November 2000

Gas energy measurement

A consultation document

Summary

The introduction of the proposed EC Measuring Instruments Directive, possibly as early as July 2002, is likely to require changes to the way gas is measured and billed. This may have a considerable impact on the industry's billing systems.

The existing UK legislation relating to accuracy of meters and the calculation of thermal energy makes the use of temperature and pressure conversion devices on gas meters difficult. However, existing and proposed EC law allows the use of such meters. The rationale of the proposed Directive is to create a single European market for gas meters. It follows that if the proposed Measuring Instruments Directive is implemented, and UK legislation is amended as a result, the industry's billing systems (depending on their functionality) may require consequent modification.

There is a small inaccuracy inherent in the present arrangements for gas measurement. Differences in pressure mean that fewer than one in fifty customers are affected by over measurement of more than 2%. For a typical small customer, with an annual bill of £190.64, measurement error causes inaccuracies ranging between an overpayment of £12.28 to an underpayment of £8.26.

The need to change industry billing systems may create the opportunity to make other changes at low marginal cost. Ofgem has identified some potential changes that would improve the accuracy of energy measurement for the benefit of consumers. These include the use of different temperature conversion factors according to the location of the meter and including a site specific pressure conversion factor in meter asset details.

If the MID is, for any reason, not enacted, Ofgem will need to review with the industry the appropriateness and timing of other potential changes.

Ofgem welcomes comments on the changes outlined in this document and how best to take these forward.

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1. Introduction

Background

1.1 If proposed EC legislation in its present form is introduced, the present UK legislation relating to the use of gas meters, and the method by which thermal energy is calculated, will need to be amended. This is likely to require consequential changes to the gas industry's billing systems.

1.2 These legislative changes are principally necessary in order to allow the use of meters which measure the pressure and temperature of the gas used, and take this into account in the calculation of energy. At present, for the vast majority of sites in the UK, the temperature and pressure of gas are assumed to be constant, i.e. for the purposes of calculating thermal energy, they are taken to be fixed factors. In future, billing systems will need to be able to recognise where a meter which measures actual temperature and pressure is used.

1.3 The present use of fixed factors for temperature and pressure leads to some consumers being over or undercharged for the amount of gas they use. The use of meters which measure actual temperature and pressure will largely remove these sources of error. However, their use will not be mandatory and it may be many years before they are in widespread use. It therefore seems appropriate that, as billing systems are changed as a consequence of the new legislation, consideration is given to making other changes which improve billing accuracy.

1.4 The purpose of this document is twofold. First, it is to make the industry aware of the changes likely to be required by the proposed new legislation. Second, it is to discuss the opportunities for other concurrent changes which could be made to improve the accuracy of billing.

References

- The proposed Measuring Instruments Directive. "Proposal for a Directive of the European Parliament and of the Council on measuring instruments." Document 500PC0566

- The Gas (Calculation of Thermal Energy) Regulations 1996

- The Gas (Meters) Regulations 1983
- Gas prices compared factsheet, Ofgem, October 2000

Rationale

1.5 The purpose of the proposed EC Measuring Instruments Directive is to create a single European market for measuring instruments. At present, the UK legislation relating to gas meters and the calculation of thermal energy makes the use of certain meters, which may legally be used in other member states, very difficult.

1.6 The proposed Directive will allow the use of meters which measure the temperature and/or pressure of gas. Because such meters generally improve the accuracy of measurement of thermal energy, it is in consumers' interests that there are no barriers to their use. Such barriers could be created if the industry's billing systems were not able to accommodate the use of these meters. Given Ofgem's new principal objective is to protect the interests of consumers, we will wish to ensure that industry billing systems provide, as far as practicable, for the accurate measurement of thermal energy.

1.7 Considering how changes might be made, we are mindful of the potential impact on the industry's systems. It is for this reason that we are bringing the issue to the attention of the industry and are seeking to work with the industry to find cost-effective solutions.

1.8 The proposals set out in this document form part of a wider strategy for metering which Ofgem is developing. We aim to publish a document setting out this strategy in the near future.

Structure of this document

1.9 Chapter 2 of this document describes the present situation, how energy is measured and the accuracy of this measurement. Chapter 3 sets out the proposed changes to the measurement of thermal energy. Chapter 4 summarises the changes and proposes a way forward.

