meter upon removal from service and the result of the test together with all data taken at the time of the test in sufficiently complete form to permit the convenient checking of the methods employed and the calculations.

(c) *Meter Record:* A record shall also be kept, numerically arranged, giving for each meter owned or used by any utility, the date of purchase, its identification, and the repairs and tests to which it has been subjected, with dates and general results of all tests.

(d) *Tabulation of Meter Tests:* Monthly and annual tabulations of the results of all meter tests shall be made, arranged according to types of meters and intervals of test.

RULE 6. *Meter Readings on Bills.*—Bills rendered periodically to consumers for metered service shall show the readings of the meter at the beginning and end of the period for which the bill is rendered, the number and kinds of units of service supplied, the dates of the meter readings and the price per unit of service. On all bills which are computed on any other basis than a definite charge per unit of service, the other factors used in computing the bill shall be clearly stated so that the amount may be readily computed from the information appearing upon the bill.

RULE 7. *Complaints.*—Each utility shall make a written acknowledgment to consumers of the receipt of all complaints; shall make a full and prompt investigation of all such complaints, and shall keep a record which shall show the name and address of the complainant, the date and nature of the complaint, and the adjustment or disposal thereof.

RULE 8. *Interruptions of Service.*—Each utility shall make all reasonable efforts to eliminate interruptions of service and when such interruptions occur shall endeavor to re-establish service with the shortest possible delay. Whenever the service is interrupted for the purpose of working on the distribution system or the station equipment, this shall be done at a time which will cause the least inconvenience to consumers and those most seriously affected by such interruptions shall if possible be notified in advance.

SPECIAL GAS SERVICE RULES

RULE 9. *Definition of a Cubic Foot of Gas.*—For testing purposes, a cubic foot of gas shall be taken to be the amount of gas in a volume of one cubic foot when saturated with water vapor, at sixty degrees Fahrenheit, and at a pressure of thirty inches of mercury.

For purpose of measurement to a consumer, a cubic foot of gas shall be the amount of gas in a volume of one cubic foot under the conditions existing in such consumer's meter as and where installed; but provided consumer's meters shall not be set so close to any source of artificial heat as to subject them to a temperature exceeding seventy-five degrees Fahrenheit.

RULE 10. *Meter Testing Equipment.*—Each utility furnishing metered gas service shall own an approved meter prover of not less than five cubic feet capacity, and shall maintain the same in proper adjustment to register the accuracy of the meters to within one-half per cent (½%). The meter prover shall be so placed as to be shielded from excessive temperature variations and shall be equipped with suitable thermometers and other necessary accessories.

The accuracy of all provers and methods of operating same may be established from time to time by a representative of the commission. All alterations, accidents, or repairs which might affect the accuracy of a prover or the method of operating same shall be promptly reported in writing to the commission.

RULE 11. *Gas Meter Accuracy.*—(a) *Method of Testing.* All tests to determine the accuracy of registration of a gas service meter shall be made with a suitable meter prover. At least two test runs shall be made on each meter, the results of which shall agree with each other within one-half per cent (½%).

(b) *Installation Test.* Every gas service meter, whether new, repaired, or removed from service for any cause, when installed for the use of any consumer shall be in good order and shall have been adjusted to be not more than one per cent (1%) in error when passing gas at six (6)

cubic feet per hour per rated light capacity. Each such meter shall be marked by the utility testing it with the date of the last test made on that meter.

(c) *Allowable Error.* Whenever a meter is tested to determine the accuracy with which it has been registering in service, it may be considered as correct if found no more than two per cent (2%) in error, and no adjustment of charges shall be entailed unless the error is greater than this amount.

(d) *Prepayment Meters.* No utility shall use prepayment meters geared or set so as to cause a rate or amount higher than would be paid if a standard meter was in use, unless the consent of the commission is first obtained in writing.

RULE 12. *Periodic Tests of Gas Meters.*—No gas service meter hereafter installed shall be allowed to remain in service more than five years from the time when last tested without being retested as specified in Rule 10, and if necessary readjusted to be correct within one per cent before being set for use.

During each period of twelve months after these rules take effect, until all meters now in service shall have been tested, each gas utility shall remove and test not less than twenty per cent of all meters now in service, those longest in service being removed first.

RULE 13. *Referee Tests.*—Upon written application to the commission by a consumer a test will be made of said consumer's meter, as soon as practicable, by an inspector employed by the commission. The application for such test shall be accompanied by a remittance of the amount fixed below as the fee for such test. If the meter is found to be more than two per cent fast, this fee shall be paid to the consumer by the utility.

The fees for referee meter tests are:

Not exceeding ten lights capacity, each	$2.00
Exceeding ten lights, but not exceeding forty-five lights capacity, each	4.00
Exceeding forty-five lights capacity, each	8.00

This rule shall not interfere with the practice of a utility in its tests of gas service meters, except that in the event of a written application to the commission by a consumer for a referee test the utility shall not remove or interfere with said meter without the consent previously given in writing of the consumer.

RULE 14. *Calorimeter Equipment.*—Each utility whose gas output exceeds twenty million cubic feet per year shall equip itself with a complete standard calorimeter outfit of a type approved by the commission and shall test the heating value of gas supplied using methods of test in accordance with the best practice. The heating value of manufactured gas shall be determined on at least three days each week and of natural gas at least three times a year.

RULE 15. *Heating Value.*—Each utility furnishing manufactured gas shall supply gas which at any point at least one mile from the plant and tested in the place where it is consumed, shall have a monthly average total heating value of not less than 565 British thermal units per cubic foot, and at no time shall the total heating value of the gas at such point be less than 530 British thermal units per cubic foot.

To arrive at the monthly average total heating value of a gas the results of all tests of total heating value made on the days prescribed for testing during the calendar month shall be averaged and the average of all such daily averages shall be taken as the monthly average.

Provided further that in case gas is carried by mains at five pounds pressure or over per square inch, there shall be an allowance in the service of such high pressure district of 35 B. t. u. per cubic foot in the monthly average, and the minimum heating value shall not fall below 520 B. t. u. per cubic foot. No utility shall lower its present standard heating value without first obtaining in writing the consent of the commission.

RULE 16. *Purity of Gas.*—(a) *Hydrogen Sulphide.* Manufactured gas distributed in this State shall not contain more than one grain of hydrogen sulphide per hundred cubic feet. Any test

approved by the commission may be used for the determination of hydrogen sulphide. This purity requirement will be considered as satisfied if a strip of white filter paper recently moistened with a solution of 100 grains of lead acetate in 100 cubic centimeters of water be exposed to the gas for one and one-half minutes in an apparatus previously purged through which the gas is flowing at the rate of approximately five cubic feet per hour, the gas not impinging directly from a jet upon the test paper, and after this exposure the test paper be found not distinctly darker than a second paper freshly moistened with the solution and not exposed to the gas. Test papers shall be kept for one year by a safe and secure method, and shall be available to the commission if and when desired in that period.

(b) *Total Sulphur.* Manufactured gas distributed in this State shall not contain more than thirty grains of total sulphur per hundred cubic feet.

(c) *Tests of Gas Purity.* Each utility supplying manufactured gas shall for the purposes of record daily test the gas leaving its holders for the presence of hydrogen sulphide in the manner specified.

Each utility supplying manufactured gas whose sales exceed fifty million cubic feet of gas per year shall provide and maintain such approved apparatus and facilities as are necessary for the determination of total sulphur; and each such utility shall daily determine the amount of total sulphur in the gas distributed by it.

RULE 17. *Pressure of Gas.*—(a) *Pressure Variation.* The pressure of gas supplied by any utility as measured at the outlet of any consumer's meter shall not be less than two inches nor more than eight inches of water pressure, except where greater pressure is specified and provided for in the contract between the utility and the consumer, and provided there be no unfair and unreasonable discrimination or preferences. Within said limits, the daily variation of pressure at the outlet of any one meter on the system shall never be greater than one hundred per cent of the minimum pressure at that outlet, provided that variations in pressure entirely beyond the control of the utility shall not be considered as a violation of this rule.

(b) *Pressure Surveys.* Each gas utility shall provide itself with one or more portable graphic recording pressure gages and shall make frequent measurements of the gas pressure and of the pressure variation throughout the system.

RULE 18. *Record of Interruptions.*—Each utility shall keep a record of all interruptions to service on its entire system or on any portion thereof, which record shall contain the time, cause if known, extent and duration of the interruption.

RULE 19. *Extension of Mains.*—(a) *Definitions.* For the purpose of this rule a high pressure system shall be taken to mean one in which the gas is carried at a pressure of two pounds or over per square inch to the consumer's premises where a service governor is installed to obtain a reduced pressure on such premises. A low pressure system shall mean a system in which the consumer's service is connected directly to a main carrying less than two pounds per square inch water pressure.

(b) *Free Extensions.* Each utility shall upon written request for service by a prospective consumer or a group of prospective consumers located in the same neighborhood make free of charge a street main extension necessary to give service provided that the length of the entire extension is not greater than that obtained by allowing 100 feet per consumer for a low pressure system and 200 feet per consumer for a high pressure system.

