Gas Measurement Requirements and Procedures

November 2015

GAS INDUSTRY COMPANY LIMITED

About Gas Industry Co.

Gas Industry Co is the gas industry body and co-regulator under the Gas Act. Its role is to:

- develop arrangements, including regulations where appropriate, which improve:
  - the operation of gas markets;
  - access to infrastructure; and
  - consumer outcomes;
- develop these arrangements with the principal objective to ensure that gas is delivered to existing and new customers in a safe, efficient, reliable, fair and environmentally sustainable manner; and
- oversee compliance with, and review such arrangements.

Gas Industry Co is required to have regard to the Government's policy objectives for the gas sector, and to report on the achievement of those objectives and on the state of the New Zealand gas industry.

Gas Industry Co's corporate strategy is to 'optimise the contribution of gas to New Zealand'.

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1. Introduction

In New Zealand gas must be sold by energy content and be measured by a gas measurement system (GMS)[1]. The Gas Act 1992 defines a GMS as:

> ***...*** *a system for measuring the quantity of any gas or the energy content of any gas, whether by actual measurement or estimation; and includes any equipment that forms part of, or is ancillary to, any such system*

This broad description is needed because it applies to the full spectrum of gas measurement from small residential through to major plants such as power stations, petrochemical plants and industrial complexes. The GMS at a major plant is in some ways the easiest to understand because all its components are located at one physical metering station. In contrast, the on-site elements of a residential GMS comprise just the meter itself (to measure gas volume) and a pressure regulator (to maintain a stable delivery pressure). The other elements of a residential GMS are remote from the meter location. They include ancillary equipment such as gas chromatographs (instruments that measure the energy quantity of standard volumes of gas) and the hardware and software for calculating the various adjustments necessary to convert the measured volume into an energy quantity.

Objective of this report

This report provides an overview of the legal requirements and technical standards that apply to gas measurement, and a description of common industry practice and terminology. It will also tell you where to find more detailed information. If you're not an expert in this area we're sure you'll find the report useful, but please let us know if anything isn't clear. If you are an expert, please let us know if you spot anything that isn't correct.

You shouldn't assume this report is a complete and accurate description of all metering requirements. It's not meant to be a replacement for original documents. So go back to the source document if you need to get into the detail.

Some basics

In New Zealand metric units are used to measure gas flow.

A 'standard' volume of gas is the volume it occupies at 'standard conditions', ie at a temperature of 15°C and a pressure 101.325 kPa (kilopascals)[2].

[1] Gas (Safety and Measurement) Regulations 2010 r21(2)
[2] NZS 5259:2004 s1.2.3.2

The energy content of gas is commonly measured in gigajoules and may be scaled down to megajoules or up to terajoules or even petajoules, depending on the quantum of gas being discussed.

Megajoule (MJ) – is equal to one million joules (10^6)

Gigajoule (GJ) – is equal to one billion joules (10^9)

Terajoule (TJ) – is equal to one trillion joules (10^{12})

Petajoule (PJ) – is equal to one quadrillion joules (10^{15})

An average residential user consumes around 24 GJs/year.

Residential gas bills frequently express energy usage in kilowatt hours (kWh) (1 GJ is approximately 278 kWh). All other commercial gas transactions reference GJs.

The total quantity of gas consumed in New Zealand in 2014 was 203 PJs.[3]

[3] 2015 Energy in New Zealand

2. Gas Measurement Fundamentals

This chapter describes the basic physics of gas measurement including the various conversions necessary to convert actual measured volumes into energy.

2.1 The energy content of gas

The energy content of a standard volume of gas – its calorific value (CV) – is generally measured in units of megajoules (MJ) per standard cubic meter (scm). Here 'standard' refers to standard conditions of 15 degrees centigrade (°C) and 101.325 kilopascals (KPa). The CV is a measure of the amount of heat that would be generated by combustion of the gas.

Natural gas sold in New Zealand typically has a CV in the range of 39-41 MJ/scm.

2.2 Standardisation of metered quantities

A gas meter measures the volume of gas passing through it at actual conditions, i.e., at the prevailing temperature and pressure of the gas at the gas meter. This volume is recorded in units of actual cubic meters (acm). However, in order to calculate how much energy that measured volume contains, it is necessary to first convert the measured volume (in acm) to a standard volume (in scm). This is done using the Ideal Gas Law, possibly adjusted for altitude and compressibility, as explained below.

The Ideal Gas Law

The volume of a gas increases as its temperature increases (Charles' Law) and decreases as its pressure increases (Boyle's Law). This relationship is described in the 'Ideal Gas Law':

$$\mathbf{P_1V_1/T_1 = P_2V_2/T_2}$$

where P is the absolute pressure of gas; V is the volume of gas; and T is the absolute temperature of the gas. For example, the first state (1) could be at actual metering conditions and the second state (2) could be at standard conditions. The formula can then be transposed to give:

$$\begin{aligned} V_{standard} &= V_{actual} \times (P_{actual} / P_{standard}) \times (T_{standard} / T_{actual}) \\ &= V_{actual} \times F_P \times F_T \end{aligned}$$

Adjusting for altitude

As noted earlier, the 'P' factor in the Ideal Gas equation is 'absolute' pressure, i.e., measured with reference to a vacuum. On-site pressure measurement devices typically measure gauge pressure (i.e., the difference between the absolute pressure of gas in the pipeline and the ambient atmospheric pressure), so the atmospheric pressure must be added to the gauge pressure measurements to obtain the absolute pressure.

The atmospheric pressure is usually assumed to be the 'standard' pressure of 101.325kPa. This standard was adopted in 1954[4] based on the average atmospheric pressure at mean sea level at the latitude of Paris, France. It is also a reasonable proxy for atmospheric pressure at sea level in New Zealand.[5]

However, atmospheric pressure varies significantly with altitude, so simply adding 101.325kPa to a gauge pressure to obtain an absolute pressure is not always good enough. For example, Stratford is at an elevation of approximately 1000m so the atmospheric pressure there is about 12kPa lower than 101.325kPa, ie about 12% lower[6]. Stratford is an extreme example, but even within Wellington there are areas nearly at sea level – like Lyle Bay and Petone – and parts that are much higher – like Mount Victoria, at nearly 200m above sea level – so the effect can be significant.

Care is therefore needed to ensure that absolute pressures derived by adding atmospheric pressure to gauge pressure readings take account of altitude effects. To make this explicit the altitude adjustment is specified as a separate adjustment, ie where F_P has been calculated by adding 101.325 kPa to the Gauge pressure, a separate factor F_A is introduced to adjust for the altitude of the meter.[7]

Adjusting for compressibility

Natural gas is not an 'ideal' gas, so the Ideal Gas Law requires some adjustment. The adjustment is known as 'compressibility' (Z), and its value depends on the physical composition of the gas as well as the temperature and pressure it is measured at. The effect is particularly marked at low metering temperatures or high metering pressures.

In the New Zealand gas industry, the generally accepted means of calculating compressibility is the American Gas Association Report no 8 (AGA8) methodology (see section 4.3 for more detail on American Gas Association publications). The simplest method provided by AGA8 is the 'gross characterisation method' which requires as inputs the carbon dioxide (CO_2) and nitrogen (N_2) concentrations and the Specific Gravity (SG) of the gas.

2.3 The calculation of billing quantities

The application of the measurement fundamentals to calculating billing quantities is neatly set out in NZS 5259 and reproduced here as Figure 1.

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[4] It was adopted by the 10th Conférence Générale des Poids et Mesures, and later incorporated into the International System of Units in 1960.

[5] For example, Conference Paper #69 (1999) entitled The Measurement of Whole Building Energy Usage for New Zealand Houses, Andrew R. Pollard, presented at the IPENZ Technical Conference in Auckland, July 11-12, 1999, noted (s4.3.3 Gas Pressure) that 'Hourly reduced mean sea-level pressure data from the NIWA Climate database was examined for 1998 from Wellington Airport (NIWA agent no 3445). The hourly pressure data had a sample standard deviation of 0.9 kPa. Using the standard pressure (101.325 kPa) in-place of the hourly data will consequently result in an uncertainty of approximately 0.9 kPa.'

[6] To give some indication of the relative importance of altitude, the difference between high and low pressure weather systems is typically about 20mbar or 2kPa, and residential meters typically operate at a pressure of 1.5kPa… so altitude can be relatively more significant than either of those.

[7] Note that no altitude adjustment is required if the absolute pressure is measured directly (and absolute pressure transducers are becoming more common). In that case the F_P factor is calculated using that absolute pressure directly.