Timetable

1.10 The provisional implementation date for the proposed Measuring Instruments Directive is July 2002. The European Commission has indicated that it expects the relevant UK legislation to be amended to comply with the Directive by this date. It follows that any necessary changes to billing systems will need to be completed before then.

1.11 This document sets out an outline of changes that might be necessary or which would improve the accuracy of consumers' bills. It may be appropriate to develop these proposals by means of further consultation documents or through existing or new industry fora. This is discussed in Chapter 4. Ofgem will consider the best means of taking this forward in the light of respondents' views.

Views invited

1.12 If you wish to express a view on the issues raised in this document, or any related matter, it would be helpful to receive your reply no later than Friday 19th January 2001. Responses should be addressed to:

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1.13 It is open to all respondents to mark all or part of their responses as confidential. However, we would prefer as far as possible that responses were provided in a form that could be placed in Ofgem's library. If you have any queries concerning this document Courtnay Sayer on 0116 278 5354, e-mail address courtnay.sayer@ofgem.gov.uk, will be pleased to help.

2. The present situation

Introduction

2.1 This chapter describes the relevant legislation and how the amount of energy used by gas consumers is calculated. It also describes the sources of error in making the calculation and the impact of those errors on consumers.

How thermal energy is calculated

2.2 At present, all gas and electricity consumers are billed on the basis of the amount of energy consumed (in kWh). Electricity meters directly measure energy consumption. In contrast, gas meters measure the volume of gas consumed. The amount of energy consumed (known as thermal energy) is related to the pressure and temperature of the gas and the calorific value (CV) or amount of heat energy in the gas.

2.3 Gas pressure, temperature and CV are not fixed quantities. Gas pressure varies with atmospheric pressure which is also related to height above sea level. Gas temperature varies with ambient temperature and is influenced by the local conditions of the meter installation. The CV varies depending on the source of the gas. See appendix 1 for a fuller explanation.

2.4 The method of calculating thermal energy used is illustrated in the figures below. There are two methods used, depending on the expected annual consumption of the site.

Figure 1 : Sites with an annual consumption of less than 732,000 kWh

Energy used = **Volume measured** x **Temperature and Pressure factor** x **CV**

From meter readings

Fixed factor for temperature and pressure of 1.02264

Measured by PGT

Figure 2 : Sites with an annual consumption of more then 732,000 kWh

Energy used = **Volume measured** x **Temperature factor x Pressure factor** x **CV**

From meter readings

Fixed factor of 1.0098

Fixed factor calculated from altitude of meter and regulator pressure

Measured by PGT

2.5 These figures illustrate that the calculation of energy used assumes that temperature and pressure are constant and that therefore, the appropriate factors are fixed values.

2.6 As an alternative to using these fixed factors, a device known as a converter may be used. This measures the temperature, or alternatively the pressure and temperature, of the gas as it flows through the meter.[1] Devices which measure temperature only are known as 'temperature converters'. If such a device is incorporated into the meter, the meter is known as a 'temperature converted meter'. Devices which measure temperature and pressure are known as 'volume converters'. These are always separate to the meter.

2.7 The measurements of temperature and pressure 'convert' the volume of gas measured by the meter and remove the need to use a fixed factor for either temperature or temperature and pressure as appropriate. This conversion can be done within the meter, or separately by the billing system.

2.8 In the UK, volume converters are fitted to all sites on Transco's network with an expected annual consumption of more than 2,928,000 kWh. However, this is a feature of Transco policy and is not required by law.

[1] Conversion devices which only measure temperature are generally used where short-term variations in pressure are not expected to have a significant influence on the average energy measurement. Systems which measure temperature and pressure are generally only used on larger meters where daily variations of pressure are likely to be significant. Although it is possible to measure only pressure, this is generally not done.

Legislative background

2.9 There are two pieces of UK legislation which are relevant to this document: the Gas (Meters) Regulations 1983 and the Gas (Calculation of Thermal Energy) Regulations 1996. These are referred to in this document as the Meters Regulations and the Thermal Energy Regulations.

