

Gas Billing Factors Guideline

Subject	Gas (Downstream Reconciliation) Rules 2008 Billing Factors Guideline
Version	2.0
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1. Introduction

- 1.1. The Gas (Downstream Reconciliation) Rules 2008 (Reconciliation Rules) include obligations on meter owners and retailers with regard to metering accuracy and conversion of measured volume to volume at standard conditions and then to energy. The purpose of this guideline is to assist retailers and meter owners to meet their obligations under the Reconciliation Rules.
- 1.2. This guideline is explanatory, and is not legally binding. It needs to be read in conjunction with the Reconciliation Rules and suggests methods of compliance, but these do not reduce the requirement on allocation participants to know and comply with their obligations under the Reconciliation Rules.

2. Background

- 2.1. The need for billing factors arises because gas meters measure the volume of gas flowing through a gas user's meter, while that gas user is billed according to the amount of energy it has used. The energy content of a measured volume of gas changes according to the conditions at the time of measurement; including the gas composition, meter pressure and meter temperature. Billing factors are the parameters required to convert measured gas volumes into energy quantities.
- 2.2. This conversion occurs in several stages. First, the volume of gas passing through the meter is measured and recorded at the temperature and pressure conditions prevailing at the meter. The recorded or measured volume is then converted to volume at standard conditions, assuming the gas behaves as an ideal gas. This means that the volume of measured gas is converted to the volume it would be if it were under an absolute pressure of 101.325 kPa at a temperature of 15°C.
- 2.3. At high meter pressures, the assumption that the gas behaves as an ideal gas no longer holds, and the volume of the real gas will be greater than of an ideal gas. To adjust for this, a compressibility factor is applied to obtain the volume of the real gas.
- 2.4. Finally, the volume at standard conditions ('standard volume') calculated in the step above is converted to energy by multiplying it by the calorific value of the gas.

3. Governance of gas measurement arrangements

3.1. A number of documents govern the measurement and reporting of volumes of gas sold to customers.

Safety and Measurement Regulations

3.2. The Gas (Safety and Measurement) Regulations 2010 ('Safety and Measurement Regulations') specify that:

- every person who sells gas must conform with the requirements of Part 1 of NZS 5259 (unless seller and purchaser have agreed otherwise);
- gas is required to be sold by energy content;
- maximum permissible errors for the gas measurement system, corrections of volume to standard conditions, and calorific value measurement must not exceed the limits set out in s21; and
- owners of gas measurement systems must manage those to ensure that accuracy meets the requirements of NZS 5259.

3.3. The Safety and Measurement Regulations are administered by the Ministry of Business Innovation and Employment.

Reconciliation Rules

3.4. The Reconciliation Rules set out meter owner and retailer obligations relevant to metering equipment and billing factors, and they cite NZS 5259:2004 Gas Measurement (or any subsequent amendments or replacements) as the reference standard for compliance. The purpose of the Reconciliation Rules is to *'establish a set of uniform processes that will enable the fair, efficient, and reliable downstream allocation and reconciliation of downstream gas quantities'*. A key prerequisite for achieving that purpose is that gas is measured as consistently and accurately as reasonably possible by all allocation participants.

3.5. The Reconciliation Rules require that:

- retailers ensure metering equipment is installed and interrogated at each customer site;
- certain minimum rates of meter reading be undertaken for various allocation groups (or sites within allocation groups);
- conversion of measured volume to standard conditions and then to energy complies with NZS 5259; and
- meter owners ensure all metering equipment complies with NZS 5259.

Switching Rules

- 3.6. The Gas (Switching Arrangements) Rules 2008 ('Switching Rules') set out industry participants' obligations with respect to the gas registry. Of relevance to billing factors is:
- each distributor's responsibility for maintaining current and accurate information in the gas registry for Network Pressure (nominal operating pressure of the network at the point of connection), ICP Altitude and Gas Gate for each ICP for which it is the responsible distributor; and
 - each meter owner's responsibility for maintaining current and accurate information in the gas registry for meter pressure, register multiplier, register reading digits, as well as flags to indicate whether the meter is operating at network pressure, is an advanced meter and/or a TOU meter.
- 3.7. Gas Industry Co is responsible for overseeing compliance with the Reconciliation Rules and Switching Rules. Gas Industry Co commissions performance audits of allocation participants, registry participants, the registry operator and the allocation agent on a regular basis; under the Reconciliation Rules event audits may be commissioned from time to time in response to specific situations.