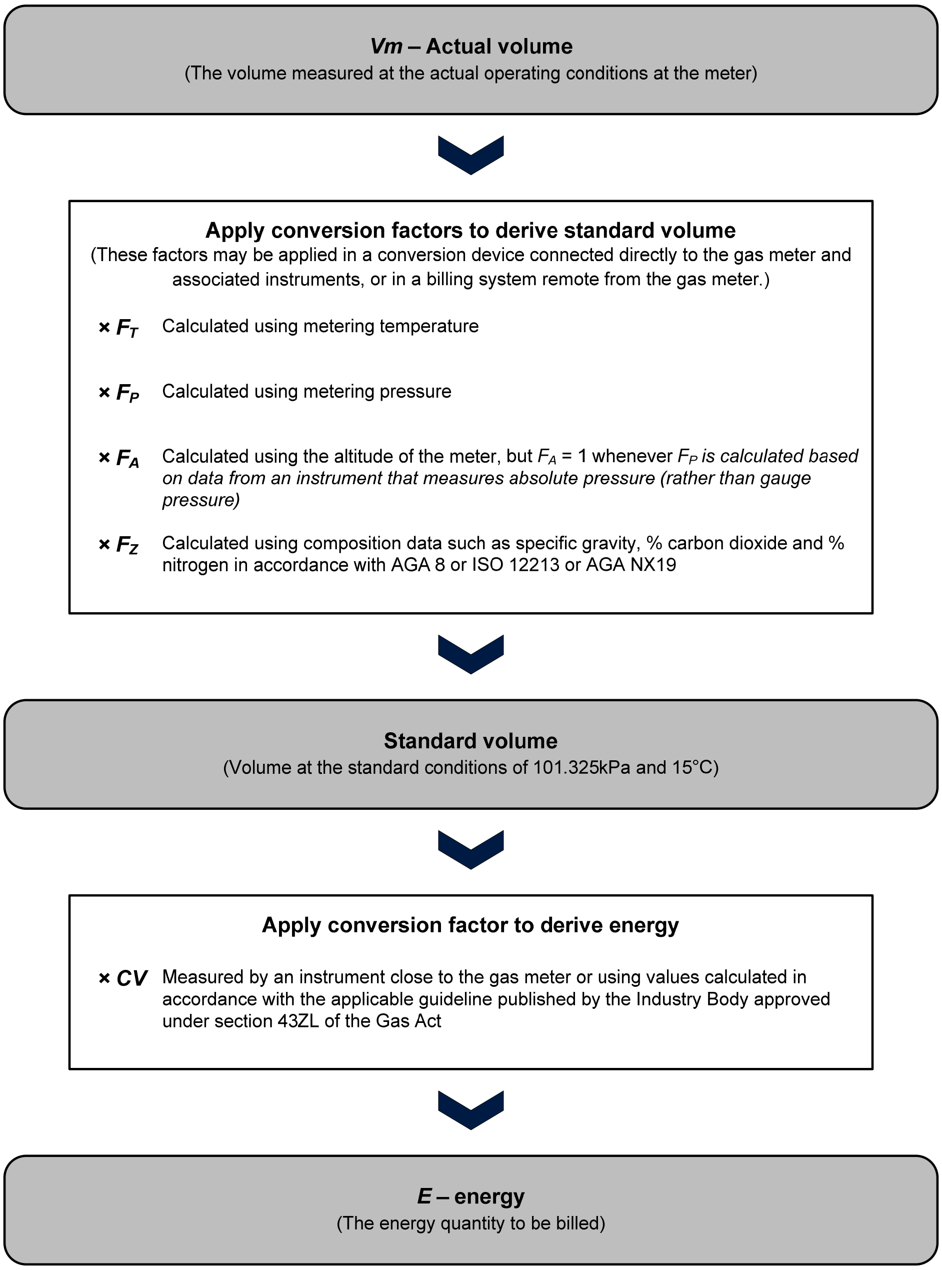


Figure 1 - Energy conversion process
(source: NZS 5259)

The above diagram illustrates the general equation for converting volume to energy:

$$\mathbf{E = V \times F_T \times F_P \times F_A \times F_Z \times CV}$$

Where

E is energy to be billed;

$\mathbf{V_m}$ is actual volume of gas delivered;

$\mathbf{F_T}$, $\mathbf{F_P}$, $\mathbf{F_A}$ and $\mathbf{F_Z}$ represent the correction for temperature, pressure, altitude and compressibility; and

CV is the calorific value of the gas.

Where calculations are done

Many GMSs do some of the above calculations on-site, but it is generally only the largest metering installations that perform the full conversion of measured volume to energy on-site. It is therefore common for at least some of the calculation to be done as back-office routines in retailers' billing systems.

Retailers commonly obtain metering services from third-party service providers, and they must be careful to identify which parts of the energy calculation are being done on-site (and already allowed for in the 'meter readings' they obtain), and which parts remain to be done in their billing systems.

To assist retailers to comply with the legal requirements and industry best-practice, Gas Industry Co issues a guideline on how the calculations to convert volume to energy should be done: *Gas (Downstream Reconciliation) Rules 2008 Billing Factors Guidelines.*[8]

2.4 Mass based approach to gas measurement

The previous sections of this chapter relate to the gas measurement calculations required where a meter measures the volume of the flowing gas. The vast majority of gas flow meters measure volume, but several technologies – thermal meters and Coriolis meters – allow for the direct measurement of mass flow. Aside from the inherent properties of these meters (discussed in Section 3.3), mass meters substantially simplify the conversion to energy units.

Mass can be converted to a standard volume is the specific gravity of the gas is known:

$$\mathbf{E = M \,/\, (SG \times \rho(air)) \times CV}$$

Where

E is energy to be billed;

M is mass of gas delivered;

SG is the specific gravity (or relative density) of dry gas to dry air at standard conditions;

ρ(air) is the density of dry air at standard conditions; and

CV is the calorific value of the gas measured in units of MJ/scm.

[8] The Billing Factors Guidelines can be found at http://www.gasindustry.co.nz/dmsdocument/2849.

Or, if the CV is measured in units of MJ/Kg, the mass can be converted to energy in a single step:

$$\mathbf{E = M \times CV_M}$$

Where

E is energy to be billed;

M is mass of gas delivered; and

$\mathbf{CV_M}$ is the calorific value of the gas measured in units of MJ/Kg.

3. Overview of Gas Measurement

This chapter describes the basic physics of gas measurement including the various conversions necessary to convert actual measured volumes into energy.

3.1 Purpose and location of gas measurement

Gas flows can be measured for system monitoring and control (operational) purposes and/or for commercial (fiscal) purposes. As a general rule, a higher standard of accuracy is required for fiscal measurement, but frequently one measurement system will serve both purposes.

The focus of this report is fiscal measurement, which needs to occur at all locations where the ownership or control (custody) of gas changes. These locations are illustrated in Figure 2.

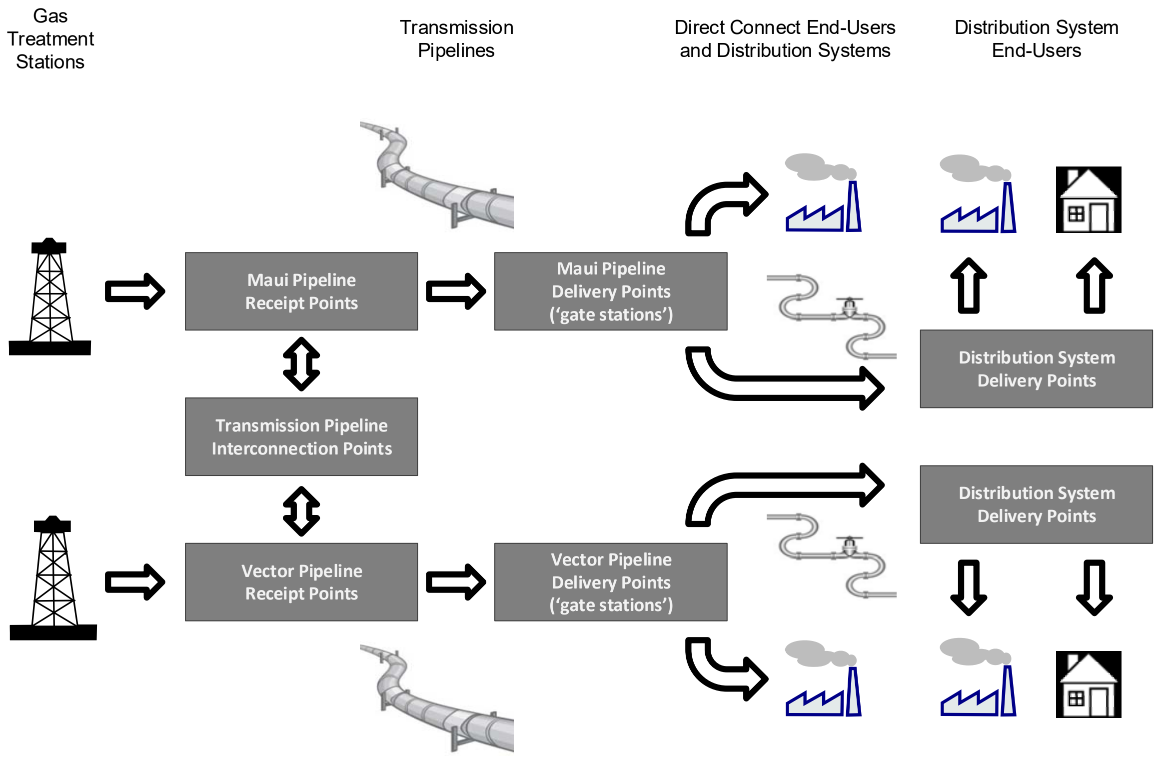


Figure 2 - Fiscal Measurement Locations

At each location where fiscal measurement is required, a metering station comprising at least a pressure regulator, a meter and a set of isolation valves exists. At locations where producers inject gas into the transmission pipeline (transmission pipeline 'receipt points') and at major industrial factories, petrochemical plants and electricity generation stations, more sophisticated high-pressure metering stations are built. Typically these stations are self-contained and include all the equipment necessary to determine the quantities of energy delivered. They often comprise several metering 'streams' to provide a degree of redundancy, gas analysers to provide real time measurement of gas composition from which CV and SG can be derived, and flow computers to perform all the calculations necessary to give real time energy readouts.