2.10 Before being used for the sale of gas in the UK, meter designs must be approved. This approval can either be granted by Ofgem under the terms of the Gas Act (1986) and the Meters Regulations or under the terms of the relevant EC Directive. Once approval has been granted, individual meters must be tested and stamped to show that they conform with the UK or EC approval as appropriate.

2.11 The principal difference between the UK and EC legislation is that the former does not recognise the use of temperature and pressure conversion devices. For the purposes of gaining UK approval, meters may be fitted with such devices, but, providing they do not interfere with the operation of the meter, these are ignored for the purpose of granting the approval.

2.12 The method of calculating the thermal energy supplied to consumers, as described above, is prescribed by the Thermal Energy Regulations. These regulations permit the use of volume converters on any meter, but only allow the use of temperature converters on sites with an annual consumption of more than 73,200 kWh. If a converter is not used, temperature and pressure are taken to be fixed factors.

2.13 Although the use of converters is permitted, there are no standards for accuracy prescribed by UK law (in contrast with the meter itself) and the use of the converter is entirely discretionary.

Sources and magnitude of error

2.14 Each of the components of the measurement of thermal energy contributes to the overall energy measurement accuracy. The potential sources of error in each component and an indication of the magnitude of error are described below.

Gas meters

2.15 Gas meter designs are approved by Ofgem (or under EC legislation). Individual meters are examined and stamped to indicate that they conform with statutory standards of accuracy. If individual meters are found to be inaccurate, the stamp is cancelled, but the power to revoke the approval of groups of meters is limited. The Meters Regulations require that all meters measure (or register) the volume of gas used to within plus or minus 2% of the actual value.

Gas temperature

2.16 At present unless a conversion device is used, the gas temperature is assumed to be 12.2ºC, regardless of geographical location or local conditions. If the actual gas temperature is different to this, the consumer's energy measurement will be subject to an error of 0.35% for every 1ºC difference in temperature.

2.17 An investigation conducted by Ofgem indicates that the gas temperature found in domestic meters may lie in a range of 0°C to 24°C, rather than the assumed average of 12.2°C. A survey carried out by Transco in July 2000[2] found that there was a wide range of temperatures in domestic meters and that there was a difference between internally and externally located meters.

2.18 If substantiated, these findings would indicate that measurement errors caused by using a fixed temperature factor lie in a range of –4% to +4%.

Gas pressure

2.19 For sites with a consumption of less than 732,000 kWh which use a national fixed pressure factor, the pressure is taken to be the average pressure at an altitude of 66m above sea level. Any consumer at a different altitude will be subject to a measurement error of 0.12% for every 10m difference in altitude.

2.20 The pressure factor on higher consumption sites, which use a factor based on the altitude and the pressure set by the meter's pressure regulator, will be reasonably accurate over a long period. However, for shorter periods, where atmospheric

[2] "The domestic meter temperature survey 2000" BG Technology, 6 July 2000

pressure varies from the yearly average, the factor may not be accurate. It is for this reason that volume conversion systems are used on Daily Read meters.[3]

2.21 The relationship between altitude and error makes it relatively straightforward to calculate the average effect on consumers. Table 1 below shows the distribution of domestic consumers in the UK in relation to altitude. It also shows the measurement error caused by the difference in altitude from the average.

Table 1 : Distribution of domestic consumers by altitude

Altitude Band (metres)	Number of consumers (millions)	Percentage of consumers	Change in volume (%)
0 to 66	10.21	58	+0.8% to 0
66 to 150	5.87	33	0 to -1
151 to 230	1.33	8	-1 to -2
231 to 320	0.14	1	-2 to -3
321 plus	0.03	Less than1	over -3

Calorific value

2.22 Measurements of CV at a number of points on Transco's system are used to calculate an average CV for each of Transco's Local Distribution Zones (LDZ). Because the CV can vary within the LDZ, this averaging results in measurement errors for certain groups of consumers. In general, the larger the LDZ, the larger the error. The development of landfill gas and coalbed methane sources producing gas of low calorific value may result in larger variations in CV in the future.

2.23 Water can enter the distribution system from several sources including damage to pipes, leaking joints etc. A volume of gas containing moisture (known as 'wet gas') has less thermal energy than dry gas. Where wet gas occurs, Ofgem issues a determination which specifies the amount of water in the gas. Consumers' bills are then calculated using the calorific value corresponding to that amount of water in the gas.