Measurement Standard

- 3.8. NZS 5259:2015 replaces NZS 5259:2004 which in turn NZS 5259:1997.
- 3.9. NZS 5259 Part 2 – Performance Requirements – deals with the mandatory performance criteria for gas measurement. It sets out the requirements for each of the elements of a gas measurement system together with maximum permissible errors (MPEs). Part 3 – A Means of Compliance – provides a range of information with respect to the design, installation, commissioning, operation and maintenance of gas measurement systems. Of particular relevance to this guideline are sections 2.11 to 2.15 dealing with the various steps involved in converting measured volume to energy.
- 3.10. In relation to the choice between using fixed factors or a conversion device, NZS 5259 states that:
- Under normal circumstances, combined errors for pressure, altitude, and compressibility consistently in excess of 2% shall be regarded as unacceptable and errors consistently in excess of 1.5% undesirable when considering the use of factors or conversion devices. If, however, the individual quantity is very small, larger errors may be acceptable when the cost of avoiding these would be unreasonably high.

(NZS 5259 s3.8.1)

4. Conversion formula

4.1. The general equation governing the process of converting register readings to energy is:

$$E = V \times M \times F_T \times F_P \times F_A \times F_Z \times CV$$

Where:

E is energy to be billed

V is the volume indicated by the meter (typically the difference between two consecutive register readings)

M is the register (or meter) multiplier (or 1 where no multiplier is required)

F_T , F_P , F_A , and F_Z are the correction factors for temperature, pressure, altitude and compressibility, respectively

CV is the calorific value of the gas being measured, i.e. the energy content in megajoules of one cubic metre of that gas (measured at standard conditions). The means of determining the calorific value is discussed in section 6, Gas composition and characteristics.

5. Billing factors

5.1. Each of the factors in the conversion formula is discussed below with a view to identifying the impact on overall accuracy and providing some guidance on the approach retailers should take to ensure compliance with the relevant governance arrangements.

Register multiplier

5.2. The register (or meter) multiplier is a fixed factor used to scale the register reading to cubic metres (uncorrected). For most meters, the register reading shows the volume, in cubic metres, of gas that has passed through the meter, uncorrected for differences in temperature and pressure from standard conditions. For these meters, no register multiplier is required; i.e. the register already shows cubic metres. In those instances, the value of M in the above equation is one.

5.3. Some meters, however, register in tenths, or tens, or hundreds of cubic metres. For such meters, it is essential that the correct register multiplier is used to obtain actual gas volumes in cubic metres. For example, registers that record one-tenth of gas volumes require a register multiplier of 10; those recording ten times actual gas volumes require a register multiplier of 0.1; and so on. Failure to use the correct register multiplier will have a large impact on volumes charged to customers and reported to the Allocation Agent.

5.4. Sources of error include:

- metering information being incorrectly recorded when meters or conversion devices are first installed, or where they are changed;
- conversion devices being incorrectly programmed;
- retailers incorrectly processing data from meter owners regarding meter or conversion device set-up;
- multiplier set-up being miscommunicated or misinterpreted when an ICP switches retailer; and
- inconsistent treatment of a fixed digit (often a trailing 0) on a meter index (either not accounted for or double counted by meter reader and retailer).

5.5. From 14 September 2015, register multiplier and register reading digits for mass market ICPs are populated in the registry by meter owners. From 14 March 2016, the register multiplier and register reading digits in a retailer's switch file must match the values held in the registry. This will reduce the likelihood of errors associated with these parameters.

Gas Industry Co expectations regarding register multipliers

- 5.6. Meter owners will populate and maintain the register multiplier and register reading digits parameters in the registry with the correct values to ensure it remains the database of record.
- 5.7. Retailers will use the registry as the database of record to establish the correct register multiplier and register reading digits to be used in conversions from meter readings to standard volume.
- 5.8. Meter owners and retailers will work together to resolve any discrepancies between the values held in the registry and those held by the retailer.
- 5.9. Retailers will perform regular checks to ascertain whether the consumption being recorded for a meter is consistent with the volumes for which that meter is intended.

Temperature factor

5.10. When gas becomes warmer, it expands; and when gas cools, it contracts. Thus, for a given pressure, the number of gas molecules per cubic metre changes with changes in temperature. Using a temperature factor makes allowance for this effect in converting a measured gas volume to a gas volume at a standard temperature of 15°C.