(c) *Extensions Above Free Limit.* If the main extension required in order to furnish service at any point within the corporate limits of any city or village, or for any adjacent suburb of a city or village, is greater than the free extension specified above, such an extension shall be made under the following conditions: The utility may require a deposit of the cost of the extension above the free limit and shall, in such a case, refund an amount equal to the cost of the free main extension for each additional consumer whose service shall be taken off of the entire extension within a period of ten years from the making of such an extension, but at no time shall the

rebate made exceed the original deposit. If the extension is of such length and the prospective business which may be developed by it is so meager as to make it doubtful whether the business from the extension would ever pay a fair return on the investment, the facts shall be reported to the commission for investigation and determination as to the reasonableness of such extension.

This rule shall not be construed as prohibiting any utility from making free extensions of lengths greater than above specified or from providing a method of return of deposits for extensions more favorable to consumers so long as no discrimination is practiced between consumers whose service requirements are similar.

(d) *Contract for Service.* Utilities will not be required to make street main extensions as described in this rule unless those served by such extensions shall contract to use the service for at least one year.

9. INDIANA

The Public Service Commission of Indiana has full authority over utility matters and has adopted the following regulations for gas service (dated July, 1913). The inspection work has to date (June, 1914) consisted entirely of tests on complaint, but it is expected to establish the routine test work in the near future.

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 complete 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 Public Service Commission a test shall be made upon the consumer's meter by an inspector employed by the Public Service Commission, such test to be made as soon as practicable after receipt of the application. For such test a fee of two dollars ($2) shall be paid by the consumer making application for the test 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 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 inspection by any user of the service of the company.

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.

10. 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. The commission now has under consideration certain rules for gas service, but these will be largely for the regulation of natural-gas companies, since very little artificial gas is made in this State.[42a] Some preliminary testing work has been done in cooperation with the chemistry department of the Kansas University.

11. MAINE.

The act of this State establishing a Public Utilities Commission with full authority over service furnished by utility companies was confirmed by referendum vote in September, 1914, and the commission has been appointed.

12. 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.

The old regulations which thus place limitations upon the authority of the commission refer only to candlepower and purity of gas to be supplied in Baltimore and in the town of Easton. In the former city the candlepower specified is 20; in the latter, 20 candlepower and a limit of 20 grains of sulphur per 100 cubic feet of gas are prescribed.

The commission is carrying on regular gas-inspection work in Baltimore, and tests of gas are made on complaint from other points throughout the State. Routine testing of gas meters has been done in Baltimore and also in some of the larger towns.

[42a] Rules were recently adopted by the Public Utilities Commission of Kansas in the form shown on page 191ff.

The 1914 legislature of this State amended the public utilities commission act, enlarging their authority considerably. The exact provisions of this act have not yet been published (April, 1914).

13. 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 necessary 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 74 to 75.

14. MISSOURI

The Public Service Commission of Missouri has full authority over public-service commission matters, including gas companies. This commission has now under consideration rules for gas quality and service.

15. MONTANA

The railroad and public service commissioners of the State of Montana have authority over gas and other utilities service. The following set of rules for gas service has been prescribed by the commission (dated April 30, 1914). The basis of measurement for testing is not specified in the rules, but it is understood that the heating value is to be 475 B. t. u. per cubic foot measured under local barometric pressure (value to be used not specified).

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 five years without checking it for accuracy and readjusting it if found incorrect.

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

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

RULE 5. The company furnishing gas which, within a one mile radius from the distributing center, gives a monthly average total heating value of not less than 475 B. t. u., with a minimum which shall never fall below 450 B. t. u. may be considered as giving adequate service as far as the heating value of the gas is concerned.

RULE 6. 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. A record of these tests shall be made and kept open for public inspection.

RULE 7. Gas pressure as measured at meter inlets shall never be less than one and one-half inches nor more than five inches of water pressure, with an allowance of one inch increase for each one hundred and twenty-five feet increase in elevation above the holder, 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 8. Each company shall make frequent measurements of the pressure and pressure variations, and these shall be kept on record and open for inspection by any user of the service of the company.

RULE 9. In no case shall the gas contain more than thirty grains of total sulphur per one hundred cubic feet, and not more than a trace of sulphur as sulphuretted hydrogen.

[Rules 10 to 18, inclusive, deal with electric service.]

RULE 19. 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 action taken to satisfy.

RULE 20. Bills rendered periodically by the company shall designate the readings of the meter at the beginning and end of time for which the bill is rendered, and give the dates at which the readings were taken.

RULE 21. Each gas or electric company shall make a test of the accuracy of a meter upon request of a consumer, provided such meter has not been tested by the utility or by the Commission within a period of one year preceding the request. 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. Settlement for overcharge, if such is found to exist, shall be made on basis of

the disclosed error and for a period of time covering one-half of the interim since date of last test; unless it is shown conclusively that the irregularity existed for some definite period.

RULE 22. If a consumer is dissatisfied with the test made by the utility, and makes written application to the Public Service Commission, a test shall be made on the consumer's meter by an inspector employed by the Public Service Commission, such test to be made as soon as practicable after receipt of the application. For such test a fee covering the actual expense (minimum $2.00), 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 limit, and by the company owning the meter if the meter is found to be fast beyond the allowable limit.

RULE 23. A copy of all schedules of rates as well as all rules and regulations on file with the Commission, shall be kept on file in each office of any and all utilities where payments are made by consumers, and such schedules of rates, rules, and regulations shall be open to the inspection of the public.

16. NEVADA

The Public Service Commission of Nevada has complete authority to regulate the gas service in that State. The inspection work is limited to tests of meters upon complaint. 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 one and one-half inches nor more than six 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 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 one hundred 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.

17. NEW HAMPSHIRE

The Public Service Commission of New Hampshire, which has full authority over standards for utility service, has adopted the following rules regulating gas-company operations. The companies' testing equipment has been calibrated by the commission, and routine inspection work is being planned for.

RULE 1. In the interpretation of these rules, the word "Commission" shall be taken to mean the Public Service Commission; the word "utility" shall be taken to mean any public utility engaged in supplying to the public water gas, coal gas, or a mixture of the two; and for purposes of testing, a 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. No utility shall supply gas to the public having a monthly average total heating value of less than 600 British thermal units per cubic foot, tested anywhere within a one-mile radius of the manufacturing plant; and at no time shall the heating value of gas so supplied at such point be less than 550 British thermal units per cubic foot.

RULE 3. Each utility which in any year shall have sold more than 20,000,000 cubic feet of gas shall equip itself with a calorimeter and all necessary accessories therefor, and shall determine the heating value of its gas on at least three days in the week. A record of each such test shall be made and kept open to the public.

RULE 4. No gas shall contain more than thirty grains of total sulphur, or ten grains of ammonia, per one hundred cubic feet, or more than a trace of hydrogen sulphide. Gas shall be deemed to contain 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, after being exposed for one minute to a stream of the gas flowing at the rate of approximately five cubic feet per hour, the gas not impinging directly from the jet upon the paper, appears perceptably darker than a second paper freshly moistened with the same solution.

RULE 5. Each utility shall daily test the gas leaving its holders for the presence of hydrogen sulphide in the manner specified in Rule 3, and shall keep a record of such tests.

RULE 6. The Commission will, from time to time, inspect the methods of manufacture, and test the quality of gas supplied by each utility. Under the provisions of section 2 of chapter 124 of the Laws of 1913, a fee of fifteen dollars will be collected from the utility for each such inspection.

RULE 7. Gas pressure, as measured at the outlet of the utility's service to any consumer, shall never be less than two inches nor more than eight inches water column. The maximum daily pressure variation at the outlet of the utility's service to any consumer shall not exceed three inches water column.

RULE 8. Each utility shall provide itself with one or more portable recording pressure gauges, and shall regularly, and not less frequently than the Commission may direct, make measurements of the gas pressure, and pressure variation, throughout the system. Records of these measurements shall be kept open to public inspection at the office of the utility.

RULE 9. No gas service meter shall be placed in service which has an error in measurement in excess of two per cent. when passing gas at the rate of six cubic feet per hour per rated light capacity of such meter.

RULE 10. All new meters purchased by the utility, and all old meters which have been repaired, adjusted, or removed from service for any cause, shall be tested and marked with the date of test before being placed in service; and all meters shall be removed and tested at least once every five years. During each period of twelve months, until all such meters have been tested, each utility shall remove for test not less than twenty per cent. of the meters now in service, those longest in service being removed first.

RULE 11. Each utility shall without charge make a test of the accuracy of any gas service meter upon request of the consumer, provided the consumer does not make such request more frequently than once in twelve months. A report giving the results of each request test shall be made to the consumer.

RULE 12. Any gas service meter may be tested by an inspector employed by the Commission, upon written application of the consumer, and deposit of the fee fixed for inspection by the Commission. If the meter is found to be more than two per cent. fast the fee paid by the consumer will be returned to him, and shall then be paid by the utility. Each application to the Commission for test of a meter shall be accompanied by a fee of one dollar, which is fixed as the fee for testing upon complaint any meter having a rated capacity not greater than ten lights. For meters of greater capacity a deposit equal to the estimated cost to the Commission will be required.