[3] These are sites which are required by Transco's Network Code to be read daily.

Effect of measurement errors on domestic consumers

2.24 This section summarises the ranges of estimated errors for each of the components of the energy calculation described above (where a converter is not fitted) and indicates the effect on consumers' bills.

2.25 The errors described above are cumulative and randomly distributed. This makes it difficult to estimate actual levels of billing error experienced by consumers. However, it is possible to calculate a range of errors using nominal values of meter accuracy, pressure and temperature. Table 2 below illustrates this range of errors by referring to a 'best' and 'worst' case. The 'best case' is a consumer living at sea level with a meter installed outside (assuming a notional average gas temperature of 8°C) which under-registers by 2%. The 'worst case' is a consumer living at 320 metres above sea level with a meter installed inside (assuming a notional average gas temperature of 16°C) which over-registers by 2%. In both cases, the measurement of CV is assumed to be accurate.

Table 2 : Effect of extremes of measuring accuracy

Component	Measurement error 'Best case' (%)	Measurement error 'Worst case' (%)
Meter	-2.00	+2.00
Temperature	-1.46	+1.32
Pressure	-0.79	+3.05
Total energy measurement error	-4.25	+6.37

2.26 Table 3 below converts these measurement errors into the billing error for small, medium and large domestic consumers (using the consumption figures from Ofgem's gas prices factsheet). The figures given use British Gas Trading's standard credit tariff.

Table 3 : Effect of measurement error on typical annual domestic bill.

Consumption band	Bill (£)	'Best case' billing error (£)	'Worst case' billing error (£)
Small (10,000 kWh)	190.64	-8.10	+ 12.14
Medium (19,050 kWh)	316.71	-13.46	+ 20.17
Large (28,000 kWh)	441.38	-18.76	+ 28.10

2.27 It should be noted that these errors are randomly distributed about a mean. If the fixed factors for temperature and pressure accurately represent the true mean values, then the net effect of these errors is zero. In other words, any improvement in accuracy would benefit some consumers at the expense of others.

2.28 These illustrative figures also assume that all the energy supplied in the UK is billed. In reality, some energy in the gas market is not billed directly to consumers. This is attributed to factors such as leakage from the network, use of gas in compressors, gas used at unregistered sites and theft. There is no reliable estimate of the total amount of unbilled energy. However, it is important to note that the cost of this energy is smeared over all consumers. Therefore any reduction in unbilled energy would benefit all consumers; possibly by a comparable amount to addressing any of the sources of inaccuracy described above. Treatment of this issue is outside the scope of this document although it is more fully discussed in the forthcoming metering strategy document.

3. The Need for Change

Introduction

3.1 This chapter explains why changes are likely to be required as a consequence of the introduction of the proposed Measuring Instruments Directive and discusses the opportunity for other concurrent changes.

The Measuring Instruments Directive

3.2 All European Community member states have legislation which seeks to secure minimum standards of accuracy of measuring instruments, including gas meters. The European Commission agrees that such national legislation is generally in the public interest. However, it believes that the lack of harmonisation of standards leads to a barrier to trade between member states.

3.3 For this reason, the Commission has attempted to create an internal market for measuring instruments by harmonising national legislation. This process started in 1971 with the introduction of Directive 71/316/EEC. However, the Commission has indicated that this Directive is not sufficient, partly because of its optional nature. For this reason, it proposes to replace the existing Directive with the “Measuring Instruments Directive” (MID). The Commission is currently consulting on the provisions of the MID which may come into force as early as July 2002.

3.4 Unlike the existing Directive, the proposed MID will be mandatory. It seems likely that, as a consequence, the Meters and Thermal Energy Regulations will need to be amended to make them consistent with the requirements of the MID. This would mean that they would allow the approval of meters fitted with temperature or volume converters.

Impact on billing systems

3.5 The figures below show the energy measurement calculation used where a temperature converted meter and a volume converter is used.