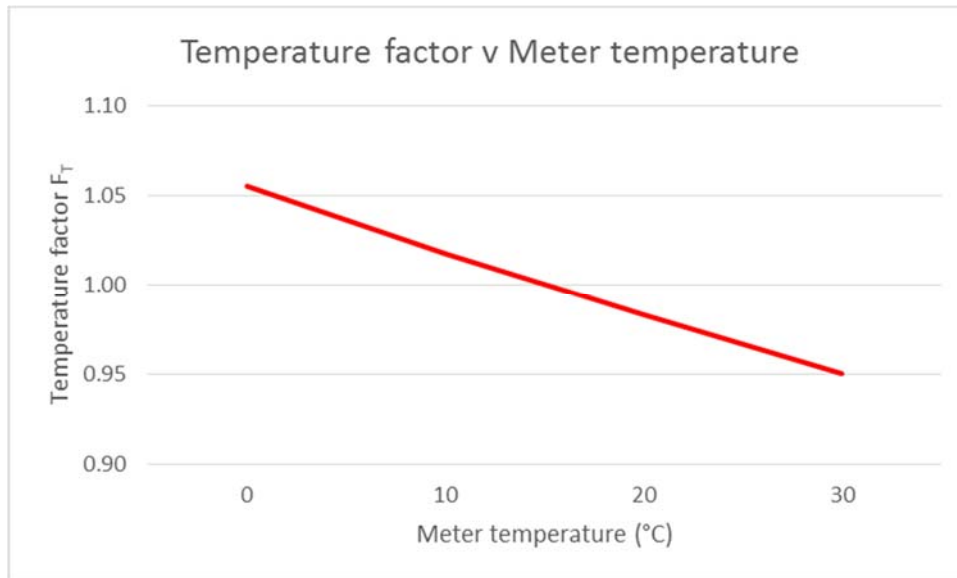
5.11. The temperature factor is calculated as¹:

$$F_T = \frac{288.15}{273.15 + t}$$

Where t is the estimated average temperature of the flowing gas in degrees Celsius (taking into account any other temperature influences such as the Joule-Thomson effect, described later).

¹ The ratio of standard temperature over the gas temperature, both expressed in degrees Kelvin.

5.12. The following chart shows the sensitivity of the temperature factor to changes in temperature. It illustrates that a variance of five degrees from the standard temperature requires a correction to the recorded volume of around two per cent.



5.13. Sites with a conversion device that includes temperature correction have a live feed from a temperature sensor located in the gas stream just upstream of the meter. The conversion device corrects for temperature in real time, so no further conversion for temperature is required.

5.14. For sites without a conversion device and temperature correction, it is necessary to estimate the temperature of the gas stream. NZS 5259 sets out four options for doing this.

Options for estimating gas temperature

5.15. In the absence of actual measurements of gas temperature, NZS 5259 s3.8.2.1 lists the following options (in decreasing order of preference).

- (a) Gas temperature records for the GMS location under flowing conditions. NOTE – Historical records can be used if similarity is preserved.

Gas Industry Co Comment: This would be appropriate where a corrector with a live temperature feed had been installed at the site for some time but had subsequently been removed, or found to be faulty, and the usage remained reasonably similar to the historic usage.

- (b) Records of gas temperature in similar installations at similar locations over corresponding periods. NOTE – For example, the ratio between volume corrected for temperature and uncorrected volume at a similar installation over a corresponding period will provide an estimate for F_T .

Gas Industry Co Comment: This option is likely to have limited application.

- (c) The average ground temperature at 300 mm depth for compact installations directly connected to short risers and well shaded from direct sunlight, taking into account seasonal variations. NOTE – Where the temperature of the gas is in the vicinity of ground temperature, reliable and relevant climate temperature records, including published data, provide a basis for estimating average 300 mm ground temperatures.

Gas Industry Co Comment: This is a practical option given that it applies to the common configuration of the majority of GMS installations, and NIWA has many stations recording average ground temperature in areas where gas is supplied.

- (d) For installations where the inlet pipes are exposed to ambient air conditions the temperature may be estimated from 'mean temperature' records, taking into account seasonal variations. NOTE – Method (d) is unsuitable unless the pipework and GMS are shaded from direct sunlight.

Gas Industry Co Comment: This option is unlikely to be suitable for many GMS installations as riser pipes are generally quite short and the gas would be unlikely to achieve ambient temperature.

Joule-Thomson effect

5.16. A related matter is the Joule-Thomson effect, which describes the decrease in temperature of a gas that results from pressure reduction. In situations where:

- a temperature measure at the meter is not available to calculate F_T ; and
- the pressure drop immediately upstream of the meter is significant;

the estimated metering temperature should include an adjustment for the Joule-Thomson effect. Failing to do so will understate gas consumption and contribute to UFG (albeit to a small level).