By contrast, small metering installations, such as those for residential consumers, operate at low-pressure and only have a few components of the GMS located on-site. These installations rely on remote systems to measure gas composition, CV and SG; and flow calculations (i.e., the conversion of actual metered quantities to energy) are generally done by back-office billing systems on a batch basis when invoices are prepared.

3.2 Components of a GMS

The *equipment* components of a GMS include:

- **Meter:** one or more meters to measure the amount of gas being delivered;
- **Temperature measurement device:** to measure the flowing gas temperature;
- **Pressure measurement device:** to measure the flowing gas pressure;
- **Gas analyser:** to analyse the chemical composition of the gas and calculate its properties, such as its calorific value and specific gravity;
- **Conversion device:** to perform the flow calculations (this can be an on-site device known as 'flow computer' or 'corrector', or a back-office billing system);
- **Regulator:** one or more regulators to reduce the pipeline pressure to a metering pressure (may also be a downstream regulator reducing the metering pressure to a delivery pressure, but this would not be a component of the GMS);
- **Filter, flow conditioning device, flow restrictor, and isolation valves:** a filter to remove contaminants from the gas stream; a flow conditioner to remove any swirl in the gas stream caused by upstream pipework configurations that could otherwise affect the accuracy of the meter; a flow restrictor to prevent excess flow through the meter; and isolation valves to allow for meter removal; and
- **Indexes and gauges:** to allow instruments and conversion devices to display measurements and indicate the quantity of gas measured (these can be mechanical or electronic).

The *system* components of a GMS include:

- **Systems for determining gas composition and properties:** where gas composition and properties are not measured on-site, systems exist for calculating the gas composition and properties of the different mixtures of gas delivered at various locations (there are currently 14 such 'gas types'); and

- **Systems for calculating energy from measurement inputs:** these systems may be entirely automated (for example, in a flow computer at a large metering installation) or be a combination of administrative arrangements and software (as in the arrangements for bringing together all the elements of a residential gas invoice: meter readings; conversion factors for pressure, temperature, altitude and compressibility; and CV).

Figure 3 - Filters at the start of two metering 'streams' on a transmission system delivery point
(source: Vector Gas Transmission Asset Management Plan 2013)

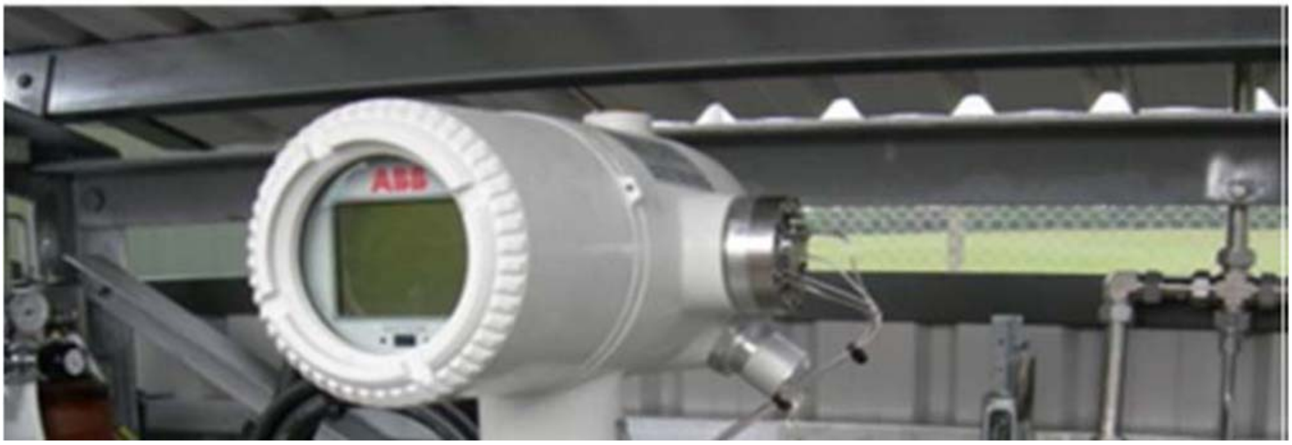


Figure 4: Typical gas analyser
(source: Vector Gas Transmission Asset Management Plan 2013)

3.3 Main types of meter technology

Ultrasonic meters

An ultrasonic meter sends a sonic 'ping' through the flowing gas and measures the speed with which the sound travels. It uses relatively modern, sophisticated and reliable technology with no moving parts and causes no obstructions in the gas stream. Ultrasonic meters have now largely replaced orifice meters and turbine meters in New Zealand as the preferred means of measuring large gas flows at major stations.

Figure 4 - two ultrasonic meter streams
(source: Vector Gas Transmission Asset Management Plan 2013)

Turbine meters

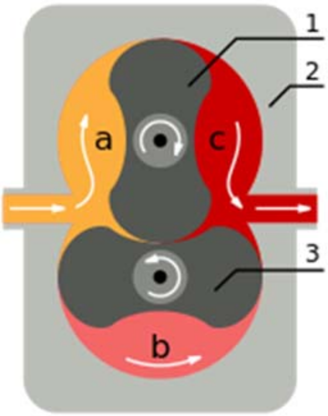
A turbine meter is a velocity measuring device. It works by the use of a small internal turbine wheel that rotates proportionately to the speed of the gas and is connected to a mechanical counter or through a magnetic drive to a flow computer. The moving parts are subject to wear and tear, so periodic re-calibration against a standard is required.

Coriolis meters

A Coriolis meter measures gas by vibrating a section of pipe carrying the flowing gas. Sensors measure changes in frequency and produce a signal that is proportional to the mass flow rate and is accurate over a wide range of flow rates. When CNG was used as an automotive fuel in New Zealand, Coriolis meters were used to measure gas flow from dispensers. Although generally more expensive, they are often assessed as an alternative to ultrasonic meters for large sites.

Rotary meters

A rotary meter contains two interlocking figure of eight-shaped rotors. When the rotors spin, they move a specific quantity of gas with each turn, which drives a mechanical counter or sends electrical pulses to a flow computer.



1	Rotor 1
2	Casing
3	Rotor 2
a	Low pressure gas in
b	Fluid compressed in rotor void
c	Higher pressure gas out

Figure 6 - Operating principle of a rotary gas meter
(source: http://en.wikipedia.org/wiki/Gas_meter#mediaviewer/File:Roots_blower_-_2_lobes.svg)

Diaphragm/bellows meters

A diaphragm meter contains two movable diaphragms. The gas flow is directed to fill one diaphragm as the other discharges, then re-directed to fill the discharged diaphragm while the full diaphragm discharges. This in turn moves levers that can drive a counter mechanism or can produce electrical pulses for a flow computer. This is typically the type of meter used for small gas users, including residential consumers.

Figure 5 - residential gas meter installation
(source: https://upload.wikimedia.org/wikipedia/commons/thumb/a/a8/Gas_meter.JPG/220px-Gas_meter.JPG)

3.4 Safety

Gas is combustible and is therefore a hazardous substance when mixed with air in certain proportions (5 to 15% gas in air). As a result, precautions are required around certain GMS components. For example, pressure regulators, which in normal operation release small amounts of gas, must be vented to a safe area. Also, any electrical equipment used to power meters (i.e., non-mechanical meters such as ultrasonic meters or Coriolis meters), analyse gas composition, or carry signals from sensing devices such as pressure and temperature transducers must meet certified standards of 'intrinsic safety'.

Under the Gas Act, Worksafe NZ has special powers in relation to GMS (see section 4.1 below). The Electrical (Safety) Regulations 2010 reference standards that require all electrical equipment used in a hazardous zone and all electrical installations in hazardous areas to comply with a hazardous protection technique as outlined in NZS 60079.14:2009 Explosive atmospheres – Electrical installations design, selection and erection.

In addition, NZS 5259 requires every GMS to be designed and manufactured in such a way that all practicable steps are taken to ensure that all identified hazards and risks are eliminated or reduced to be as low as reasonably practicable[9].

3.5 Advanced Metering

Advanced meters record energy consumption in intervals of an hour or less and allow two-way communication between the meter and a centralised system. Some can also be programmed to remotely disconnect and reconnect the gas supply, and some have the ability to apply a temperature correction. However, they generally do not have the wide functionality of electricity smart meters, such as communicating with domestic appliances or providing data directly to consumers.

Because of the safety issues that arise when electricity is in close proximity to areas where gas and air could potentially mix, advanced gas meters are very low-power devices designed to run on batteries. To prolong battery life, the meters are not always 'live', and are generally programmed only to communicate with the central system once a day (and only to retry once or twice more if initial contact fails). This sacrifices some aspects of what might be described as pure 'smart' metering as the communication is effectively only one way.