Figure 3 : Temperature converted meter used

Energy used = **Volume measured** x **Pressure factor** x **CV**

From meter readings converted for temperature

Fixed factor

Measured by PGT

Figure 4 : Volume converter used

Energy used = **Volume measured** x **CV**

Measured by PGT

From meter readings converted for temperature and pressure

3.6 The calculation in figure 4 is presently used for all sites on Transco's system with an annual consumption of more than 2,928,000 kWh as they have volume converters fitted. The introduction of the MID implies that temperature converted meters may be used at any site and that therefore the calculation in figure 3 will need to be used.

3.7 With the introduction of the proposed MID, either non-converted meters, temperature converted or volume converted meters may be used on any site. This may be instigated by the supplier or consumer. (It should be noted that, after the Metering Liberalisation Date of 1st January 2001, a supplier cannot refuse to supply a domestic consumer on the grounds of the consumer's meter arrangements.)

3.8 The implication is that billing systems will need to recognise whether or not a converter is fitted, and its type, and apply appropriate energy measurement calculation (as illustrated in figures 1 to 4). It follows that the recording of meter asset details for each meter point will need to specify the meter and converter type and be linked to the billing system.

3.9 It should be noted that meters which directly measure energy, i.e. measure volume, temperature, pressure and CV, are being developed. Whether these meters will come to market, and when, is not certain. Nevertheless, it may be prudent to ensure that any changes made to billing systems also take account of this development.

Opportunities for other changes.

3.10 Because changes to billing systems are likely to be required (depending on the functionality of existing systems), there is an opportunity to make other changes at low marginal cost.

3.11 Ofgem would like to explore the possibility of other changes which improve the accuracy of energy measurement and could be incorporated into the required changes described above. Any proposals for such changes would recognise that the use of temperature or volume converters would generally improve measurement accuracy for individual consumers, however, they would be unlikely to be in widespread use in the near future.

3.12 Potential improvements that could be considered are set out below for each of the components of the energy measurement calculation.

Meter accuracy

3.13 Meter accuracy does not directly impact the method of calculating thermal energy and is therefore outside of the scope of this document. We propose to consider this issue in the forthcoming metering strategy document.

Temperature

3.14 There is sufficient evidence that the assumed average temperature of 12.2°C is not appropriate, to warrant further investigation. It is difficult to specify what changes might be made until this investigation is complete; however, the use of different temperature factors depending on the location of the meter may be appropriate. This could be achieved by linking the Meter Point Reference Number to separate data on the meter location.

Pressure

3.15 Because of the present cost of volume converters, it is unlikely that these would be used on domestic sites. However, as it will be necessary to link meter asset details for each site to the billing system, it is possible that the inclusion of a site-specific pressure conversion factor could be achieved at low marginal cost. In essence, this would remove the threshold at which site specific pressure factors are currently used, i.e. 732,000 kWh per annum.

Calorific value

3.16 The present Thermal Energy Regulations allow gas transporters to define the area used to average the measurement of CV. As noted above, these areas presently coincide with Transco's LDZs. In May 1997, Transco proposed a modification to Transco's Network Code to create smaller areas than the LDZs currently used. This modification was rejected on the grounds that the costs of systems changes were not justified by the benefits. It is possible that this argument is no longer valid and that smaller areas could now be used.

4. Conclusion and way forward

Introduction

4.1 This chapter summarises the changes that may be required, discusses some issues raised by the proposed changes and proposes a way forward.

Summary of changes

4.2 At present, industry billing systems only need to recognise where a site consumes more than 732,000 kWh in order to apply an altitude specific pressure conversion factor, or sites with a consumption of over 2,928,000 kWh where Transco has installed a volume converter. In both cases, the consumption of the site is the driver for the application of the appropriate energy measurement calculation.

4.3 In future, the application of temperature or volume converters is likely to become more diverse. This will be in response to the increased availability of converters as a result of the proposed legislative changes. It may also be in response to recognition by gas suppliers that the present application of volume converters is a feature of Transco's metering policy. As Transco's charge for the use of a converter is now separately identified[4], shippers may choose to avoid that charge by requesting the removal of the converter.[5]

4.4 These changes mean that it is likely that industry billing systems will need to select the appropriate energy measurement calculation on the basis of the type of meter or converter installed at each site.