5.17. NZS 5259 s3.8.2.1 recommends that for large pressure drops or high flow rates, the actual temperature drop should be measured.

5.18. The magnitude of the Joule-Thomson effect can be estimated as 0.5°C for every 100kPa of pressure reduction.

Gas Industry Co expectations regarding the temperature factors

5.19. Wherever practical, particularly in situations where failure to do so will result in conversion errors greater than those allowed in Table 3 of NZS 5259, the flowing temperature of gas should be measured rather than be estimated.

5.20. Where a metering temperature is estimated, retailers should:

- select weather stations relevant to the area supplied by each gas gate at which they are trading. Weather stations should have at least five years of historical ground temperature data at 300 mm depth;
- obtain daily or monthly average temperature data based on the previous five years of weather records for each chosen weather station;
- use daily or monthly average temperature data to construct average temperatures;
- refresh temperature data on a regular basis, at least every five years; and
- include an assessment of the Joule-Thomson effect if there is a significant pressure reduction before gas enters the meter. The pressure reduction can be assessed as the difference between the network pressure in the registry and the metering pressure.

5.21. Network owners will ensure nominal operating pressures are correctly populated in the registry for all ICPs on their networks.

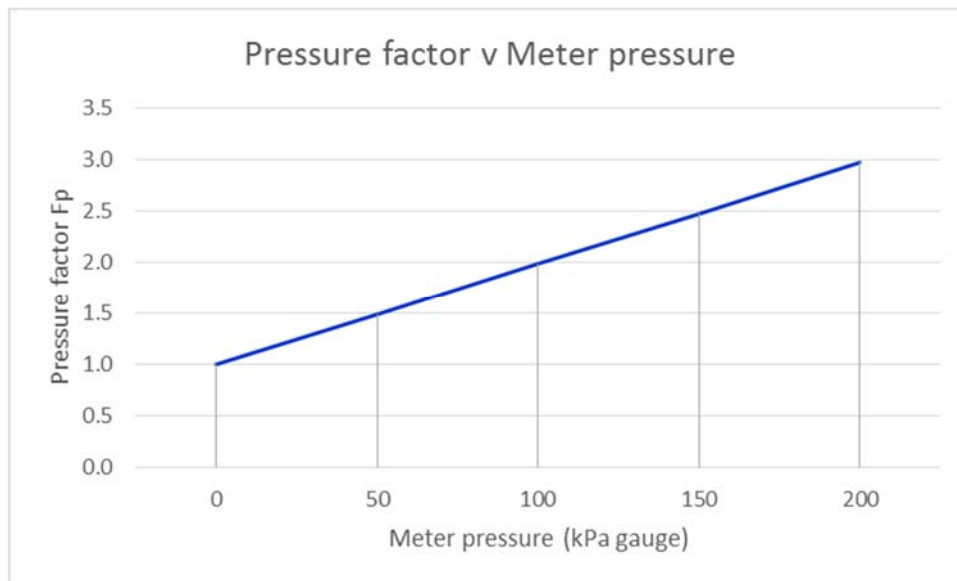
Pressure factor

5.22. Increasing the pressure of a gas causes it to contract; lowering the pressure causes it to expand. Thus, for a given temperature, the number of gas molecules per cubic metre changes with changes in pressure. Using a pressure factor makes allowance for this effect in converting a measured gas volume to gas volume at a standard absolute pressure of 101.325 kPa.

The pressure factor is calculated as²: $F_p = \frac{P_g + 101.325}{101.325}$

Where P_g is the meter pressure (gauge) measured in kPa. Meter pressure is set by the regulator immediately upstream of the meter and it is essential that this pressure is accurate in converting measured gas volume to volume at standard conditions. The chart below shows how the pressure factor changes with changes in meter pressure.

² The ratio of the absolute pressure of the gas (the sum of gauge pressure and atmospheric pressure) to standard atmospheric pressure. The calculation assumes that the gauge pressure is measured at mean sea level. The next factor, altitude, corrects for any deviations to this assumption.



- 5.23. The chart illustrates that for sites where the meter pressure is substantially greater than atmospheric pressure, the pressure factor has a dramatic effect on the conversion from volume to energy. Hence it is critical that the correct meter pressure is known and used.
- 5.24. On larger customer sites, a conversion device may be installed with a live pressure feed from the gas stream just upstream of the meter. Such sites automatically compensate for meter pressure, in which case the pressure factor is 1.000.
- 5.25. From 14 September 2015, meter pressure for mass market ICPs is populated in the registry by meter owners. From 14 March 2016, the meter pressure in a retailer's switch file must match the value held in the registry.