The principal benefit of advanced metering is the saving of meter reading costs, so it is gas retailers who would be motivated to adopt this new technology. However, different retailers have different internal system requirements for communication, different data formats and different data content requirements. So it has proved difficult to define a common metering service standard.

[9] NZS 5259:2004 s1.2.1.2

Despite these hurdles, some advanced gas meters are on trial in New Zealand and the companies involved are optimistic of rolling out the technology to the wider market. Three types of technology are under consideration: a data collection/communication unit that can be bolted on to an existing diaphragm meter, a diaphragm meter with a digital index, and a fully integrated ultrasonic meter with integrated communications and battery. The bolt-on solution does not offer the remote reconnection and disconnection functionality. Full coverage of domestic consumers is likely to take several years.

Figure 8 - Ultrasonic meter with integrated comms and battery
(Image supplied by EDMI)

4. Legal framework

This chapter outlines the main Acts, Regulations, Rules, contracts and technical standards relating to gas measurement.

4.1 Legislation

Gas Act 1992

The Gas Act 1992 (Gas Act) regulates the supply and use of gas in New Zealand and includes a number of provisions relating to gas measurement, including:

- **S2 Interpretation**

GMS is defined as '… a system for measuring the quantity of any gas or the energy content of any gas, whether by actual measurement or estimation; and includes any equipment that forms part of, or is ancillary to, any such system.'

- **S7 Inspection of distribution systems, etc.**

This section enables WorkSafe to inspect any part of any distribution system, gas installation or gas appliance, including the testing of any GMS (s7(4)(b)).

- **S9 Special powers of WorkSafe**

WorkSafe may require any gas wholesaler, gas distributor, gas retailer or consumer to replace any GMS (or part of a GMS) it owns, and deliver the replaced system (or part of the system) for inspection and testing. This applies where the GMS is part of a distribution system or gas installation (s9(2)(a)&(b)).

- **S54 Regulations**

This section allows for the making of regulations for the purpose of:

- regulating and controlling the installation, use and maintenance of GMSs used for or in connection with the supply or use of gas (s54(1)(f));
- providing for the testing and sealing of GMS and calibration equipment; prescribing the manner in which and the means by which such testing and sealing shall be done and regulating the manner in which and the means by which GMSs and calibration equipment are reassembled in connection with such testing (s54(1)(m));
- requiring types or categories of GMSs to be approved by WorkSafe before being offered for sale in New Zealand (s54(3)); and

- o requiring compliance with any gas code of practice or official standards (ie within the meaning of the Standards Act 1988) (s54(2)).

Gas (Safety and Measurement) Regulations 2010

The Gas (Safety and Measurement) Regulations 2010 detail responsibilities and obligations for the safe supply of gas. Part 3 'Requirements for all gas distribution systems about measurement of gas' requires:

- **Regulation 21 Gas measurement**

- o gas must be sold in accordance with NZS 5259 unless the seller and purchaser have agreed otherwise in writing (reg 21(1));
- o gas must be sold by energy content measured by a GMS, and must not exceed margins of error listed (reg 21(2));
- o every GMS owner must manage the system to ensure accuracy and ensure records are kept (reg 21(3));
- o compliance with NZS 5259 is sufficient to be deemed compliant with this Regulation's accuracy and record keeping requirements (reg 21(4)); and
- o any person not complying with these requirements is liable to Level 2 penalties[10].

- **Regulation 22 Testing and installation of GMS**

On a GMS being placed in service, or being returned to service after maintenance or recalibration:

- o it must be tested for accuracy and sealed by a competent authority (reg 22(2)). Compliance with part 2 of NZS 5259 is sufficient to comply with this requirement (reg 22(3));
- o a GMS that does not pass the test must not be sealed, and any seal that may have been placed on the system must be removed or destroyed (reg 22(4));
- o the GMS owner must ensure that the calibration is unaffected by the GMS being transported before being put into service (reg 22(5));
- o any person who installs or uses a GMS contrary to this regulation is liable to a Level 2 penalty (reg 22(6));
- o any competent organisation that seals a GMS contrary to this regulation is liable to a Level 2 penalty (reg 22(7)); and

[10] Reg 6 provides that a level 2 penalty is, in the case of an individual, a fine not exceeding $10,000; and (b) in any other case, a fine not exceeding $50,000.

- any person, who is not a competent organisation, but breaks the seal of any GMS is liable to a Level 1 penalty[11].

- **Regulation 23 Records of tests of GMSs must be kept**

- reg 22 test results must be kept by the competent authority undertaking the test and the operator of the GMS (reg 23(1));
- the operator must keep the records for as long as it operates the GMS (reg 23(2)); and
- a GMS operator who fails to keep any test result records is liable to a Level 1 penalty.

Gas (Downstream Reconciliation) Rules 2008 (Rules)

The purpose of the 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 (rule 2). Most of the provisions relate to office-based allocation and reconciliation processes, but some apply to site-based metering equipment.

(More information about the reconciliation and allocation aspects of the Rules can be found in Gas Industry Co's Gas Reconciliation – Requirements and Procedures paper)

The focus of the Rules is the allocation of amounts of gas delivered into a distribution network at a 'gas gate' among the gas retailers operating on that network.

The Rules do not use the term GMS but instead refer to meters and metering equipment. Metering equipment includes equipment used to measure gas supplied to an individual consumer (termed an installation control point or ICP) or gas injected at an allocated gas gate.

In the Rules, a meter owner means the person who owns or controls a meter used to measure gas consumption for a consumer installation.

- **Rule 27 Metering equipment accuracy**

- meter owners must ensure that equipment complies with NZS 5259 (rule 27.1.1);
- metering equipment is considered to be accurate if within margin of error specified in NZS 5259 (rule 27.1.2); and
- verification of accuracy must be done in accordance with NZ S5259 (rule 27.1.3).

- **Rule 28 General obligations of retailers**

Retailers have a number of obligations, but in respect of metering equipment each retailer is required to ensure:

[11] Reg 6 provides that a level 1 penalty is, in the case of an individual, a fine not exceeding $2,000; and (b) in any other case, a fine not exceeding $10,000.

- metering equipment is installed and interrogated at each installation it is responsible for (rule 28.1); and
- the conversion of measured volume to volume at standard conditions, and the conversion of volume at standard conditions to energy, comply with NZS 5259 (rule 28.2).

- **Rule 29 Retailer to ensure certain metering interrogation requirements are met**

Rule 29 lays out the requirements on retailers for metering equipment installation and interrogation for consumer installations with different consumption levels. In summary, each retailer is required to:

- ensure a time of use (ToU) meter is installed within 3 months of becoming aware that the annual consumption at a consumer installation exceeds, or is likely to be, 10 TJ (rule 29.1.1);
- ensure a ToU or non-ToU meter is installed at all other consumer installations (rule 29.2.1);
- assign the consumer installation to the appropriate allocation group, depending on the size of the installation, whether ToU or non-ToU meters have been installed, whether there is telemetry and the type of profile to be applied (if relevant) (rule 29.1.2 and 29.2.2); and
- ensure register readings (meter readings) are recorded each day for sites over 10TJ per annum, every month for sites between 250GJ and 10TJ per annum, and every 12 months for all other sites. In addition, each retailer must ensure readings are obtained at least every 4 months for 90% of their consumer installations with non-time of use meters.

- **Schedule 1 – Correcting for consumer metering errors and Schedule 1A – Correcting for gas gate metering errors**

- Schedule 1 notes the requirement for retailers and transmission system owners to use the best information available to them when calculating daily metered energy quantities. Tables set out the measures that should be taken in the event of various equipment failures and data loss scenarios.

Health and Safety in Employment (Pipelines) Regulations 1999

These regulations are made under s21 of the Health and Safety in Employment Act 1992 and apply to high pressure transmission pipelines (not distribution)[12].

Reg 8 requires an employer to take all practicable steps to ensure the pipeline is designed, constructed, operated, maintained and suspended or abandoned in accordance with:

- AS 2885 Pipelines - Gas and liquid petroleum; or
- NZS 5223 Code of Practice for High Pressure and Petroleum Liquids Pipelines 1987; or
- the provisions of ANSI B 31 American National Standards Institute Code for Pressure Piping; or

[12] See definition of pipeline in regulation 2 of the Health and Safety in Employment (Pipelines) Regulations 1999

- if none of these are applicable to any part of the pipeline operation, a generally accepted and appropriate industry practice.

The owners of New Zealand's open access transmission systems – Maui Development Limited (MDL) and Vector Gas Ltd (Vector) – have opted to use AS 2885.

4.2 Contracts

Metering on the open access transmission pipelines is subject to requirements of the access codes. These codes – the Maui Pipeline Operating Code (MPOC) and the Vector Transmission Code (VTC) – set out the multilateral terms of access to the respective transmission systems.

MPOC metering requirements

Schedule 1 of the MPOC details the technical requirements for pipeline receipt and delivery points and other stations on the Maui pipeline. This includes the interconnection points between the Maui and Vector pipelines (referred to in the MPOC as Transmission Pipeline Welded Points).