Issues raised

Distributional effects

4.5 The arbitrary distribution of energy measurement errors coupled with the facility to choose where to use a converter raises an important issue. Consumers who perceived themselves to be disadvantaged by differences between the

[4] From 1st April 2001, Transco's charge for the provision, installation and maintenance of a converter will be £217.19 per annum.
[5] The use of a converter is not requried by Transco's Network Code.

temperature or pressure of their site and the averages in use, may seek to have a converter fitted. Similarly, suppliers could make choices about the application of converters depending on their view of consumer response. This 'gaming' in the use of converters could lead to an undesirable distributional effect which would alter the apparent number of therms conveyed and distort the distribution of measurement errors and costs.

4.6 One approach to this issue would be to prescribe the application of converters. Ofgem considers that this would be difficult to achieve fairly and runs counter to the principle of securing choice for consumers. It therefore seems that the application of converters is a matter for the competitive supply market to resolve. However, in the interests of protecting consumer interests, it may be appropriate to minimise the distributional effect.

4.7 One way of achieving this would be to minimise the degree of conversion applied by the converter by introducing fixed factors which better represented actual site conditions. For example, using pressure factors based on altitude for all sites (rather than limiting this to sites over 732,000 kWh per annum as at present) would make the pressure factor more reflective of the actual pressure and so greatly reduce the advantage to be gained by using a volume converter.

Accuracy of converters

4.8 The present EC legislation relating to the accuracy of gas meters, as well as the proposed MID, prescribe accuracy standards for temperature converted meters and for meters with built in volume converters. However, there are no statutory accuracy requirements for separate converters. Inaccurate converters could, at worst, lead to greater measuring errors than would be encountered if a converter was not used. We would welcome views on the need for such accuracy standards.

Unbilled therms

4.9 As discussed in Chapter 2, the cost of unbilled energy is recovered from all consumers. Any assessment of the costs and benefits of addressing the measurement errors described in this document should take this into account. One aspect of accurate measurement of energy is to ensure that all the energy supplied is measured. More practically, any reduction in the amount of unbilled energy potentially benefits all consumers.

Way forward

4.10 Although it is likely that changes to billing systems would be unavoidable on the implementation of the proposed MID, Ofgem would, as far as possible, like to work with the industry to seek cost effective solutions which maximise consumer benefit.

4.11 Any proposed changes should ideally be based on sound information on measurement errors. It therefore might be necessary to conduct further investigations into, for example, the distribution of gas temperatures and the relationship of temperature to meter location. Such investigations could form the basis of a reasonably accurate cost benefit analysis of any proposed changes.

4.12 For these reasons, Ofgem proposes to establish an industry group to consider the issues raised in this paper and provide advice on how they might best be taken forward. We would welcome views on the optimum make up of this group.

Appendix 1 Technical background

Introduction

1.1 The thermal energy, in kilowatt hours, of a quantity of gas supplied to premises is calculated from the relevant calorific value of the gas and the volume of gas supplied using the following formula (The Gas (Calculation of Thermal Energy) Regulations 1996): -

Number of kilowatt hours = AxB/3.6

where
A is the volume of the gas in cubic metres (at a temperature of 15°C and a pressure of 1013.25 millibars), and
B is the calorific value in megajoules per cubic metre (at a temperature of 15°C and a pressure of 1013.25 millibars).

A temperature of 15°C and a pressure of 1013.25 millibars are referred to as "Standard Conditions".

1.2 Only the metering systems used by the largest industrial consumers actually register volume at standard conditions. Some metering systems may be temperature converted such that they register volume as though measured at the standard temperature and then a site specific pressure conversion factor is applied. For other metering systems, for example domestic meters, the volume of gas registered by the meter is the volume at the actual temperature and pressure of operation of the meter. In these latter cases a volume conversion factor is applied to the volume registered by the meter in order to obtain the volume at standard conditions.

1.3 The calorific value used in the energy calculation may be measured at the metering station, as is the case with the largest industrial consumers. Generally however the calorific value is measured at a number of places on the gas supply system and a value determined to be used for all premises in a charging area. The Gas (Calculation of Thermal Energy) Regulations 1996, as amended by the

Gas (Calculation of Thermal Energy)(Amendment) Regulations 1997, allow public gas transporters to use either the lowest calorific value of any gas flowing into a charging area or the flow-weighted average calorific value of all the gases flowing into the charging area.