Gas Industry Co expectations regarding pressure factors

- 5.26. Meter owners must populate and maintain the correct meter pressure for each ICP in the registry except for ICPs with meters operating at network pressure or with correctors installed.
- 5.27. Retailers should treat the registry as the database of record and use the meter pressure field in the registry when calculating the pressure factor for an ICP.
- 5.28. Meter owners and retailers should work together to resolve any discrepancies between the value stored in the registry and in their own systems.

Altitude factor

- 5.29. The altitude factor corrects for the change of barometric pressure with change in altitude. To calculate the corrected volume, the pressure at the meter must be an 'absolute' pressure value. The pressure correction factor outlined above converts gauge pressure to standard pressure presupposing that the gauge pressure is measured at mean sea level. Accordingly, a further correction must be made to account for sites at altitudes above mean sea level.

5.30. For altitudes under 1000 metres, the average barometric pressure can be approximated by:

$$P_m = 101.325 \times \left[1 - \frac{h}{k_2} \right]$$

Where:

h is the altitude in metres

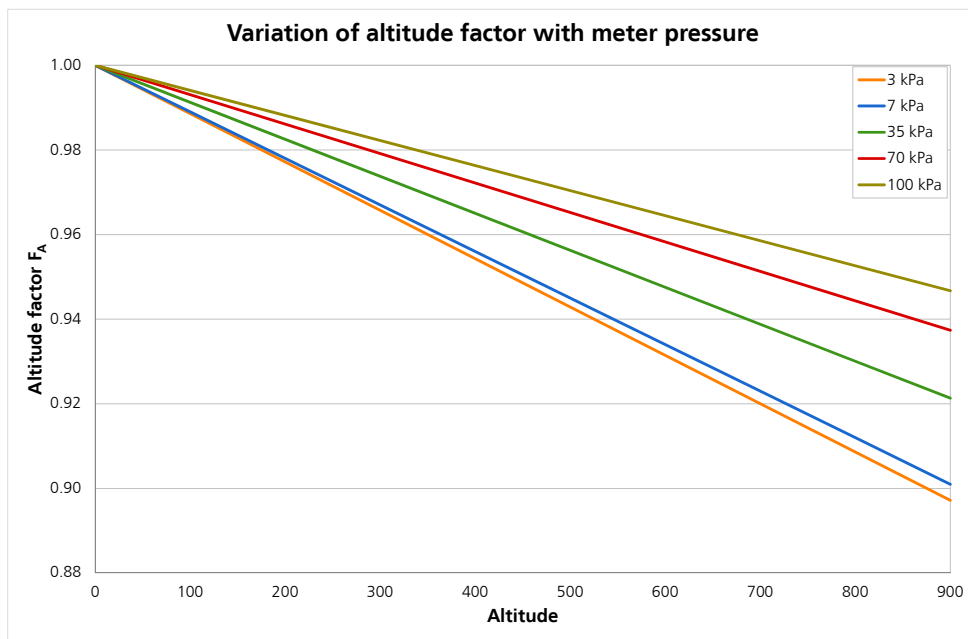
$k_2 = 8500$ m

P_m is the calculated absolute pressure at the given altitude, expressed in kPa.

As a result, the altitude factor (for a fixed factor meter) is defined as:

$$F_A = 1 - \frac{h/k_2}{F_p}$$

5.31. The chart below shows how the altitude factor changes in relation to both meter pressure and altitude.



- 5.32. NZS 5259 s3.8.2.3 includes a note: *'Where the exact altitude cannot be determined by physical measurement it is acceptable to apply the midpoint value for each 10 m band, that is, 0 – 10 m may be determined as 5 m.'*
- 5.33. NZS 5259 s3.8.2.3 indicates that areas of similar altitude may be defined and the average altitude for that area used for the purpose of calculating the altitude factor. It notes that the difference between the maximum and minimum altitudes in such an area should be such that the maximum permissible errors associated with meter pressure and altitude are not exceeded.
- 5.34. NZS 5259 Table 3 cites the maximum permissible errors for altitude conversion as $\pm 1\%$ for installations where the metering pressure is less than 100 kPa and $\pm 0.5\%$ otherwise. This could be interpreted as meaning that any installation with an altitude of 90 metres or less (and operating at sub-100 kPa) would not require altitude correction. However, that table also specifies in the notes that when *'factors are used to convert the measured volume to the volume at standard conditions the **combined** MPEs shall not exceed $\pm 1.5\%$ '* (emphasis added). This suggests that compliance with NZS 5259 does require a reasonably accurate assessment of, and correction for, altitude, so that the combined MPE of $\pm 1.5\%$ is not exceeded.
- 5.35. Distributors have worked to improve the accuracy of the altitude fields of ICPs in the gas registry. As a result it is expected that the quality of the data in those fields is now very good.