RULE 13. The Commission will, from time to time, test such meters of each utility as it shall judge expedient. Under the provisions of section 2 of chapter 124 of the Laws of 1913, a fee of fifty cents will be collected from the utility for each meter so tested which is of not greater than ten lights rated capacity, and for each meter of greater capacity a fee equal to the cost to the Commission of testing the same.

RULE 14. Whenever a meter is tested under Rules 11, 12 or 13 and is found to be more than three per cent. fast, the company shall refund to the consumer 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 the time of removal; provided, however, that the Commission in any case may relieve the utility from this requirement to such extent as the facts may appear justly to require. Whenever a meter so tested is found to be more than three per cent. slow, the utility may make application to the Commission for authority to render a bill to the consumer for gas supplied during the preceding six months, not covered by bills previously rendered; but such application should be made only in cases of substantial importance, and should be accompanied by a statement showing the utility not to be in fault for allowing the incorrect meter to be in service.

RULE 15. 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 removed, and the result of the test, 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. Records shall also be kept, numerically arranged, indicating approximately when each 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 16. Each utility shall maintain a suitable meter prover in proper condition to test the accuracy of any meter. 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, and shall be approved and sealed by the Commission.

RULE 17. 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 18. Each utility shall keep a record of all complaints made in regard to service, which shall include the name and address of the complainant, the date and nature of the complaint, and the disposition of the same.

RULE 19. Each utility shall provide, equip and maintain a station for the testing of gas and gas meters, and such equipment therefor as may be necessary for the testing required by any rules of this Commission, and shall provide such facilities for the use of the Commission's inspector as the Commission may prescribe, to be arranged in a location and according to plans approved by the Commission.

RULE 20. Each utility, at such times and in such form as the Commission shall prescribe, shall report to the Commission the result of all tests made of heating value, purity and pressure of the gas supplied by it, and the number of meters purchased, installed, removed from service, tested, adjusted and repaired.

18. 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 Board of Public Utilities Commissioners has a complete gas inspection outfit, including the portable apparatus necessary for calibration of the company's equipment; and the city of Newark has a fully equipped gas-inspection laboratory, where tests are made daily of the heating value of gas and where all consumer's meters which are to be used in this city are tested and sealed. In addition to the inspection of plant and operating methods of the companies an examination is made by inspectors of the commission of the company's records of gas quality, gas pressure, complaints, etc. Following the practice first adopted in Wisconsin, the testing done by the companies is supervised and checked up at intervals by the commission. The following rules are now in force:

RULE 1. 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 2. 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 3. 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 five hundred meters shall report monthly; each company having less than five hundred meters shall report quarterly. Blank forms will be furnished by the Board on which reports are to be made.

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. 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 5. 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 6. 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 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; 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 8. 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 one dollar, may be made to cover the actual expense of making the change.

RULE 9. 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 10. 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 11. 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 12. 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 13. In no case shall the gas contain more than thirty grains of total sulphur per one hundred cubic feet, and not more than a trace of sulphur as sulphuretted hydrogen.

RULE 14. 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 15. 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 16. 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.

19. 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.

The original law included a considerable number of special provisions, which the commissions were required to enforce, and certain other regulations affecting companies in cities of the second class and in a few cases special acts applying to a single city were not repealed by the original law establishing the commissions. However, the 1913 legislature 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 quoted below will be superseded by the orders which they may issue.

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 decided that a heating-value requirement is desirable, but until recently it has been without power to fix any such regulation.

A more extended statement of the inspection work of this commission is made on pages 75 to 76. The following extracts from the State law indicate the special provisions which are still regarded as in force:

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 reaconable 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.

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. There are also several State acts which affect only the gas companies in some individual cities.

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 puropses.

Ordered 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.

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The commission for the first district has been engaged in testing of meters for several years, but more recently has taken up other questions of gas service rules. Certain municipal requirements of gas quality are still in force, and the rules of the commission have not yet been extended to cover candlepower, heating value, or purity of gas.

The following rules adopted by the commission are in force in New York City; they 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 (2½″) 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 inch, ($\frac{8}{10}$″) 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 inch ($\frac{8}{10}$″) 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 inch ($\frac{5}{10}$″) 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.

20. NORTH CAROLINA

The State of North Carolina Corporation Commission has authority over utilities service. No rules for gas service have yet been adopted (March, 1914).

21. OHIO

The Public Service Commission of Ohio was superseded by the Public Utilities Commission, the latter being established by an act approved May 5, 1913. The new act made very little change in the jurisdiction or authority of the commission as far as utility service is concerned. 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. These regulations and some of the municipal regulations are still in force. The Public Utilities Commission has, however, considerable authority concerning all of these service matters and is now (July, 1914) considering a set of regulations covering the subject of gas quality and gas service.

22. OKLAHOMA

The Corporation Commission of Oklahoma has full authority to regulate gas and other utility rates and service in that State. No general rules relating to gas service have yet been enacted (March, 1914), but plans are being formulated for inspection work to be done in cooperation with the State University.

23. OREGON

The Railroad Commission of Oregon has complete authority in regard to utility service and rates.

The commission has established a laboratory in Portland, where regular tests are made on the gas supplied in this city. In the enforcement of

the rules recently adopted it is proposed to extend this inspection work throughout the State, with a view to exercising supervision over the regular testing required of the companies.

The following set of rules has just been adopted by the commission (May, 1914):

General Rules

Rule 1. *Application of Rules; Definitions.*—(a) The adoption of these rules and standards shall not preclude the Commission from altering or amending the same in whole or in part, or from requiring any other or additional service, equipment, facility, or standards, either upon complaint or upon its own motion, or upon the application of any utility.

(b) 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 Oregon as a public utility.

(c) The word "utility" used in these rules shall be construed to mean any person, firm or corporation engaged in such business.

(d) The word "Commission" used in these rules shall be construed to mean the Railroad Commission of Oregon.

(e) The word "customer" used in these rules shall be construed to mean any person, company, firm or corporation, supplied by any utility with gas, electricity or water.

Rule 2. *Testing Facilities.*—(a) Each utility shall provide such laboratory, meter-testing shop, and other facilities as may be necessary to make the tests required by these rules. All tests made by any utility under these rules shall be carried out in a manner and at such places as may be approved by the Commission, and the apparatus and equipment used for these tests shall be at all times available for the inspection or use of any member or authorized representative of the Commission.

Rule 3. *Records of Tests and Meters.*—(a) A complete record of all tests of quality, service, or meter accuracy as made under these rules, shall be kept by each utility accessible to the public during business hours at the principal office in the town or city where the service is furnished, or at such other place as the Commission may designate. The record so kept shall contain complete information concerning each test, including the date and hour when the test was made, the name of the inspector conducting the test, the number of any meter tested and its capacity, the point at which pressure, voltage or other tests were made when not made at the regular testing laboratory of the utility, the results of the tests, and such other data as may hereinafter in these rules be specially required or as the Commission may from time to time require, or as the utility making the test may deem desirable.

(b) Whenever any service meter is tested, the original test record shall be preserved, 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, in sufficiently complete form to permit the convenient checking of the methods employed and the calculations.

(c) A record shall also be kept, numerically arranged, indicating approximately when each meter was purchased, its size, its identification, its various places of installation and removal, and the dates and general results of all tests.

Rule 4. *Meter Testing.*—(a) Every meter hereafter installed for measuring gas, electric current, heat or water to any customer shall be tested and if necessary repaired and adjusted by the utility installing it before being placed in use, or, in the case of electricity meters, within 30 days thereafter, as provided by Rule 21; and every meter tested (except water meters installed

under ground) shall have firmly attached thereto a tag or label, or be stencilled, giving the date of test, which tag, label or stencilled mark shall not be defaced or removed until a subsequent test shall have been made.

RULE 5. *Meter Testing on Request of Customer.*—(a) Each utility shall, at any time when requested by a customer, test the accuracy of the meter in use by him free of charge, provided such meter has not been tested by the utility or by the Commission within the period of one year immediately preceding the request.

(b) Any customer may at any time make application to the Commission for a test of his meter and shall deposit with the Commission a fee for said test, fixed as hereinafter in these rules provided. Such fee shall be returned to the customer by the Commission, and the amount thereof paid by the utility to the Commission, if the meter is found to be fast in excess of the following limits, viz:

Gas meters (when passing gas at the rate of six cubic feet per hour per rated light capacity) three per cent.

Electricity meters, four per cent.

Water and other meters, two per cent.

RULE 6. *Adjustments of Bills for Meter Error.*—(a) If on test of any meter, for any cause, either on removal from or while in service, it shall be found fast beyond the limits specified in Rule 5b, the utility shall refund to the customer such percentage of the amount of the bills of the customer for the period of three months just previous to such test of the meter as the meter shall have been shown to be in error at the time of said test. If the meter is found not to register or to register less than 50 per cent of the actual consumption, an average bill may be rendered to the customer by the utility, subject to the approval of the Commission.