In Schedule 1:

- Part 1 sets out general requirements, such as the regulations and codes applicable to station design, construction, operation and maintenance;
- Part 2 sets out the metering requirements, such as when verification meters need to be installed, where gas chromatographs are required etc;
- Part 3 sets out the requirements for meter testing, such as when testing meters using air is acceptable, or what other means of re-validation are acceptable; and
- Part 4 details the approach for correcting measurements made by meters that are found to be inaccurate.

VTC metering requirements

The VTC references a document called 'Metering Requirements for Receipt Points and Delivery Points' (Vector Metering Requirements), which is posted on OATIS. It performs essentially the same function as the MPOC Schedule 1.

Standards relevant to transmission metering

The MPOC Schedule 1 and Vector Metering Requirements replace NZS 5259 within the context of the transmission system except for a few specific matters[13]. In addition, these documents provide for one matter that NZS 5259 does not: correcting for inaccurate meters.[14] The documents also invoke some other standards. Both reference AGA 8 (as well as some alternatives) for the calculation of compressibility and AGA 9 for the testing of ultrasonic meters.

[13] S2.2 and s3.2(a)(i) of MPOC Schedule 1 make reference to NZS 5259 in the context of testing meters using air at atmospheric pressure.
[14] Note that for meters on distribution systems the obligation for data correction sits with the retailer and the correction criteria are in the Gas (Downstream Reconciliation) Rules 2008.

The MPOC Schedule 1 and Vector Metering Requirements replicate each other to a large extent. However they do differ in some important respects, such as the tolerances for what is considered 'accurate'.

S3.2(h)(i) of MPOC Schedule 1 provides that:

> A meter shall be deemed to be Accurate if its Uncertainty, when tested against an approved Calibration Standard, is:
>
> (i) No more than +/- 0.8% for Large Stations
> (ii) No more than +/- 1.5% for Small Stations

By contrast, s2.1(a)(v) of the Vector Metering Requirements provide that:

> The Uncertainty of the meter complies with… the following requirements:
>
> (A) for Large Stations, no more than:
> ±1.5% between Qmin and 20% of Qmax; and
> ±0.8% between 20% of Qmax and Qmax;
>
> (B) for Small Stations with rotary-type meters, no more than:
> ±2.5% between Qmin and 10% of Qmax; and
> ±1.5% between 10% of Qmax and Qmax;
>
> (C) for Small Stations with meters other than rotary-type, no more than:
> ±2.5% between Qmin and 20% of Qmax; and
> ±1.5% between 20% of Qmax and Qmax;

Although common standards would be expected, Vector does have a much larger number of delivery points with a much more diverse range of flow conditions and equipment.

Other contracts

Contracting parties should not assume that the metering requirements in the transmission codes apply in all situations. Other contracts such as upstream sales agreements, downstream retailer sale agreements and transmission system interconnection agreements may have more stringent metering provisions.

4.3 Technical standards

Legislative and contractual arrangements refer to various technical standards. The standards most relevant to gas measurement are outlined below.

NZS 5259:2004 Gas measurement

The standard contains mandatory requirements, advice and recommendations. Part 1 covers scope and definitions, Part 2 sets out the performance measures for a GMS and its components, and Part 3 includes a means of compliance with Part 2.

Part 2, section 1.2.3.1, specifies:

- maximum permissible errors for meters;
- maximum permissible errors for other components of the GMS; and
- how to convert measured volume to energy.

Part 3 provides information about equipment selection, installation, operation and maintenance, including acceptance testing intervals for GMS components. It also sets out methods for calculating the various factors for converting measured volume to energy.

NZS 5259 is referenced by most industry supply and transportation contracts and key legislation such as the Gas (Safety and Measurement) Regulations and the Gas (Downstream Reconciliation) Rules.

American Gas Association publications

Certain American Gas Association publications relating to gas measurement are occasionally cited in NZ standards and operating procedures:

- **AGA Report no. 3:**

Orifice metering of natural gas and other related hydrocarbon fluids: pertains to the design of orifice meters and the calculation of flow through orifice meters. Although orifice meters are no longer used for fiscal measurement in New Zealand, they are still commonly used as process meters in industrial plants.

- **AGA Report no. 7:**

Measurement of natural gas by turbine meter: specifically aimed at the measurement of gas by turbine meters, but the AGA 7 flow equations are also applicable to any kind of meter that produces a known count of pulses per unit volume flowed, such as ultrasonic meters.

- **AGA Report no. 8:**

Compressibility factor of natural gas and related hydrocarbon gases: AGA 8 is the most frequently referenced authority for calculating compressibility. It offers three alternative calculation methods, requiring different input detail.

- **AGA Report no. 9**

Measurement of gas by multipath ultrasonic meters: specifies performance standards and outlines the method for calculating uncorrected volumes using an ultrasonic meter.

- **AGA Report no. 10**

Speed of sound in natural gas and other related hydrocarbon gases: sets out how to calculate the speed of sound in natural gas, necessary for the collaboration of ultrasonic meters.

- **AGA Report no. 11**

Measurement of natural gas by Coriolis meter: specifies performance standards for flow measurement of natural gas by Coriolis meter.

ISO standards

ISO (International Organization for Standardization) is an independent, non-governmental membership organization and the world's largest developer of voluntary International Standards. Several of these standards are occasionally cited in New Zealand standards and operating procedures:

- **ISO 6976:1995**

sets out methods for calculating calorific values, density, relative density and Wobbe index from gas composition.

- **ISO 2213-2:1997 (E) and 2213-3: 1997 (E)**

provides an alternative to AGA 8 for calculating gas compressibility.

AS/NZS 2885 1997 Pipelines - Gas and liquid petroleum

Both open access transmission pipeline companies – MDL and Vector – have elected to design and operate their pipelines according to AS/NZS 2885, one of the standards cited as a means of compliance by the HSE Pipeline Regulations. The standard is in several parts:

- Part 1 – Design and construction;
- Part 2 – Welding;
- Part 3 – Operation and maintenance;
- Part 4 – Submarine pipeline systems; and
- Part 5 – Field pressure testing.

Section 6 of Part 1 relates to gas metering and provides that proprietary equipment such as meters, regulators, and testing and monitoring equipment will comply with a nominated Standard or, where none exists, an approved Standard, which may include the manufacturer’s standard.

4.4 How the framework fits together

The requirements on transmission systems and distribution networks are different.

The Gas (Safety and Measurement) Regulations and Gas (Downstream Reconciliation) Rules both relate to GMSs on distribution networks, and both invoke NZS 5259 as the appropriate measurement standard (see Figure 6).

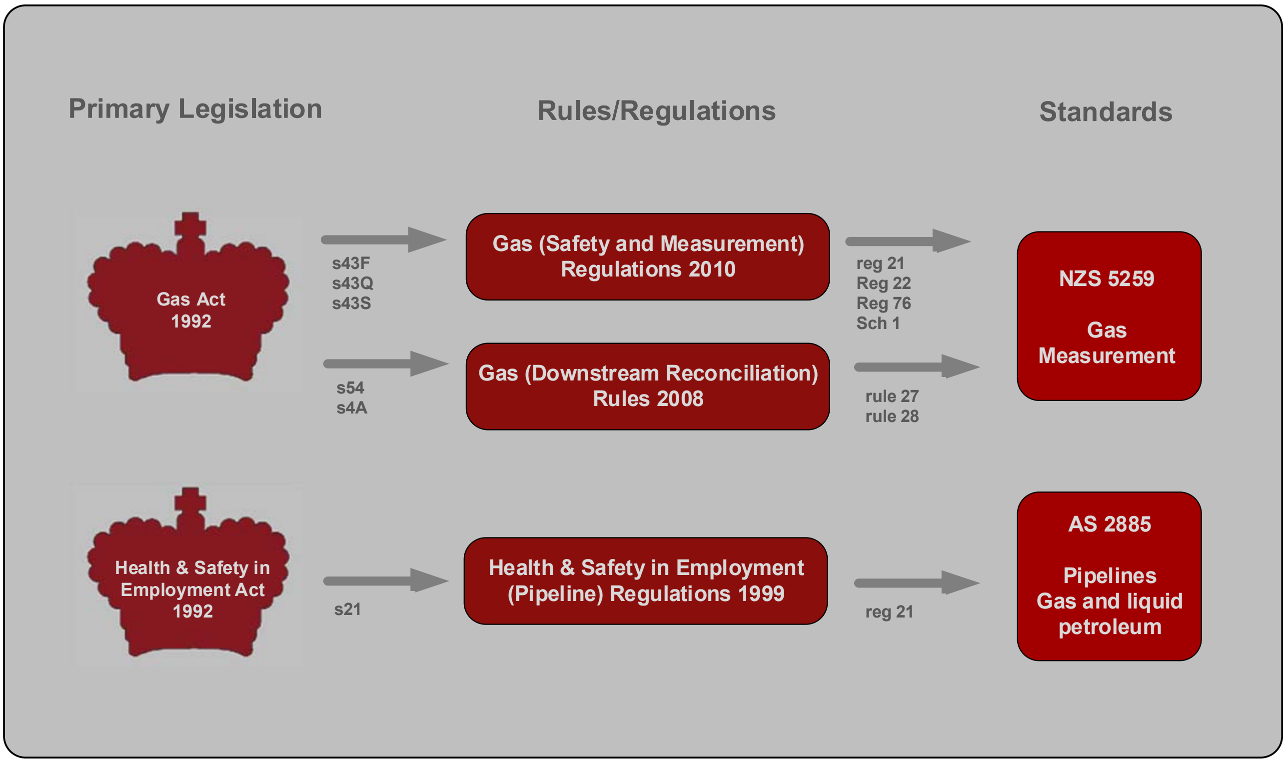


Figure 6 - Standards invoked by Rules and Regulations

NZS 5259 is oriented towards smaller, lower pressure GMSs, and is not well suited to the large, high pressure transmission GMSs found on the transmission systems. This is why MPOC Schedule 1 and the VTC each specify tailored requirements for transmission GMSs and reference AS/NZS 2885.1: 1997 Pipelines - Gas and Liquid Petroleum, Part 1: Design and Construction as the relevant standard (under the umbrella of the Health and Safety in Employment (Pipelines) Regulations 1999).