Gas Industry Co expectations regarding altitude factors

- 5.36. Distributors will populate the registry with altitude information to within 10 m for each ICP on its network.
- 5.37. Where absolute pressure is not measured directly, retailers will use ICP-specific altitude in the registry in conversions from metered volume to standard volume.

Compressibility factor

- 5.38. The compressibility factor F_Z is used to correct for deviations from ideal gas behaviour.³

The compressibility factor is defined as:

$$F_Z = Z_b / Z$$

Where:

- Z_b is compressibility at standard conditions for the gas being measured, and
- Z is compressibility at operating conditions.

- 5.39. NZS 5259 s3.8.2.4 recommends use of any of the following methods to calculate compressibility:
- a) AGA 8;
 - b) AGA NX-19; or
 - c) ISO 12213.

³ Compressibility is a function of gas temperature, pressure and gas composition; and it accounts for differences between the behaviour of the measured gas compared to an ideal gas. In an ideal gas, molecules are assumed not to interact, but in a real gas, they do if the density is high enough. At low density, the volume of measured gas is similar to that of an ideal gas. At somewhat higher densities, the molecules are closer together and the interaction forces between the particles are attractive, so the volume of the gas is less than that of an ideal gas in the same conditions. At still higher densities, the molecules are excessively close together, resulting in repulsive interaction forces. This results in the volume being greater than it would for an ideal gas.

- 5.40. NZS 5259 requires that a compressibility factor be applied whenever the error due to non-application of such a factor would give rise to errors in excess of the limits defined in Table 3 ($\pm 0.2\%$ for metering pressures below 500 kPa and $\pm 0.25\%$ otherwise). The rule of thumb, as recommended in NZS 5259, is to correct for compressibility at pressures above 50 kPa.
- 5.41. Section 7 of this guideline provides advice on choosing a suitable method of calculating compressibility. It notes that the ISO and AGA methods are now generally preferred to the somewhat dated NX-19. Accordingly, retailers undertaking system changes who are currently using AGA NX-19 may want to consider changing to one of the other recommended methods.
- 5.42. The calculation of compressibility typically requires as input values certain information about the gas composition and characteristics. The availability and use of this data is discussed below.

Gas Industry Co expectations regarding compressibility factors

- 5.43. In all cases where gas is metered at a pressure above 50 kPa, retailers will apply the F_z factor in the calculation of standard volumes.
- 5.44. Where gas is metered at a pressure of 50 kPa or less, a retailer may choose not to apply the F_z factor where it assesses that the likely effect of doing so will not breach the NZ5259 Table 3 limits.
- 5.45. A retailer may choose at what interval to apply the F_z factor (eg continuously, hourly, daily or for the whole billing period), where it assesses that the likely effect will not breach the NZ5259 Table 3 limits.
- 5.46. For each of its customers, a gas retailer will identify the relevant gas type and use gas composition and characteristic data for that gas type in the calculation of the F_z factor (see discussion on gas composition and characteristics below).
- 5.47. When composition and characteristic data for a period longer than a day is to be used, a simple arithmetic average will apply.

6. Gas composition and characteristics

- 6.1. The chemical composition of gas in the pipelines is measured at all receipt points into the transmission system, at major delivery points (ie power stations and petrochemical plants) and at a number of key locations on the transmission system using gas analysers. Using that information, the analysers can calculate certain gas characteristics such as specific gravity (also known as 'relative density') and calorific value.
- 6.2. Different sections of the transmission system have different 'gas types' depending on which gasses are being injected and co-mingled in that part of the system. There are currently 14 gas types. The transmission system owner provides a document entitled Delivery Point Gas Types

advising which gas type is applicable to each area of the system (available at <https://www.oatis.co.nz/Ngc.Oatis.UI.Web.Internet/Common/Publications.aspx>)

- 6.3. Each day, the transmission system owner posts on OATIS⁴ information relevant to each gas type – its proportions of carbon dioxide and nitrogen, and its specific gravity and calorific value (%CO₂, %N₂, SG and CV). The %CO₂, %N₂ and SG are commonly used in the calculation of the F_z factor. The CV is used to convert standard volume to energy.