RULE 7. *Meter Readings and Bill Forms.*—(a) Every meter shall indicate clearly the cubic feet, kilowatt hours, gallons, or other units of service for which charge is made to the customer. In cases where the dial reading on a meter must be multiplied by a constant to obtain the units consumed, the proper constant to be applied shall be clearly and plainly marked on the meter.

(b) Bills rendered customers by utilities shall show the readings of the meters at the beginning and end of the period of time for which rendered, the number and kinds of units of service supplied, and the price per unit, and on all bills computed on demand or connected load basis, the amount of connected load, maximum demand, or other factors used in computing the bill, shall be clearly stated, and all bills shall be made out in such a way that the amount may be readily recomputed from the information appearing plainly upon the face of the bill.

(c) On written request by a customer, the utility shall cause the meter reader at the time time the customer's meter is read, to leave on such meter or with the customer a card showing the date and time such reading was made, and the reading of the meter, expressed either in cubic feet, gallons, kilowatt hours, or other units of service upon which the charge is made, or the position of the hands on the meter dials.

RULE 8. *Deposits and Meter Rentals.*—(a) Any utility may require from any customer or prospective customer a deposit on account of current bills (1) in the case of customers whose bills are payable in advance, not to exceed an estimated 30 days' bill; (2) in the case of customers whose bills are not payable in advance, not to exceed the estimated 60 days' bill of such customer. Interest thereon, at the rate of six per cent per annum, payable annually or upon the return of the deposit, shall be paid by the utility to each customer making such deposit, for the time such deposit was held by the utility and the customer was served, unless such period of time be less than three months.

(b) No utility may require from any customer or prospective customer a deposit to pay any part of the cost of installation, except under rules and regulations approved by the Commission and set out in the published schedules of the utility.

(c) No rental shall be charged by any utility for any meter installed by it, which is used by the utility as the basis for the rendering of bills.

Rule 9. *Interruptions of Service.*—(a) Each utility shall keep a record of all interruptions of service upon its entire system or major divisions thereof, including therein a statement as to the time, duration and cause of such interruptions. Such record shall be open at all times to public inspection and the Commission may at any time require from the utility a copy thereof.

Rule 10. *Complaints.*—(a) Each utility shall make full and prompt investigation of all complaints made to it by its customers, either directly or through the Commission, and it shall keep a record of all complaints which shall show the name and address of complainant, the date and character of the complaint, and the adjustment or disposition made thereof. The information contained in such record shall be furnished the Commission upon its request.

Rule 11. *Information to Customers.*—(a) Every utility shall specifically inform its customers as to the conditions under which efficient service may be secured from its system, and render its customers reasonable assistance in securing lamps or other appliances best adapted to the service furnished.

Special Rules—Gas

Rule 12. *Cubic Foot of Gas.*—(a) When the gas itself is to be tested under these rules a cubic foot shall be considered as that amount of gas which occupies the volume of one cubic foot at 60 degrees Fahrenheit when under 30 inches of mercury pressure and when saturated with water vapor; and for the purpose of measurement to a customer shall be considered as that amount of gas which occupies the volume of one cubic foot at the temperature and pressure of gas in such customer's meter as and where installed.

Rule 13. *Required Heating Value.*—(a) Every gas utility must supply gas which shall have a monthly average total heating value of not less than 570 British thermal units per cubic foot in the case of oil gas, or 600 British thermal units per cubic foot in the case of all other gas, as referred to the standard conditions of temperature and pressure prescribed in Rule 12, when tested at any point within a radius of one mile of the manufacturing works, and also, in case the gas is manufactured outside the city, when tested at any point within the city near the center of consumption, or at a regular laboratory of the Commission within the city; and the total heating value of the gas at any such points shall never fall below 550 British thermal units per cubic foot; provided, that for the period of six months after the taking effect of these rules, unless the Commission shall otherwise order, the minimum monthly average required shall be 550 British thermal units, and the minimum at any time shall not fall below 525 British thermal units per cubic foot. In obtaining the monthly average, the results of all tests of heating value made on any day during the calendar month shall be averaged, and the average of all such daily averages obtained therefrom.

Rule 14. *Calorimeter Equipment.*—(a) Every gas utility whose sales of gas, either from a single manufacturing works or in any locality, exceeds 10,000,000 cubic feet per year, shall equip itself with a complete standard calorimeter outfit, and therewith shall determine the heating value of the gas supplied by it on at least three days in each week.

Rule 15. *Purity of Gas.*—(a) In no other case shall gas sold for lighting or heating contain more than twenty-five grains of total sulphur per 100 cubic feet, nor more than five grains of ammonia per 100 cubic feet, nor an amount of hydrogen sulphide (sulphuretted hydrogen) detectable by the following test: The gas shall be considered free from hydrogen sulphide if a strip of white filter paper moistened with a solution of lead acetate shows no darkening perceptible on comparison with another paper freshly moistened with the same solution, after the first paper has been exposed for one minute to a stream of gas flowing at the rate of five cubic feet per hour, the gas not impinging directly from a jet upon the test paper. Each utility furnishing gas service shall daily test the gas supplied by it for the presence of hydrogen sulphide in the manner specified.

RULE 16. *Gas Meter Testing Equipment.*—(a) Every utility furnishing metered gas service shall own a suitable meter prover and maintain the same in proper adjustment to register the condition of its meters within one-half of one per cent. Every meter prover shall be so placed as to be shielded from excessive temperature disturbances, and shall be equipped with suitable thermometers and other necessary appliances.

RULE 17. *Gas Meter Accuracy.*—(a) Every gas meter, whether new, repaired, or removed from service for any cause, shall be adjusted to be correct within one per cent when passing gas at six cubic feet per hour per rated light capacity before being installed for use of any customer.

(b) No gas meter hereafter installed shall be allowed to remain in service more than 60 months without being retested, and, if necessary, readjusted to be correct within one per cent.

(c) During each period of twelve months after these rules take effect, until all meters now in service shall have been tested, each gas utility shall remove not less than 20 per cent of such meters, as nearly as possible in the order of the length of time since they were last tested, the longest in service to be first removed. Such removed meters shall not be reinstalled until tested and made to comply with the other provisions of these rules.

RULE 18. *Fees for Meter Tests by Commission.*—(a) The amount of fee to be collected for meter tests made by the Commission in accordance with paragraph "b" of Rule 5 shall be as follows:

For each gas service meter—

Not exceeding 10 lights capacity	$2.00
Exceeding 10 and not exceeding 45 lights capacity	4.00
All others	8.00

RULE 19. *Gas Pressure.*—(a) The pressure of the gas distributed by any utility, as measured at the outlet of the service pipe to any customer, shall never be less than equivalent to two inches of water pressure; and shall never be greater than equivalent to six inches of water pressure unless the customer in writing agrees to the maintenance of such pressure, or the Commission by its order modifies this rule.

(b) 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 within the limits fixed under Rule 19a. Gas shall be supplied by the utility at such normal pressure as nearly as practicable at all times and the pressure of the gas as measured at the outlet of the service pipe of any customer shall never vary during any day by more than the following amounts: until December 31, 1914, two and one-half inches of water pressure; and at any time on and after January 1, 1915, two inches of water pressure.

(c) The normal pressure fixed by each utility and any changes thereafter proposed in any such normal pressure shall be reported to the Commission and shall be approved by the Commission before going into effect.

(d) Every gas utility shall maintain on its distributing system at least one recording pressure gauge for each district fixed under the provisions of this rule and no utility shall maintain less than two such recording pressure gauges by which a continuous record of the gas pressure shall be made.

24. PENNSYLVANIA

The Public Service Commission of the Commonwealth of Pennsylvania, established by an act of the 1913 legislature, has full jurisdiction within the State. The following set of regulations was adopted April 9, 1914; an inspection staff is being organized and plans are being formulated for routine inspection work:

Part I—General

Definition.—The term "Utility" as used in these rules includes all public service companies, corporations and persons, as defined in The Public Service Company Law, engaged in the production, sale or distribution of gas within the jurisdiction of the Commission.

I. *Statutory.*—It shall be the duty of every public service company to furnish and maintain such service, including facilities, as shall in all respects be just, reasonably adequate, and practically sufficient for the accommodation and safety of its patrons, employees, and the public, and in conformity with such reasonable regulations or orders as may be made by the Commission.

II. *Pressure Variation.*—Each utility furnishing manufactured gas shall maintain at the consumer's meter outlet a gas pressure of not less than one and one-half inches nor more than eight inches of water pressure; and within said limits the daily variation of pressure at the outlet of any one meter on the system shall never be greater than one hundred (100%) per cent. of the minimum pressure. Each utility furnishing natural gas shall maintain at the consumer's meter outlet a gas pressure of not less than one and one-half inches, nor more than fourteen inches of water pressure, except when greater pressure is specifically provided in the contract between the utility and the consumer, provided there shall be no unfair and unreasonable discrimination or preference; and within the said limits the daily variation of pressure at the outlet of any one meter on the system shall never exceed four inches of water pressure above or below the normal pressure maintained at such point of delivery, unless it can be shown to the Commission that such greater variation is due to extraordinary demand in extreme weather.