Nonetheless the transmission code requirements were influenced by the NZS 5259 standard when they were drawn up and there are some specific cross references to specific parts of NZS 5259 (see Figure 7).

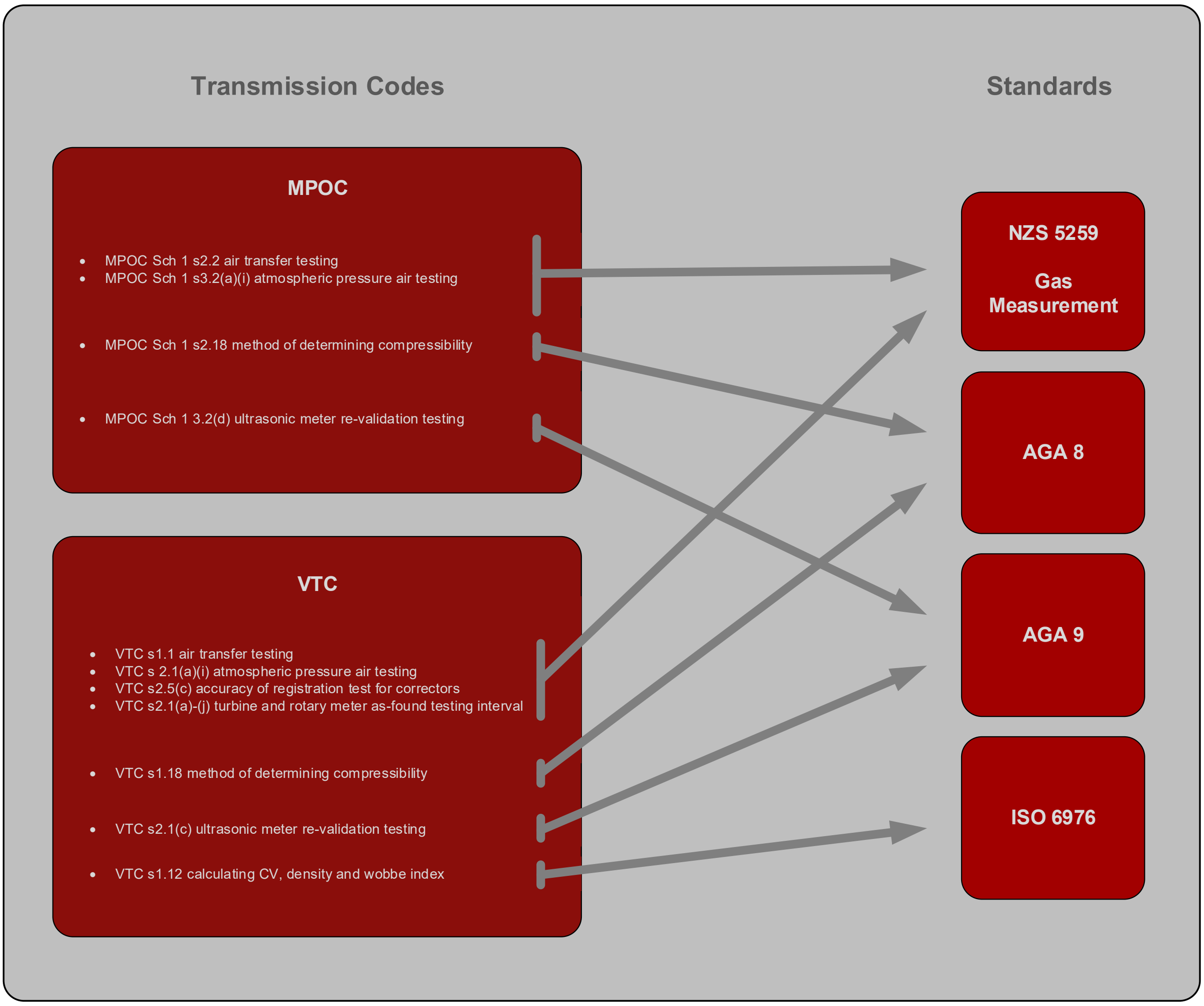


Figure 7 - Standards invoked by codes

Differences between transmission and downstream metering requirements

Generally the differences between the design, operation and maintenance of transmission system GMSs and downstream GMSs arise from the scale of the installations. The main areas of difference are:

Accuracy standards

The MPOC Schedule 1 requirements are generally the simplest and most stringent, as there are fewer GMS types across the small number of Maui pipeline stations. Vector transmission has a larger number of stations with a greater diversity of GMSs, some of which measure relatively small flows are significantly less sophisticated than GMSs for larger flow. Accordingly, the accuracy standards required by the Vector Metering Requirements are less stringent than those of MPOC Schedule 1. However, both set more stringent requirements than NZS 5259.

Diversity of equipment and processes

The Vector Metering Requirements reference equipment (such as rotary meters) that is not used on the Maui pipeline and is not referenced in MPOC Schedule 1.

Data correction

The MPOC and VTC each specify how data should be corrected when equipment is found to be faulty or inaccurate. Although NZS 5259 does not address data corrections, the Gas (Downstream Reconciliation) Rules 2008 do. (Further information about metering corrections can be found in Gas Industry Co's Gas Reconciliation – Requirements and Procedures paper).

Installation

Installation effects (such as insufficient straight pipe, pipe roughness, elbows and tees) can cause a general swirling motion or an uneven flow profile, causing measurement inaccuracy. However, the design of GMS installations is not specifically addressed in either of the transmission codes. Instead, it is covered in the broader requirements of AS 2885.

NZS 5259 does not apply to transmission GMSs[15] but does detail requirements for the installation of distribution system GMS.

[15] Except that the MPOC does provide that, where air transfer testing is employed, the relevant sections of NZS 5259:2004 will apply.

Testing

In the transmission codes there are three types of testing: 'acceptance' testing on receipt of a new piece of equipment, 'in service' testing performed on site, and 'as-found' testing, performed in a laboratory on equipment recently removed from site.

NZS 5259 requirements for distribution network GMSs focus on 'acceptance' and 'as-found' testing.

5. GMS design and installation

This chapter describes the basic requirements for the design and installation of GMSs located on transmission and distribution systems.

5.1 Transmission GMS requirements

The basic provisions of MPOC Schedule 1 and the Vector Metering Requirements relating to GMS design and installation are:

- **Equipment to be installed to prevent contaminants from affecting metering equipment**

  (MPOC Schedule 1 s1.7(m) and Vector Metering Requirements s1.2)

- **Stations to be designed to allow verification of a meter on site**

At large stations16 a verification meter shall be installed in series with any primary meter which can readily be used in series for verification testing. (MPOC Schedule 1 s2.4 and Vector Metering Requirements s1.4)

At small stations where only a single meter is installed there should be space for a second meter to be installed in series for verification testing. (MPOC Schedule 1 s2.3 and Vector Metering Requirements s1.3)

At any station where multiple primary meters are installed they shall be capable of achieving the same accuracy, resolution and repeatability. (MPOC Schedule 1 s2.5 and Vector Metering Requirements s1.5)

Any meter used as a verification meter shall be capable of achieving accuracy at least equal to the relevant primary meter. (MPOC Schedule 1 s2.6 and Vector Metering Requirements s1.6)

A back-up meter may be used as a verification meter, providing it has only been utilised infrequently since its own accuracy was last verified. Where dual ultrasonic meters are installed, it is permissible to operate both meters simultaneously in series during normal operation, as long as the difference between the meters is monitored and alarmed. (MPOC Schedule 1 2.8 and Vector Metering Requirements s1.8)

[16] Both the MPOC and VTC consider a large station to be one that is designed for a flow rate of more than 5,000 scm per hour. For Vector, a small station that is a receipt point is subject to the same requirements as a large station.