1.4 The calorific value used may be based on either the wet or dry gas state. Gas is assumed to be dry unless there is an Authority's wet gas Determination in place specifying that the gas supplied to a defined area contains water vapour.

1.5 Each of the steps involved, from the measurement of gas volume and calorific value through to the determination of energy, is discussed below.

Meter accuracy

1.6 The Gas (Meters) Regulations 1983 require that the volume registered shall not differ by more than 2% from the volume actually passed through the meter. Gas meters designed for flow rates in excess of 1600 cubic metres per hour are exempt from the regulations. This standard of accuracy has to be met when the meter is examined and stamped at production.

1.7 When a stamped meter is installed in premises then the inaccuracy of that meter at the time of stamping becomes a systematic uncertainty with respect to the use of that meter in those premises.

Temperature and pressure effects

1.8 The volume of a given mass of gas will change as the temperature or pressure of that gas is changed.

1.9 If the temperature of the gas is increased so the volume occupied by that mass of gas increases and the density, and hence the energy content of a fixed volume of the gas, decreases. If the pressure of the gas is increased so the volume occupied by that fixed mass of gas decreases then the density, and hence the energy content, increases. Consequently it is necessary to reference the gas volume to standard conditions of temperature and pressure.

1.10 Where the volume of gas registered by the gas meter is not at standard conditions a volume conversion factor is applied which converts that volume to an equivalent volume measured at the standard conditions. The factors to be applied to different metering situations are given in the Gas (Calculation of Thermal Energy) Regulations 1996. The temperature and pressure effects in the use of the combined factor are considered separately below.

Temperature

1.11 Most gas meters actually measure the gas volume at the temperature of operation of the meter and it is necessary to apply a conversion factor to the measured gas volume to obtain the volume as though measured at 15°C.

1.12 The Gas (Calculation of Thermal Energy) Regulations 1996 provide for a conversion factor based on an average gas temperature at the meter of 12.2°C.

1.13 This average temperature was determined by the former British Gas from studies of gas temperatures at meters in industrial and commercial sites. It is possible that a different temperature would apply to domestic meters. In practice, the gas temperature at the meter will be a function of the initial temperature of the gas, the temperature of the environment surrounding the gas meter and inlet pipe, the gas flow rate and the effectiveness of the inlet pipe and gas meter in transferring heat to/from the gas. For example :-

- where a meter is located inside a centrally heated house, the gas would be warmed by the environment and as a result the meter would over register the quantity of gas supplied;

- where a meter is exposed to external conditions then the gas would be cooled during the winter, when of course demand is greatest, and as a result the gas meter would under register the quantity of gas supplied. Conversely, during the summer the gas would be warmed and the meter would over register, but this is at a time when demand is low or in some cases nil.

1.14 Temperature converted meters are available which have an index registering the volume of gas as through measured at the standard temperature of 15°C. Although such meters are commercially available they have not been approved for use in the UK because the standards of accuracy prescribed in the Gas (Meters) Regulations 1983 effectively make their approval impossible. As noted above, the standard of accuracy requires there to be less than a 2% difference between the volume registered by the meter and the volume of gas actually passing through the meter. Changing the reference temperature of a gas volume by more than 6°C would result in a change of volume of more than 2%, thus temperature converted meters would not meet the existing prescribed standard.

Pressure

1.15 Gas meters actually measure the gas volume at the pressure of operation and it is necessary to apply a conversion factor to the measured gas volume to obtain the volume as though measured at 1013.25 millibars. The total pressure of gas at the inlet to a gas meter is the sum of the local atmospheric pressure plus the additional governed pressure at which gas is conveyed to the meter. Local atmospheric pressure is a function of altitude, the pressure decreasing with increasing altitude.

1.16 The governor on the supply to the meter is set to provide a constant pressure of gas at the inlet to the meter, which for domestic premises is 21 millibars.

1.17 Hence the total pressure of gas, P, at the meter is given by :-

$$P = 1013.25 + M - A$$

Where

M is the governed pressure above local atmospheric pressure in millibars; and

A is the number of millibars of pressure to be deducted on account of the height of the meter above mean sea level.