Gas Industry Co expectations regarding calorific value

- 6.4. For each of its customers, a gas retailer will identify the relevant gas type and use CV data associated with that gas type in the calculation of energy.
- 6.5. The CV used in the energy calculation will be calculated by simple arithmetic average of the daily data between meter reading dates. No attempt should be made to correct for time lags between CV measurement and gas delivery.

7. Background information

Choosing a suitable method of calculating compressibility

- 7.1. NZS 5259 proposes that acceptable methods for calculating compressibility are: NX-19, AGA-8, or ISO 12213. Here we compare these and suggest which may be the best to use in particular situations. Note that NZS 5259 uses the term 'compressibility factor' (F_z), while in Europe the term 'compression factor' is used, and in NX-19 'super-compressibility factor' (F_{pv}) is used. The compressibility factor and the compression factor are the same and are equal to the square of the super-compressibility factor.

Calculating compressibility using the full mole fraction analysis as input

- 7.2. AGA-8 and ISO 12213 both provide calculation methods that can be used when the operating pressure, operating temperature, and the full mole fraction analysis of the gas being measured are known⁵. These methods give the most accurate results when the gas composition is being frequently sampled, and the calculations are being frequently refreshed. They are also suitable where the gas is not a typical pipeline quality gas (for example, for LPG).

Calculating compressibility using five factor inputs

- 7.3. Where the gas being measured is a typical pipeline quality gas, NX-19, AGA-8 and ISO 12213 each provide methods of calculating compressibility using only five inputs: operating pressure, operating temperature, and three of either mole percent CO₂, mole percent N₂, CV or SG. The operating pressure and operating temperature are specific to each GMS while the other factors are related to the gas type being measured. These methods are suitable where the full mole fraction is not readily available, or not regularly updated. Daily values of the gas type information

⁴ OATIS (Open Access Transmission Information System) is the web based system that allows the transmission system owner to interact with pipeline users. Key documentation relating to the operation of the open access regime can be found on the Publications page of OATIS.

necessary to perform these calculations are available from the Gas Composition Details page of OATIS.

NX-19

7.4. The NX-19 equation calculates super-compressibility following the methods outlined PAR Research Project NX-19, published in December 1962 by the Pipeline Research Council International. Although the ISO and AGA methods are now generally preferred, the somewhat dated NX-19 method still produces quite acceptable results when frequent sampling results are not available, and where metering pressures are not high.

ISO 12213

7.5. ISO 12213 is in three parts. Part 1 is an introduction and guideline. Part 2 applies where a detailed molar composition of the gas is known. Part 3 applies when any three of the factors CV, SG, CO₂, or N₂ are known, but the preferred method is to use CV, SG and CO₂. This simplified method is only for use where the gas is of a typical pipeline specification and, importantly, when its hydrogen content must be less than 0.1 mole fraction. Given exact values of all the relevant input variables, the Part 3 method is expected to achieve the same $\pm 0.1\%$ uncertainty as the Part 1 method.

AGA-8

7.6. The latest version of AGA-8, published in late 1992, sets out two possible ways to compute super-compressibility (F_{pv}); the Gross method, and the Detailed method. The Gross method is designed to be applicable for pipeline quality natural gas at normal pipeline pressures and temperatures, and is applicable over a narrower range of operating conditions than the Detailed method.

Suitability of methods to NZ gas types

7.7. While it is possible to have a pipeline gas specification that meets the NZS 5442 standard but does not meet one or other of the criteria of the AGA-8 normal range or the ISO 12213 pipeline quality gas range, in practice all gas types can be assumed to meet those criteria. The table below gives an indication of how a NZ gas type B specification (final column) compares

⁵ Both standards allow for some simplification, such as using a composite C₆ fraction. However, a full analysis would include mole percentages of nitrogen, carbon dioxide, argon, methane, ethane, propane, n-butane, iso-butane, n-pentane, iso-pentane, hexanes, heptanes, octanes, nonanes, decanes, hydrogen, carbon monoxide, hydrogen sulphide, helium, oxygen and water.