Provided, That variations in pressure caused by operation of consumer's apparatus in violation of contract or the rules of the utility, or by causes entirely beyond the control of the utility, shall not be considered a violation of this rule.

III. *Required Heating Value.*—Each utility furnishing manufactured gas service must supply gas which when tested within a one mile radius from the point of manufacture, shall give a monthly average of not less than 570 British thermal units total heating value per cubic foot, as referred to standard condition of temperature and pressure, except gas which in the opinion of the Commission, is produced as a by-product in the manufacture of coke, which gas shall give a monthly average of not less than 550 British thermal units per cubic foot. The minimum heating value of manufactured gas shall never fall below 520 British thermal units except for by-product coke oven gas as indicated above, which shall never fall below 500 British thermal units. Manufactured gas delivered to the mains under pressure above 5 pounds per square inch shall be tested for heating value before compression. The minimum heating value of natural gas supplied by any utility shall never fall below 800 British thermal units per cubic foot, as referred to standard condition of temperature and pressure.

IV. *Sulphur Requirements.*—In no case shall manufactured gas contain more than 30 grains of total sulphur per 100 cubic feet.

V. *Service Interruptions.*—Each utility shall keep a record of all interruptions to service on the entire system or any portion thereof belonging to the utility, which record shall contain the time, cause, extent and duration of the interruption, and shall be kept as specified in Rule IX.

VI. *Complaint Records.*—Each utility shall keep a record of all written complaints received from its consumers in regard to service, which record shall show the name and address of the complainant, the date and nature of the complaint, the action taken, and the date of final disposition of the matter. This record shall be kept as specified in Rule IX.

VII. *Inspection of Equipment.*—Each utility shall inspect its equipment and facilities, including the necessary tests for water and leaks in its lines, in accordance with good practice, and in a manner satisfactory to the Commission, and shall maintain as specified in Rule IX, a

complete record of all such inspections and tests, and shall file with the Commission a statement of the condition of its equipment and facilities, and such copies of its reports of inspections, when and in such form as the Commission may require.

VII. *Accidents.*—Each utility shall keep a record of and shall furnish to the Investigator of Accidents for the Commission, in accordance with the rules of the Commission, reports of any and all accidents happening in or about or in connection with the operation of its property, facilities or service, wherein any person shall have been killed or injured, or property damaged or destroyed, with a full statement as far as possible of the causes of such accidents, and the precautions, if any, taken as prevention against future accidents of similar character.

IX. *Records and Reports.*—All records required by these Rules shall be kept within the State at an office or offices of the utility located in the territory served by it, and shall be open for examination by the Commission or its representative. Each utility shall notify the Commission of the office or offices at which the various classes of records are kept and shall file with the Commission, such reports as the Commission may from time to time require.

Part II—Meters, Calorimeters, etc.

X. *Allowable Error.*—No gas meter shall be placed in service nor allowed to remain in service which shows in comparison with a standard gas prover, an error greater than two (2%) per cent. when gas at the standard test rate of flow is passing through it.

XI. *Periodic Tests.*—No utility furnishing metered gas service shall allow a gas meter to remain in service for a period longer than five years without checking it for accuracy, or readjusting it if found to be incorrect beyond the limits established by Rule X. Proportional meters shall be tested once every five years and readjusted if necessary, and cleaned by a competent man at least once each three months.

XII. *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 the meter, together with all the 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 made. A record shall also be kept, preferably numerically arranged, indicating date of meter purchase, when purchased after July 1, 1914, name of manufacturer, its size, its identification, its various places of installation, with dates of installation and removal, and the dates and general results of all tests. These records shall be kept as specified in Rule IX.

XIII. *Installation of Meters.*—Each gas service meter installed after July 1, 1914, shall have been tested for accuracy by the utility within one year previous to its installation. It shall also be inspected by the utility for proper connections, mechanical conditions, and suitability of location within sixty (60) days after installation.

XIV. *Facilities for Testing.*—Each utility shall provide and maintain suitable and adequate facilities for testing its gas service meters, in each case to be satisfactory to and approved by the Commission. Each utility shall provide a suitable meter prover, of not less than five (5) cubic feet capacity, equipped with suitable thermometers and other necessary accessories, and shall maintain the same in proper adjustment to register the condition of the meters within one-half of one per cent. The accuracy of all provers will be established from time to time by a representative of the Commission at a place to be designated by it. After January 1, 1915, tests made with an uncertified prover will not be deemed authoritative.

XV. *Pressure Surveys.*—Each utility shall provide itself with one or more graphic recording pressure gauges, and shall make frequent measurements of the gas pressure and pressure variation throughout its system. Charts from these gauges showing the pressure variation shall be kept

for at least two years as specified in Rule IX. The accuracy of all pressure gauges will be established from time to time by a representative of the Commission at a place to be designated by it. After January 1, 1915, tests made with an uncertified pressure gauge will not be deemed authoritative.

XVI. *Calorimeter Tests.*—Each utility whose gas output exceeds twenty million cubic feet per year shall equip itself with a complete standard calorimeter outfit approved by the Commission, by which it shall determine the heat value of manufactured gas at least three days each week, and of natural gas at least three times per year. A complete record of all these tests shall be kept as specified in Rule IX. The accuracy of all calorimeters will be established from time to time by a representative of the Commission at a place to be designated by it. After January 1, 1915, tests made with an uncertified calorimeter will not be deemed authoritative.

XVII. *Meters in Service without Test Records.*—All gas meters in service on and after July 1, 1914, for which there is no record of test within five years, must be tested as soon thereafter as circumstances will permit, and in all cases within three years from July 1, 1914.

XVIII. *Request Tests.*—Each utility shall upon the written request of a consumer, and if he so desires, in his presence or that of his authorized representative, make a test of the accuracy of his meter. When a consumer desires, either personally or through a representative, to witness the testing of a meter, he may require the meter to be sealed in his presence before removal, which seal shall not be broken until the test is made in his presence. If the meter so tested shall be found to be accurate within the limits specified in Rule X, a fee determined from the schedule indicated below, shall be paid to the utility by the consumer requiring such test; but if not so found, then the cost thereof shall be borne by the utility furnishing the service. When making such request, the consumer shall agree to the basis of payment herein specified. A report of such test shall be made to the consumer, and a complete record of such test shall be kept on file as specified in Rule IX.

The amount of the fee to be charged by the utility for testing meters upon written complaint of consumers shall be determined by the manufacturers' designated rating, as follows:

POSITIVE METERS

Meters of 10-light capacity or under, or having a rated capacity of 200 cubic feet per hour or under	$2. 00
Meters of over 10-light capacity and not exceeding 30-light capacity, or having a rated capacity exceeding 200 cubic feet per hour, and not exceeding 600 cubic feet per hour	4. 00
Meters of over 30-light capacity and not exceeding 80-light capacity, or having a rated capacity exceeding 600 cubic feet per hour, and not exceeding 1,500 cubic feet per hour	6. 00
Meters of over 80-light capacity, or having a rated capacity exceeding 1,500 cubic feet per hour	10. 00

PROPORTIONAL METERS

All proportional meters not exceeding 15,000 cubic feet per hour rated capacity	15. 00
All proportional meters of over 15,000 cubic feet and not exceeding 30,000 cubic feet per hour	20. 00
All proportional meters of over 30,000 cubic feet and not exceeding 50,000 cubic feet per hour rated capacity	30. 00
All proportional meters of over 50,000 cubic feet and not exceeding 100,000 cubic feet per hour rated capacity	40. 00
All proportional meters of over 100,000 cubic feet per hour rated capacity	50. 00

Rates for testing meters not included in the above classification, or which are so located that the cost is out of proportion to the fee specified, will be furnished by the Commission upon receipt of complete specifications.

XIX. *Refunds.*—If a meter be found to be fast at any test by more than two (2%) per cent, an allowance or refund shall be made to the consumer by the utility, equal to all the excess charged the consumer, figured back from the date of test through the entire period of the current bill, unless it can be shown that the error is due to an accident or other cause the exact date of which can be determined, in which case it shall be figured back to such time.

25. RHODE ISLAND

The Public Utilities Commission of Rhode Island has authority to regulate the quality of gas and gas service. Rules covering these subjects are under consideration at this time; only the following order (dated February 26, 1913) has yet been issued (March, 1914):

(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

26. SOUTH CAROLINA

The Public Service Commission of South Carolina was established by an act passed in 1910 with authority "to fix and establish in all cities of the State maximum rates and charges for the supply of water, gas, and electricity." However, this commission has no jurisdiction in the cities of Charleston, Marion, Spartansburg, Sumter, and Union, or in the town of Conway.

This commission was appointed by the governor, but all of the members have retired from office and their successors have not yet been appointed. As far as the Bureau can determine, this commission has never been organized nor taken up utility investigations.

27. VERMONT

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

28. VIRGINIA

The authority of the Corporation Commission of Virginia has been extended recently (March, 1914) giving it authority over gas-company operations and service rendered.

29. 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; but no inspection work has yet (June, 1914) been undertaken. 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*, That 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.