- **Each meter to be fitted with a mechanical index to display the total quantity of gas**

Where applicable to the type of meter. (MPOC Schedule 1 s2.7 and Vector Metering Requirements s1.7)

- **Meters to be operated within the manufacturer's specification for flow rates**

A primary meter must operate between the minimum and maximum flow ratings (Qmin and Qmax) specified by the manufacturer, except during start up and shut down. If the expected in-service flow range is too wide, more than one primary meter shall be installed, along with an automatic switching system. (MPOC Schedule 1 s2.9 and 10, and Vector Metering Requirements s1.9 and s10)

A flow restriction device shall be installed to ensure that no meter is exposed to a flow rate high enough to damage it. Unless the meter's manufacturer says otherwise, this shall be set to 1.20 x the meter's Qmax. (MPOC Schedule 1 s2.11 and Vector Metering Requirements s1.11)

- **Gas analysers to be used at large stations**

Metering at large stations shall use the composition and properties of gas determined by a gas analyser to calculate standard volume and energy quantities. (For Vector, this requirement also applies to small stations that contain receipt points and, unless agreed otherwise, calorific value, density and Wobbe Index shall be calculated in accordance with ISO6976:1995.) (MPOC Schedule 1 s2.12; and Vector Metering Requirements s1.12)

Unless agreed otherwise, the analyser shall be a gas chromatograph and will be located at the same station as the meter and must calculate spot values and daily average values. The constituents and properties of the gas that the gas chromatograph must calculate are listed. (MPOC Schedule 1 s2.13 and Vector Metering Requirements s1.13)

For small stations an analyser is not necessary and it is acceptable for the standard volume and energy quantities to be calculated off site. (MPOC Schedule 1 s2.14 and Vector Metering Requirements s1.14)

- **Metering at all sites is to provide pressure and temperature conversion, and at large sites also compressibility and energy conversion**

All metering shall measure actual volumes, temperature and pressure at flowing conditions and apply temperature and pressure conversion factors to determine standard volume. These values will be electronically stored at least hourly. (MPOC Schedule 1 s2.15 and Vector Metering Requirements s1.15)

At large stations, metering shall also compute compressibility, standard volume, and energy quantities. These will be electronically stored at least hourly and all values will be available for remote monitoring. (MPOC Schedule 1 s2.16 and Vector Metering Requirements s1.16)

Where metering comprises more than one meter, these requirements apply to each meter separately. (MPOC Schedule 1 s2.17 and Vector Metering Requirements s1.17)

- **Metering failure at a large station is to cause an alarm**

At large stations, failure or malfunction of any gas measurement device shall cause an alarm signal to be automatically transmitted to the metering owner and the technical operator. (For Vector 'large stations' is modified to include small stations that contain receipt points). (MPOC Schedule 1 s2.19 and Vector Metering Requirements s1.19)

- **Large stations are to have mains supply electricity and back-up electrical power**

For MDL, the station owner will ensure each station has continuous supply of electrical power from the mains supply, plus an uninterruptible supply from back up batteries with a capacity of at least 4 hours. Small stations need not have a mains supply if an alternative source is sufficient. (MPOC Schedule 1 s1.13 and s1.14)

For Vector, the metering owner shall determine whether metering needs a continuous supply of electricity or whether an alternative source is sufficient. Metering which has a mains supply must also have an uninterruptible supply for at least 4 hours. (Vector Metering Requirements 1.23 and s1.24)

5.2 Distribution GMS requirements

The basic provisions of NZS 5259 relating to GMS design and installation are:

NZS 5259 s2.2 - General requirements

- **General** Every GMS shall be suitable for the duty required.
- **Safety** Every GMS shall be designed and manufactured to ensure hazards and risks are eliminated or reduced to be as low as practicable.
- **Materials** Every GMS shall be made of materials and be constructed to withstand likely physical, chemical and thermal conditions and fulfil its purpose for its service life. Every GMS exposed to outdoor environments shall be suitable for the New Zealand climate.
- **Soundness** Every GMS that will be exposed to gas pressure shall be gastight up to its maximum working pressure.
- **Integrity of data** Data transmitted between components or stored in the GMS shall be accurate to meet the maximum permissible errors (MPEs) of table 2 and 3 NZS 5259.
- **Traceability of data** Every GMS shall accurately and traceably store or record data and transmit those data between components.

- **Protection against external interference** Every GMS shall be designed, manufactured and installed such that interference or tampering capable of affecting accuracy is discouraged and is readily detectible.

Every GMS shall be capable of performing accurately and consistently in the physical, chemical and thermal conditions it is likely to be subjected to and fulfil correctly its purpose throughout its service life.

Electrical and electronic components of the GMS shall be capable of meeting the MPEs in table 2 and 3[17] when subjected to foreseeable short term fluctuations in electrical supply; mains borne or radiated high frequency signals or electrostatic discharge. (Electronic devices must meet the electromagnetic compatibility requirements under the Telecommunications Act 2001).

NZS 5259 2.3 - Specific suitability requirements

- **Meters and conversion devices** shall be accurate and verifiable to the MPEs in table 2 and 3.
- **Temperature and pressure measurement devices** shall accurately represent the temperature or pressure experienced by the volume measurement device.
- **Indicating elements** shall have an indicator with sufficient capacity/capability.
- **Regulators used to control meter pressure where a fixed pressure factor is applied** shall maintain the meter pressure to ensure the MPEs in table 3 are not exceeded.
- **Filters, flow conditioning and flow restrictors** shall be suitable for the purpose.

[17] NZS 5259 Tables 2 and 3 are reproduced in the section on testing requirements

6. GMS operation and maintenance

This chapter describes the basic requirements for the operation and maintenance of GMSs located on transmission and distribution systems.

6.1 Transmission GMS operation and maintenance

The basic provisions of MPOC Schedule 1 and the Vector Metering Requirements relating to GMS operation and maintenance are:

Failed meters are to be notified

At all stations, where the meter owner becomes aware the meter or any gas measurement device has failed, malfunctioned or become inaccurate, it shall immediately notify, for MDL, the pipeline owners, and for Vector, the affected parties. The meter owner shall then investigate the fault and repair or replace any faulty equipment.

(MPOC Schedule 1 s2.20 and Vector Metering Requirements s1.20)

Flow computers are to have 'fall-back' values

Every flow computer using the output of a gas analyser to calculate gas quantities shall be programmed to use 'fall-back' values in the event that the analyser fails or becomes inaccurate and to flag the quantities calculated accordingly. As soon as practical once aware of the problem, the meter owner shall advise the pipeline owners; repair or replace the analyser and calculate revised gas quantities (where required by part 4). For Vector, the meter owner shall notify other affected parties.

(MPOC Schedule 1 s2.21 and Vector Metering Requirements s1.21)

6.2 Distribution GMS operation and maintenance

The basic provisions of NZS 5259 relating to GMS operation and maintenance are:

GMS components are to be operated and maintained to ensure overall accuracy as required by tables 2 and 3

Performance of GMS components and populations of GMS components shall be monitored to ensure that in-service performance requirements of tables 2 and 3 are met.

(NZS 5259 s1.2.6)

Plans and procedures for safe operation are to be described, documented and implemented

(NZS 5259 2.1.5)

The on-going performance of meters and conversion devices are to be monitored for accuracy

(NZS 5259 2.5 through to 2.5.2)

There will be a preventative maintenance programme for all GMSs based on regular inspections and reported faults

(NZS 5259 2.5.3 and 2.5.4)

7. GMS testing

This chapter describes the basic requirements for testing of GMSs located on transmission and distribution systems.

7.1 Transmission GMS testing

The basic provisions of MPOC Schedule 1 and the Vector Metering Requirements relating to GMS testing are:

Meters are to be tested prior to installation

Prior to the installation of any primary meter, the metering owner will procure that:

- every primary meter shall be tested by the manufacturer, using atmospheric pressure and a calibration air curve (a graph of uncertainty versus flow rate) generated in a manner consistent with NZS 5259.
- every primary meter for a large station is tested by the manufacturer using natural gas at the meter's expected operating pressure, or as close as any testing facility available allows. If the meter will operate over a pressure range it shall be calibrated using natural gas at two or more pressures within the expected range. A calibration 'natural gas curve' (a graph of uncertainty versus flow rate) shall be generated for each test pressure and kept on record.

(MPOC Schedule 1 s3.2; Vector Metering Requirements s2.1)

In addition to the above, MDL also requires, where necessary, that a primary meter is adjusted and re-tested until it complies with the manufacturer's normal accuracy requirements for the type of meter and the accuracy requirements of MPOC Schedule1 s3.2 (i):

- A meter shall be deemed to be accurate if its uncertainty against calibration standard is no more than:

MDL Meters pre-installation testing against calibration standard	Large stations	Small stations
Between Qmin and Qmax	+/- 0.8 %	+/- 1.5 %

Vector requires the meter owner shall procure that the meter complies with the manufacturer's normal accuracy requirements and the accuracy requirements of Vector Metering Requirements 2.1 (a) (v):

Vector Meters pre-installation testing against calibration standard	**Large stations**	**Small stations (with non-rotary meters)**
Between Qmin and **20%** Qmax	+/- 1.5 %	+/- 2.5 %
Between **20%** Qmax and Qmax	+/- 0.8 %	+/- 1.5 %
		Small stations (with rotary meters)
Between Qmin and **10%** Qmax	n/a	+/- 2.5 %
Between **10%** Qmax and Qmax	n/a	+/- 1.5 %

Provided that the difference in uncertainty between the air curve and the natural gas curves is minor across the operating range of the primary meter, the air curve shall be deemed to provide an accurate accuracy benchmark in any future recalibration testing. (For Vector, 'minor' is specified as 0.5%).