	AGA-8 Normal Range	ISO 12213 Part 3 Pipeline quality gas	NZS 5442 specification for reticulated natural gas	Spot analysis of a sample of gas type B
Relative Density	0.56 to 0.87	0.55 to 0.8	0.8 max	0.7
Gross Heating Value (MJ/scm)	17.8 to 42.8	30 to 45	35.2 - 46.5	40.6
Mol percent Methane	45% to 100%	70% to 100%		81.1%
Mol Percent Nitrogen	0 to 50%	0 to 20%		0.4%
Mol Percent Carbon Dioxide	0 to 30%	0 to 20%		6.4%
Mol Percent Ethane	0 to 10%	0 to 10%		7.2%
Mol Percent Propane	0 to 4%	0 to 3.5%		3.4%
Mol Percent Butanes	0 to 1%	0 to 1.5%		1.2%
Mol Percent Pentanes	0 to 0.3%	0 to 0.5%		0.2%
Mol Percent Hexanes Plus	0 to 0.2%	0 to 0.1%		0.05%
Mol Percent Helium	0 to 0.2%	0 to 0.05%		
Mol Percent Hydrogen Assumed	0.0	0 to 10%	0.1% max	0.002%
Mol Percent Carbon Monoxide Assumed	0.0	0 to 3%		
Mol Percent Argon Assumed	0.0			
Mol Percent Oxygen Assumed	0.0		0.1% max	0.01%
Mol Percent Water	0 to 0.05%	0 to 0.015%	100mg/m3 max	
Mol Percent Hydrogen Sulfide	0 to 0.02%			
Flowing Pressure	8.3 MPa	12MPa		
Flowing Temperature	0 to 55 °C	-10 to 65 °C	2 to 40°C	
Sulphur (as S)			50mg/m3 max	
Halogens (as Cl)			25mg/m3 max	
Hydrocarbon dewpoint			2°C at 5MPa max	

Conclusion on choosing a method for calculating compressibility

7.8. From the above, it should be clear that:

- 7.8.1. For large high pressure metering installations with on-line gas analysis, it is likely that a flow computer will be used which offers the 'full factor analysis' of AGA-8 or ISO 12213. Either the AGA-8 Detailed method or the ISO 12213 Part 2 method should be used in these situations. ISO 12213 Part 2 determines the 'compression factor' using the AGA detailed characterization equation, so the results should be identical. The compression factor should be reported to four decimal places.
- 7.8.2. For smaller lower pressure metering installations without on-line gas analysis, it is more practical to use the NX-19, AGA-8 Gross Method, or ISO 12213 Part 3 method. The latter two are based on more recent research and are preferred, where available. ISO 12213 Part 3 uses a somewhat different equation to that used in the AGA-8 Gross method, but the results are essentially identical according to the ISO 12213 Part 1 guideline. Once the

gas type is known (ie depending on the location of the gas meter) the correct input data for that gas type can be sourced from OATIS.

A few words on the metering of reticulated LPG

- 7.9. Generally arrangements for reticulating LPG include a central storage facility, possibly a single storage vessel like a 20 tonne bullet or manifold cylinders. Gas is typically drawn from the storage vessel and reticulated to commercial and residential sites at a pressure in the range of 50 to 70kPa. Above this pressure there is a risk that the LPG gas may in part re-liquefy, depending on temperature. There is then a final pressure cut to suit the appliance, generally down to 3kPa (300mm of water gauge) or less.
- 7.10. It is more difficult to measure LPG (in its gaseous form) accurately by volume than to measure natural gas. LPG is generally a mixture of 40% propane and 60% butane. When gas is drawn from an LPG storage facility propane is preferentially vaporised, initially giving a mixture of 70% propane and 30% butane, becoming more butane rich as the tank empties. So, while the volume can be measured using, say, a standard residential gas meter with associated pressure regulator, the conversion factors such as CV and F_z, can be quite variable, depending on how much gas has been drawn from the tank⁶.
- 7.11. The uncertainty of LPG measurement is generally higher than the uncertainties of natural gas measurement. One method to reduce this uncertainty is to determine the propane/butane composition of the LPG during the measurement and apply the calorific values of butane and propane accordingly.

8. Governance of this document

- 8.1. Gas Industry Co will amend this document from time to time to remain consistent with relevant rules regulations and standards.
- 8.2. Any person may propose a change to this document by writing to Gas Industry Co describing the proposed change and the reasons why the person believes it is worth making.

⁶ It has been reported (Conference Paper No. 69 (1999) The Measurement of Whole Building Energy Usage for New Zealand Houses, Andrew R. Pollard Presented at the IPENZ Technical Conference, Auckland, July 11-12, 1999) that over 70% of the variance in the energy content of the gas is attributable to the high uncertainty of the calorific value of the LPG. For example, the gross calorific value of a 70/30 propane-butane mix is 108 MJ/scm, and the value for butane 125 MJ/scm, so typically a CV close to the average of this range is used.

Version Control

Date	Version	Changes	Author
22 December 2011	1.0		GIC
1 November 2015	2.0	Update to align with most recent version of Reconciliation Rules and 2015 revision of NZS 5259	GIC