30. WEST VIRGINIA

The Public Service Commission of West Virginia has adopted the following standards for gas service (approved Aug. 9, 1913). The regular testing of meters by the inspectors of the commission has been arranged about as it is done in New York State.

1. No gas meter shall be placed in service or allowed to remain in service which has an error in registration of more than two per cent.

2. No domestic gas meter shall be placed in service or allowed to remain in service which leaks or which does not register on a consumption of three cubic feet per hour.

3. All domestic meters shall be tested by an inspector of the Commission using an approved prover of at least five (5) cubic feet capacity, and a pressure of approximately two inches of water. The size of the orifice on the outlet side of the meter to be tested shall be as follows:

3 light	1/8 inch opening
5 light	3/16 inch opening
10 light	1/4 inch opening
20 light	5/16 inch opening
30 light	1/2 inch opening
45 light	5/8 inch opening

The prover shall be so constructed that the pressure shall be absolutely uniform throughout the drop of the prover bell. All meters so tested shall be date-tagged and sealed by the inspector. No meter shall be placed in service which is not so tagged and sealed.

All proportional meters shall be tested by an inspector of the Commission, using the orifice or flow-meter test. Proportional meters shall be tested at the testing laboratory of the gas company, without fee, or at the place where said meter is installed at the option of the gas company.

In all cases, except on complaint, all meters shall be tested by an inspector of the Commission at the testing laboratory of the gas company without fee, except in case of a proportional meter the gas company exercises its option of having said meter tested at the place of installation, in which case the said company shall pay for such test the fee hereinafter fixed, for the testing of a meter of the same capacity against which a complaint may be lodged with the Commission. The meter so tested and found correct shall be date-tagged and sealed by said inspector.

4. Effective May 21st, 1913, no domestic gas meter shall be allowed to remain in service for a period of over five years without being tested and date-tagged and sealed by an inspector of the Commission; and no proportional gas meter shall be allowed to remain in service for a period of over one year without being so tested, date-tagged and sealed by said inspector. In making such tests the meters longest in service without a test shall be tested first.

5. A complete record shall be kept of each test with sufficient data of record to allow checking the test calculations and the methods employed.

6. Each gas company shall maintain an approved testing laboratory with equipment for the testing of domestic meters, and also for the testing of proportional meters, subject to modification by the Commission in particular cases. In the first instance, the laboratory shall be provided with adequate facilities for changing the temperature of the water in the base of the prover and the prover shall be so located that it will not be subject to draughts or sudden changes of temperature. In the second instance, the Commission shall furnish complete specifications for each individual case.

7. On formal application to the Public Service Commission by the consumer, test shall be made upon the consumer's meter as soon as practicable, by an inspector of the Commission. A record of such test shall be forwarded to the consumer and to the company, and be filed in the office of the Chief Inspector of the Commission.

The Commission will charge the following fee for this service: For meters used in measuring natural and artificial gas:

Capacity cu. ft. per hour:	Fee.
5 to 500	$1. 00
500 to 800	1. 50
800 to 1500	2. 00
1500 to 3000	3. 50
3000 to 16000	5. 00
16000 to 40000	7. 50
40000	10. 00

For meters having a capacity greater than 40,000 the Commission will establish a suitable fee, upon application.

8. 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 date of the reading of the meter.

9. A meter inspected and sealed, but reclaimed, may be tested by the gas company, and if correct within two per cent, and the seal unbroken, the same may be installed at a new location without a new inspection by the Commission.

10. *Gas Pressure.*—Each gas company shall so far as practicable establish and maintain a standard pressure to be measured at any meter outlet of the distribution system, and at no time, so far as practicable, shall said pressure be allowed to become less than the said standard pressure.

Each gas company shall, when required so to do by the Commission, make a continuous record of the gas pressure at the inlet end of its distribution system, and a like record of gas pressure at such other point as may be designated from time to time by the Commission.

31. 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, which were adopted August 9, 1913, to supersede rules previously in force since 1908. For a number of years the inspectors of the commission have checked up the quality of gas service furnished in the various cities of Wisconsin. The larger companies are required to take heating values and pressure surveys frequently and hence are not inspected by the commission as often as the smaller plants. The routine tests are left largely to the companies, but are supervised and supplemented by the commission's inspectors who check up heating value, impurities, pressure regulation, and meter practice; they carry calorimeters and graphic recording pressure gauges and summarize records kept by the gas companies.

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.

B. MUNICIPAL REGULATIONS IN FORCE

The following compilation of gas-ordinance requirements is a practically complete tabulation of the provisions enacted up to January, 1913 (and a few regulations adopted since that time), which are now in force 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	119
State commission has authority (unexercised)	57
City ordinances in force	58
No rules in force and no State commission in authority	17
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 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
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 *
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	State *
Cambridge, Mass	State *
Camden, N. J	State *
Canton, Ohio	State
Cedar Rapids, Iowa	1, 3, 4, 5, 6
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 *
Chicopee, Mass.....State *
Cincinnati, Ohio.....State
Cleveland, Ohio.....State 1, 2, 3, 4, 5, 6
Clinton, Iowa.....1, 2, 3, 4
Columbia, S. C.....None
Columbus, Ohio .....State
Colorado Springs, Colo...State 1, 2
Council Bluffs, Iowa....2, 4
Covington, Ky.....None
Danville, Ill.....State *
Dallas, Tex.....None
Davenport, Iowa.....2, 5, 6
Dayton, Ohio.....State
Decatur, Ill.....State *
Denver, Colo.....State
Des Moines, Iowa.....2
Detroit, Mich.....1, 2, 3, 4, 5, 6
Dubuque, Iowa.....None
Duluth, Minn.....Municipal plant
Easton, Pa.....State *
East Orange, N. J.....State *
East St. Louis, Ill.....State *
Elgin, Ill.....State *
Elizabeth, N. J.....State *
Elmira, N. Y.....State *
El Paso, Tex.....2, 3, 5, 6
Erie, Pa.....State *
Evansville, Ind.....State *
Everett, Mass.....State *
Fall River, Mass.....State *
Fitchburg, Mass.....State *
Flint, Mich.....None
Fort Wayne, Ind.....State *
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 *
Hazelton, Pa.....State *
Hoboken, N. J.....State *
Holyoke, Mass.....State *
Houston, Tex.....5, 6
Huntington, W. Va.....State *
Indianapolis, Ind.....State *
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 *
Joplin, Mo.....State
Kalamazoo, Mich.....1, 4, 5, 6
Kansas City, Kans.....State †
Kansas City, Mo.....State 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.....None
Lima, Ohio.....State 2
Lincoln, Nebr.....1, 2, 3, 4, 5, 6
Little Rock, Ark.....None
Lorain, Ohio.....State
Los Angeles, Cal.....State † 1, 2, 3, 4, 5, 6
Louisville, Ky.....1, 2, 3, 4, 5, 6
Lowell, Mass.....State *
Lynchburg, Va.....State 2, 3
Lynn, Mass.....State *
McKeesport, Pa.....State *
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
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
New Bedford, Mass.....State *
New Britain, Conn.....State
Newburgh, N. Y.....State *
New Castle, Pa.....State *
New Haven, Conn.....State
New Orleans, La.....None
Newport, Ky.....None
Newport, R. I.....State *

New Rochelle, N. Y.	State *
Newton, Mass.	State *
New York, N. Y.[43]	State * 2, 3, 6
Niagara Falls, N. Y.	State *
Norfolk, Va.	State 5, 6
Norristown, Pa.	State *
Norwich, Conn.	State
Oakland, Cal.	State † 6
Ogden, Utah	1, 2
Oklahoma City, Okla.	State
Omaha, Nebr.	1, 2, 3, 4, 5, 6
Orange, N. J.	State *
Oshkosh, Wis.	State *
Pasadena, Cal.	State † 1, 3, 4, 5, 6
Passaic, N. J.	State *
Paterson, N. J.	State *
Pawtucket, R. I.	State *
Peoria, Ill.	State *
Perth Amboy, N. J.	State *
Philadelphia, Pa.	State * 2, 5, 6
Pittsburgh, Pa.	State *
Pittsfield, Mass.	State *
Portland, Me.	State
Portland, Oreg.	State *
Portsmouth, Va.	State
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.	State, municipal operation
Roanoke, Va.	State
Rochester, N. Y.	State *
Rockford, Ill.	State *
Sacramento, Cal.	State †
Saginaw, Mich.	1, 2, 3, 4, 5, 6
St. Joseph, Mo.	State
St. Louis, Mo.	State 2, 3, 5, 6
St. Paul, Minn.	1, 2, 3, 4, 6
Salem, Mass.	State *
Salt Lake City, Utah [44]	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 *
Seattle, Wash.	State *
Sheboygan, Wis.	State *
Shenandoah, Pa.	State *
Shreveport, La.	None
Sioux City, Iowa	1, 2, 3, 4, 5, 6
Somerville, Mass.	State *
South Bend, Ind.	State *
South Omaha, Nebr.	2
Spokane, Wash.	State * 6
Springfield, Ill.	State *
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 *
Toledo, Ohio	State 2
Topeka, Kans.	State †
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.	See State rules *
Waterbury, Conn.	State
Waterloo, Iowa	1, 2, 5, 6
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 *
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
Zanesville, Ohio	State

[43] See p. 146.