1.18 The Gas (Calculation of Thermal Energy) Regulations 1996 provide two means of pressure conversion :-

- for premises where the gas supply is expected to be less than 732,000 kWh (25,000 therms) per annum, a conversion factor based on an average height of 66 metres of a consumer's meter above mean sea level. This average was determined from the heights of the weather stations in the gas supply area. Meters at lower than average altitudes will under register whereas meters at higher than average altitudes will over register; and

- for premises where the gas supply is expected to be greater than 732,000 kWh (25,000 therms) per annum, a site specific conversion factor based on the actual height of a consumer's meter above mean sea level.

1.19 Site specific pressure conversion factors potentially need to take account not only of the altitude of the site but also the height of the meter above ground level, tower blocks would be the most obvious case.

Calorific value

1.20 There are two aspects which relate to calorific values :-

- the measurement of calorific value at a place under Directions issued by Ofgem; and

- the way in which calorific values from Directed places are used to determine the calorific value relevant to a charging area.

1.21 The calorific value is measured using instruments that have been approved by Ofgem as suitable for use by Transco to determine calorific values for the purposes of section 12 of the Gas Act 1986. These instruments measure calorific values to an uncertainty of less than 0.1 megajoules per cubic metre or 0.25% relative.

1.22 Under the Gas (Calculation of Thermal Energy) Regulations 1996 a public gas transporter has charging areas which are areas within which he will calculate the quantity of energy conveyed on the basis of a single calorific value. Generally there will be a number of sources of gas for a charging area and it is the public gas transporter's discretion whether he uses the lowest calorific value of any gas flowing into a charging area or the flow-weighted average calorific value of all gases flowing into the area. If the transporter uses a flow weighted average calorific value for a charging area it is subject to a cap not exceeding a value of one megajoule per cubic metre above the lowest calorific value conveyed to any premises in that area.

1.23 Prior to 1 March 1996 the former British Gas had 19 charging areas but as from that date BG plc Transco used its 13 LDZs as charging areas. Some of these LDZs contain two, or more, of the original charging areas and have much wider variations of gas calorific values than the original areas.

1.24 The large variations in the calorific values of different gases conveyed into the charging areas are functions of :-

- the differences in calorific values of gases leaving different terminals; and
- the large geographical areas of LDZs used as charging areas by Transco.

Wet gas

1.25 For the purposes of determining the quantity of thermal energy conveyed to premises the Gas Act 1986 definition of calorific value assumes that the gas is dry unless an Authority's Determination has been issued specifying the amount of water vapour present in the gas (Section 12(2)). At present Determinations specify 1.7% of water vapour in the gas, which is the amount required to saturate the gas with water at the standard temperature of 15°C. This standard may change in the future to reflect the temperature and pressure of gas in the distribution system if and when robust data becomes available.

1.26 Water vapour in the gas supply is detected and quantified by carrying out hygrometric tests at monitoring points on the Transco low pressure distribution system. Ofgem approves the hygrometers that are used for the tests and the location of the monitoring points. Although the approved hygrometers have very tight accuracy limits they are portable, spot test instruments that can only be used when an Ofgem gas examiner (or a Transco tester) visits a monitoring point. There are currently about 1600 such points covering 19 million consumers, the points being chosen to give data which is generally representative of areas rather than data which is relevant to particular premises. Practically this means that the results of the testing can only be used to indicate the presence, or absence, of water vapour in the gas in an area rather than to quantify the amount of water that could subsequently be stated in a Determination. Consequently when the Authority "determines" the amount of water vapour to be specified in the Determination, it is not a measured quantity.

1.27 Where no Determination is in place consumers are assumed to receive dry gas, however, from time to time there is water ingress into the gas distribution system. The ingress may be low level which is not immediately detected because it does not give rise to observable effects, such as supplies being cut off, and the area affected is not covered by a hygrometric monitoring point. Other cases of water ingress following a major incident such as a pipeline fracture are detected immediately. (An incident in Corby, Northants on 2 April 1997 left about 5000 consumers without gas and very large amounts of water in the local distribution system.)

1.28 The wet gas situation is dynamic with new incidents being reported as existing ones are resolved and the gas supply restored to the dry state. As of the end of October 2000 there were 130 determinations in place covering almost one million consumers.