[44] 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."

TABLE 1

Municipal Heating Value Requirements. (See also State rules)

City	Heating value required (Btu per cubic foot)	Frequency of test specified	Remarks
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.
Cedar Rapids, Iowa	600 gross	Daily	
Charleston, S. C	600		
Chattanooga, Tenn	600		
Cleveland, Ohio	600 gross		
Clinton, Iowa	600		
Colorado Springs, Colo	600		
Detroit, Mich	600 gross		
Grand Rapids, Mich	600	Daily	
Jackson, Mich	600		
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.
Louisville, Ky	700		Mixture of natural and artificial gas.
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 1¼ miles from works.
Pasadena, Cal	600 gross	Twice daily with 6 hour interval.	Test with Junker's calorimeter; some conditions of test specified.
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		
Waco, Tex	633		
Waterloo, Iowa	Equal to that of cities of like size in Iowa.		

TABLE 2

Municipal 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
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.
Charleston, S. C	20				Water gas.
Chattanooga, Tenn	16				Coal 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.
El Paso, Tex	16				Mixed gas.
Grand Rapids, Mich	16	Candles	Argand	Daily	Mixed gas.
Jackson, Mich	Coal 16; water 20			At request of council	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.
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, U ah	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.
Philadelphia, Pa	22			Daily	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.
Sioux City, Iowa	21	Pentane lamp			Mixed gas.
South Omaha, Nebr	20				Water gas.
Springfield, Mo	Water 22; coal 18				Water gas.
Springfield, Ohio	16				Water gas.
Tampa, Fla	20				Water gas.
Toledo, Ohio	18				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

Gas Purity—Municipal 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.
Cedar Rapids, Iowa	Absent	30	4		All tests daily.
Charleston, S. C	Absent	20	5		
Chattanooga, Tenn	Absent	20	10		
Cleveland, Ohio	Absent	20	10		
Clinton, Iowa	Absent				
Detroit, Mich	Absent	30	10		Inspector required to make analysis of gas.
El Paso, Tex					Shall be of "best quality."
Grand Rapids, Mich	Absent	30	10		
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.
Louisville, Ky	Trace	30	5		For manufactured gas only.
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	25	5	25	All tests monthly; methods defined.
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				
Syracuse, N. Y	Absent	20	10		

TABLE 4

Municipal 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.
Cedar Rapids, Iowa	Meter inlet	6	2 or 3	100		Minimum 3 inches within 1 mile of works, elsewhere 2 inches.
Charleston, S. C		4	1.5			
Chattanooga, Tenn		5	1.5			
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.
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	Service outlet	5 oz.	3 oz.	1.5 oz.	Regular	Higher pressure allowed on agreement with customer.
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.
Omaha, Nebr		4.5	2			
Pasadena, Cal	Service pipe		3			"At a uniform and well governed pressure;" not higher "than required to give safe and adequate service."
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		

TABLE 5

Municipal 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
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.
Cedar Rapids, Iowa	City	City	±2	Loser, 50 cents.	3 months	
Charleston, S. C		Company	±2	Loser, cost		
Chattanooga, Tenn			±2			
Cincinnati, Ohio		City	±2	25 cents and cost of removing meter.		
Cleveland, Ohio	City	City	±3			Limit of error set by State law; council reserves right to make more stringent requirement.
Davenport, Iowa		City				
Detroit, Mich		City	±2	Loser, $1		One-half fee to company.
El Paso, Tex		City		Loser, cost		
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.
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.

TABLE 5

Municipal 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
Lincoln, Nebr			+3 or −2	$1		
Los Angeles, Cal	City	City	−3 or +2	Loser, cost		Methods of test defined.
Louisville, Ky	Company	City	±1 on installation; ±2 on removal.			All tested every 5 years.
Memphis, Tenn	City	City	±2			Not oftener than 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.
Norfolk, Va	City	City	±2	Routine, 25 cents; complaint, $1 by loser.		
Omaha, Nebr	City	City	±2	Loser, $1		
Pasadena, Cal		City	±2	Loser, $0.50 to 3.00 and cost of hauling.	3 months	Method of test defined.
Philadelphia, Pa	City	City		Complainant, if not fast, $1.		Company pays fixed sum toward expense of testing.
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			Not enforced.
Savannah, Ga		City	±3			
Sioux City, Iowa		City	±2	Loser		
Waco, Tex			±2			
Waterloo, Iowa		Company	±2	Loser, $1	3 months	
Wilmington, Del		City		Loser, 50 cents		"United States Standard."

TABLE 6

Municipal Inspection Officials

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.
Battle Creek, Mich	Inspector of Weights, Meters, and Measures.
Bay City, Mich	Board of Public Works.
Cedar Rapids, Iowa	City Gas Inspector.
Charleston, S. C	City Electrician.
Cleveland, Ohio	Director of Public Service.
Davenport, Iowa	City Electrician, ex officio.
Detroit, Mich	Gas Analyst and Inspector appointed by the Commissioners of Public Works.
El Paso, Tex	Plumbing Inspector, ex officio.
Grand Rapids, Mich	Gas Inspector.
Houston, Tex	Public Service Commissioner.
Jackson, Mich	Board of Public Works.
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.
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 Chemist.
Philadelphia, Pa	Bureau of Gas.
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	Board of Public Works.
Savannah, Ga	City Meter Inspector.
Sioux City, Iowa	City Engineer, or deputies appointed by him.
Spokane, Wash	City Chemist.
Syracuse, N. Y	Purity tests are made by City Chemist.
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 very great 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 a relation to the candlepower of this flame similar to that which 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 candlepower 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 probably produce a higher mantle candlepower, because of the small volume of air consumed and high temperature reached in the flame, than a gas of the same heating value composed of methane and nitrogen. 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.

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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.

Oil gas is esentially the product of destructive distillation of a hydrocarbon oil. This accounts for the great similarity in composition of oil gas and coal gas, the former being produced from oil, the latter from bituminous coal, under such conditions that somewhat simular reactions occur. The generating machinery used for production of oil gas resembles markedly the water-gas machinery, and the process is also somewhat similar as it is carried out in alternate heating and gas-making periods. However, the chemical processes involved and the effect of various factors are so different from those found in the case of water gas that it is undesirable to make comparison with the latter when considering oil gas. Comparison may be made with the carburetting process used in water-gas manufacture, but even this has led to some misunderstandings.

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

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

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

of 5 to 10 days it is, in some plants, necessary to entirely shut down manufacture and burn out this carbon under natural drafts.

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

The heating oil is introduced into the generator with steam or under high pressure without steam; and if properly injected, it enters practically atomized. This fine oil spray is quickly vaporized by the hot checker brick and the decomposition of the vapor begins at once. The higher the temperature to which the oil vapor is subjected and the longer the time at the high temperature the more complete will be the decomposition. Practically speaking, if this decomposition went to completion the oil would be converted into hydrogen and lampblack. As a matter of fact a small portion of the oil is always decomposed in this manner, but of course a much larger part is decomposed only into those hydrocarbon gases which make up the methane, ethylene, and benzene series. In addition there are also formed complex hydrocarbons, such as napthalene.

The significance of this successive decomposition is apparent if we consider that a specification of a certain heating value for the gas will necessitate that the generator be operated at such temperature as to produce gas at least of the richness specified. The standard fixed is therefore a determining factor in controlling the works operation. Moreover, if the quality be fixed too high it will be found that certain difficulties of operation are introduced because of the low temperature which must be maintained in the generator. For example, when operating at a lower temperature a smaller amount of lampblack may be made; but this as produced is mixed with more or less of the difficulty removable tar and the resulting tar and lampblack mixture is difficult to handle. This trouble is met particularly in the case of the straight-shot machine. Another difficulty met under these conditions is the larger amount of carbon which is deposited in the generator and the resulting increase in the frequency with which the machines must be "burned out."

The numerous variations in detail make it impossible to give any generalizations as to the present operating practice in many particulars. However, two particular points on which striking differences in operating practice

have been noted, should be considered in connection with standards for oil-gas service. The first of these points has to do with the method of introducing the oil into the generator, the second with the manner of handling the gas in wash boxes and condensers.

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

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

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

C. DISTRIBUTION METHODS [45]

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 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.

[45] 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.

It should be recognized that low pressure at the burners is not always the fault of the gas company. It very frequently happens, especially in old houses, that the house piping is inadequate or in poor condition, a situation for which the company is not responsible and which should be remedied at the consumer's expense. When the piping is placed in a new building it seems desirable that the company should be allowed to have something to say, at least in an advisory way, about the size of pipe and other matters affecting satisfactory service, since it may have to investigate any complaint which may result from 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 sudden increased demand, will make a portion of the system inadequate and will require changes which can not be made quickly. In every case, however, the company should be expected and required to give the matter immediate attention and to make the necessary changes as rapidly as may be without undue expense.

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

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[46]	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[47]	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[48]	33	29	26	25	24	21	19

[46] General average 2.65. [47] General average, 76.3. [48] General average, 21.3.

TABLE 4

Gas Main Pressures

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

Companies—[49]	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

[49] 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[50]	620	620	620	625	.....

[50] 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[51]	17.5	21.0	19.0	20.5	.....	.....

[51] General average, 19.5.

RULES AND REGULATIONS ADOPTED BY THE PUBLIC UTILITIES COMMISSION OF KANSAS

EFFECTIVE January 26, 1915.

(See page 133.)

RULE 1. *Units of Measurement.*—(*a*) The cubic foot shall be the standard unit for measuring quantity, and the British thermal unit the standard unit for determining quality of all gas offered for sale to consumers in the State of Kansas.

(*b*) For purposes of testing, a cubic foot of gas shall mean that amount of gas contained in a volume of one cubic foot, when saturated with water vapor, at sixty degrees Fahrenheit and at a pressure of thirty inches of mercury.

RULE 2. *Heating Value.*—(*a*) No utility shall offer for sale to the consumers in Kansas natural gas having a heating value lower than 800 British thermal units per cubic foot, except by permission of the Commission.

(*b*) The heating value of natural gas shall be determined at least semiweekly, except when, in the opinion of the Commission, conditions warrant a different period of time.

(*c*) When a distributing utility obtains its supply from a pipe-line or producing utility it shall be deemed sufficient for the pipe-line or producing utility to make one determination and report covering the heating value of gas furnished any group of cities, provided such determination is made at a point on the line beyond which no additional gas enters, and that conditions are such that the samples tested may be accepted as fair averages of the gas furnished the cities in question.

(*d*) When such determinations are made by a pipe-line or producing utility, a certificate shall be furnished the Commission, naming the cities, and a copy of the certificate shall also be furnished the distributing utility in each city so supplied. When considered necessary, the Commission will require separate determinations to be made in each of the cities so supplied.

(*e*) Each pipe-line or producing utility, whether engaged in distributing its own output or not, whose total gas output exceeds twenty million cubic feet per year, shall equip itself with a complete standard calorimeter outfit approved by the Commission. Utilities doing a smaller volume of business may have their testing done by any other utility having an approved calorimeter.

(*f*) All operating pipe-line and producing utilities shall furnish chemical analyses of the gas from any or all wells from which their supply is obtained, at such times as the Commission may require.

RULE 3. *Pressure.*—(*a*) Distributing utilities shall furnish gas at a pressure of not less than two ounces or more than eight ounces as measured at the consumer's meter outlet. Pipe-line or producing utilities shall furnish it to the distributing utilities under such conditions as will make this possible.

(*b*) The daily variation at any consumer's meter shall not exceed 100 per cent of the minimum pressure at said meter.

(*c*) Gas under higher pressure may be furnished by special contract, providing there is no unfair or unreasonable preference or discrimination, copies of all such contracts to be filed with the Commission.

(*d*) It shall not be considered as a violation of rule 3 should compliance therewith be rendered impossible by unusual operating conditions.

RULE 4. *Pressure Surveys.*—Graphic recording portable pressure gauges shall be provided by each distributing utility, which shall make frequent measurements of the gas pressure and pressure variations, and preserve the records thereof as hereinafter provided.

RULE 5. *Meters and Equipment for Testing Same.*—(*a*) All gas services shall be metered.

(*b*) Adequate facilities for testing gas meters shall be maintained by each distributing utility, except where, in the opinion of the Commission, such requirement would be unreasonable on account of the small number of consumers.

(*c*) There shall be provided a meter prover of not less than five cubic feet capacity, equipped with suitable thermometers and other necessary accessories. It shall be maintained in such adjustment as to register the accuracy of meters to within one-half of one per cent. A prompt report in writing must be made to the Commission in case of alterations or repairs to any meter prover or in the method of operating same.

RULE 6. *Meter Accuracy.*—(*a*) No gas meter shall be placed in service or allowed to remain in service which is not in good order, and which shows, in comparison with a standard meter prover, an error greater than one per cent when passing gas at the rate of six cubic feet per hour per rated light capacity.

(*b*) Each meter tested shall be subjected to at least two test runs, which shall check with each other within one-half per cent.

(*c*) Each meter, after being tested, shall be sealed by the utility with a seal showing the date of test.

(*d*) Prepayment meters, geared or set so as to collect a higher rate than would be paid if a standard meter was in use, shall not be installed without the written consent of the Commission.

RULE 7. *Period of Service.*—(*a*) No meter shall be allowed to remain in service for a longer period than five years without being tested and adjusted in accordance with rule 6.

(*b*) During each period of twelve months, beginning January 1, 1915, until all meters in service have been tested, each utility shall remove and test not less than 20 per cent of all meters in service. Those longest in service shall be removed first.

RULE 8. *Request Tests.*—Each distributing utility, upon written request by a consumer, shall test the accuracy of the meter used by him; provided, first, that the meter in question has not been tested by the utility or by the Commission within one year previous to such test; and sceond, that the consumer will agree to accept the result of the test made by the utility as determining the basis for settlement. No charge shall be made to the consumer for any such test, a report of which shall be made to him upon his request.

RULE 9. *Testing by the Commission.*—(*a*) Any consumer may have his meter tested by the Commission by making written application thereto, and enclosing a fee, based on the size of the meter, as shown below:

Meter of 10-light capacity or under	$2.00
Meter exceeding 10 lights but not exceeding 45	4.00
Meter exceeding 45-light capacity	8.00

Fees for testing larger meters or for testing meters under extraordinary conditions will be furnished upon application.

(*b*) Such tests shall be made by a representative of the Commission as soon as is practicable after the receipt of the application, and the meter in question shall not be removed or tampered with in any way by either party before said test is made.

(*c*) If the meter is found to be more than two per cent fast, the fee shall be refunded to the consumer by the utility.

RULE 10. *Refunds.*—When, as the result of any test, a meter is found to be more than two per cent fast, the utility shall refund to the consumer the overcharge, based on the corrected

meter reading for the period in which the meter was in use, not exceeding six months, unless it can be shown that the error was due to some cause the date of which can be fixed. In this case the overcharge shall be computed back to but not beyond such time.

RULE 11. *Meter Test Records.*—The original record of all meter tests shall be preserved, This record shall contain the proper identification of the meter, the reason for the test, the reading of the meter at the time of its removal for the test, and the results of the test, together with sufficient data to permit the checking of the calculation and method employed.

RULE 12. *Records of Meters.*—A record shall be kept, preferably numerically arranged, of all meters owned or used by the utility. This record shall show the date of purchase, name of manufacturer, size, identification, places of installation, with dates of installation and removal, dates of repairs and tests, together with the general results of tests.

RULE 13. *Service Interruptions.*—A record of all interruptions of service shall be kept by all utilities. This record shall show the time, cause, extent and duration of each interruption.

RULE 14. *Complaints.*—The receipt of all written complaints shall be acknowledged in writing. Full and complete investigation shall be made and a record kept by the utility, showing the name of the complainant, the date and nature of the complaint, and the final disposition thereof, with date.

RULE 15. *Accidents.*—A record shall be kept of all accidents occurring in or about the property of any utility, or in connection with the operation thereof, in which any person is killed or injured. Such record shall contain all available information as to the cause of such accidents and the precautions, if any, taken as prevention against future accidents of similar character.

RULE 16. *Bill Forms.*—Bills rendered periodically shall show thereon the registration of the meter at the beginning and at the end of the period for which the bill is rendered, the dates of such readings, the number of units of service supplied, and the price per unit. All factors entering into the computation of any bill shall be shown thereon, in order that the amount may be checked from such information.

RULE 17. *Preservation of Records.*—(*a*) Utilities are hereby required to preserve such records as are required by these rules for a period of at least three years after they are made, unless written permission to the contrary is given by the Commission. Such records shall be kept within the State of Kansas at the office of the utility.

(*b*) All such records shall be open for examination by the Commission or its representatives.

RULE 18. *Reports.*—On or before the fifteenth day of each month each company shall transmit to the Commission reports for the previous month as follows: The result of all chemical analyses and all tests made for heating value, a summarized statement of all complaints received, and a copy of the accident record as required herein.

RULE 19. *Accuracy of Testing Instruments.*—(*a*) The Commission will establish the accuracy of all meter provers, pressure gauges, calorimeters, and other testing apparatus and the methods used in operating same.

(*b*) After June 1, 1915, tests made with uncertified apparatus will not be deemed authoritative.

RULE 20. *Discontinuance of Service.*—(*a*) No utility shall discontinue the service to any consumer for violation of its rules or regulations without first having given forty-eight hours' written notice to the consumer.

(*b*) A complete record of all transactions under this rule shall be maintained by the utility.

RULE 21. *Economical Usage.*—In order that its patrons may be taught economy in the use of gas, each distributing company and each pipe-line or producing company shall prepare and mail to each of its patrons, at the time of mailing the October bills each year, a printed pamphlet containing full information regarding the economical adjustment and use of gas-burning equipment. No such pamphlet shall be distributed, however, until it has been submitted to and approved by the Public Utilities Commission.

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