Each calibration test shall include testing the meter at flow rates corresponding to Qmin (or 0.05 x Qmax if no Qmin is specified) Qmax and at least 3 flow rates in between. (MPOC Schedule 1 s3.2 (c) and Vector Metering Requirements s2.1(iv))

In the case of a primary meter, such as an ultrasonic, where a pre-installation low pressure air test is not feasible, regular re-validation testing at the meter's normal operating pressure shall be undertaken. The metering owner shall consult a suitable standard regarding re-validation testing such as AGA9. (MPOC Schedule 1 s3.2(d) and Vector Metering Requirements 2.1(c))

Meters in service are to be regularly tested on site

At 3-monthly intervals for large stations and 12-monthly intervals at small stations, each primary meter shall be operated in series with a verification meter for at least one continuous hour at normal flow conditions. Prior to such test, the pressure and temperature transducers associated with the verification meter (or the corrector, where a corrector is fitted on the Vector system) shall be calibrated. (MPOC Schedule 1 s3.2(e) and Vector Metering Requirements s2.1(d))

If, as a result of testing the primary meter in series with the verification meter, the primary meter is found to have uncertainty with respect to the verification meter of more than the percentage difference shown below, then the pressure and temperature transducers (and for Vector, where a corrector is fitted, the corrector) will be recalibrated and the test repeated. If, after re-testing, the uncertainty is still outside the limits, the primary meter will be removed for testing (for Vector 'as-found' testing and for MDL 're-calibration' testing). (MPOC Schedule 1 s3.2(f) and Vector Metering Requirements s2.1(e))

Vector and MDL in service meters - in series with verification meter	Large stations	Small stations
Between Qmin and Qmax	+/- 1.5 %	+/- 2.0 %

Meters found inaccurate on site are to be removed for further testing

The as-found/re-calibration testing shall be conducted using natural gas at the meter's normal operating pressure in accordance with the manufacturer's procedures. The meter shall be adjusted and re-tested until the uncertainty is as close as practicable to its pre-installation natural gas curve. (MPOC Schedule 1 s3.2(g) and Vector Metering Requirements s2.1 (f))

Where a high pressure natural gas testing facility is not available in New Zealand[18], or the meter is a turbine or rotary meter, or the meter is installed at a small station, then any as-found/re-calibration testing may be done using air at atmospheric pressure. The meter shall be adjusted and re-tested until the uncertainty across its operating range is as close as possible to its pre-installation curve. (MPOC Schedule 1 s3.2(h) and Vector Metering Requirements s2.1(g))

For MDL, the uncertainty is accurate to the same standard as for pre-installation testing. (MPOC Schedule 1 s3.2(i))

MDL Meters Re-calibration testing Against calibration standard	Large stations	Small stations
Between Qmin and Qmax	+/- 0.8 %	+/- 1.5 %

[18] There is currently no high pressure gas testing facility in New Zealand, so this testing is done using air at atmospheric pressure.

For Vector the uncertainty accuracy test standard is broader than for pre-installation:

Vector Meters **As-found testing** **Against calibration standard**	**Large stations**	**Small stations** **(with rotary meters)**
Between Qmin and **10%** Qmax	+/- 2.5 %	+/- 3.0 %
Between **10%** Qmax and Qmax	+/- 1.0 %	+/- 2.0 %
		Small stations **(with non-rotary meters)**
Between Qmin and **20%** Qmax		+/- 3.0 %
Between **20%** Qmax and Qmax		+/- 2.0 %

For Vector a primary meter is inaccurate if its uncertainty in as-found testing is outside the limits above. (Vector Metering Requirements s2.1(i))

A meter owner may remove a primary meter for as-found testing at any time. The meter owner may remove any turbine or rotary meter for as-found testing at intervals not exceeding those in Table 7 of NZS 5259. (Vector Metering Requirements s2.1(j))

For both MDL and Vector, at intervals of not more than 3 months for large stations and 12 months for small stations, where applicable to the type of meter, a primary meter's pulse outputs shall be tested to ensure the actual volume measured by the meter at flowing conditions matches the actual volume recorded by the flow computer. (MPOC Schedule 1 s3.2(j) and Vector Metering Requirements s2.1(k))

Pressure, temperature and density transducers are to be regularly tested

At intervals of no longer than 3 months (large stations) and 12 months (small stations), all transducers shall be tested and if necessary re-calibrated.

Testing of any transducer shall be carried out at its normal in-service operating condition, or, where applicable, at suitable representative points over its normal operating range, when the uncertainty will be the average across the range.

A transducer shall be deemed accurate if its uncertainty against an approved calibration standard is no more than:

Vector and MDL	
Pressure transducer	+/- 0.1 bar
Temperature transducer	+/- 0.4 degrees C
Density, base density and specific gravity	+/- 0.05 kg/cubic metre

(MPOC Schedule 1 s3.3 and Vector Metering Requirements s2.2)

For Vector, these provisions apply only to separate or external transducers such as those connected to flow computers, and not to any transducer built into a corrector. (Vector Metering Requirements 2.2)

For Vector, any transducer found to be operating outside the limits shall be deemed inaccurate and immediately re-calibrated and re-tested to operate within the limits. If this cannot be achieved, it shall be replaced as soon as practical by an accurate transducer. (Vector Metering Requirements 2.2(d))

Analysers are to be recalibrated regularly

The minimum frequency of gas chromatograph or other analyser calibration is weekly for self-calibration and monthly for manual calibration. The manufacturer's recommended calibration procedures apply and instrument grade or better helium shall be used as a carrier gas.

Only certified 'Alpha' standard calibration gas traceable to a certified testing laboratory shall be used. The composition of calibration gas shall be representative of the normal composition of gas passing through the metering. The calibration gas composition programmed into the analyser shall be checked at regular intervals.

Some accuracy standards differ between MDL and Vector:

- the difference between gross calorific value determined by the analyser for the calibration gas and the certified gross calorific value of the calibration gas is 0.1% for MDL, and 0.25% for Vector;
- the difference between the nett calorific value determined by the analyser for the calibration gas and the certified nett calorific value of the calibration gas is 0.1% for MDL and 0.25% for Vector;
- the un-normalised total of all components is to be within the range 98% to 102% for sample gas and 99% to 101 % for calibration gas, the same for MDL and Vector; and
- the difference between the base density determined by the analyser for calibration gas and the certified base density of the calibration gas (or calculated base density of the calibration gas where base density is not certified) is less than 0.1% for MDL and 0.25% for Vector.

(MPOC Schedule 1 s3.4 and Vector Metering Requirements s2.3)

Flow computers are to undergo regular checks

A base volume index (BVI) check will be carried out at intervals not exceeding one month for large stations, and 6 months for small stations to test that the flow computer is functioning correctly.

The BVI check consists of applying independently-calculated factors for pressure, temperature, compressibility and any other relevant parameters to the actual volume measured by each primary meter at flowing conditions over an appropriate period of time and comparing the 'as calculated' converted volumes with the converted volume determined by the flow computer.

(For Vector only, the difference between the flow computer converted volumes and the as-found converted volumes over the period of the test should not exceed +/-1.0%).

Inputs and outputs shall be tested at intervals not exceeding 6 months to verify integrity of data flows and that the flow computer is able to receive, process and transmit data accurately.

Internal programming shall be verified at intervals not exceeding 12 months, by downloading a copy of the program and comparing with a master copy kept in secure storage off-site.

Fall-back values of gas composition and properties for use if the analyser fails shall be reviewed at reasonable intervals and updated if necessary. (For Vector, this applies to large stations only).

(MPOC Schedule 1 s3.5 and Vector Metering Requirements s2.4)

Flow correctors are to undergo regular BVI checks and be routinely removed for testing

(Vector only)

At any station where a corrector is used (i.e., as an alternative to a flow computer with separate transducers), a BVI check shall be carried out at intervals not exceeding 6 months. The check shall consist of applying independently-calculated pressure and temperature corrector factors to the actual volume measured by the primary meter (assuming the corrector does not apply a compressibility correction factor) and comparing that calculated volume, the difference not to exceed +/- 1.2%.

At intervals not exceeding 2 years, each corrector shall be exchanged with a pre-certified replacement. A corrector shall be deemed accurate for pre-certified exchange if its uncertainty is within +/-0.8%.

The corrector removed will be subjected to as-found testing in accordance with NZS 5259, including an accuracy of registration test, as soon as practicable.

A corrector shall be deemed accurate if the as-found test is within +/- 1.2%.

(Vector Metering Requirements s2.5)

Signal transmission is to be tested

Testing as a 'loop' shall be required to detect and eliminate errors due to signal transmission and conversion (for example, analog to digital) within metering. An example test would be applying a calibration signal to the field device and reading the measured value at the flow computer.

(MPOC Schedule 1 s3.6; Vector Metering Requirements s2.6)

No data corrections are to be applied if equipment is within its accuracy range

If any gas measurement device is found to be accurate, it will be deemed to have been accurate throughout the period since the last test. To the extent that the uncertainty is not zero, it will be returned as close to zero as practical, but no data correction will be done.

(MPOC Schedule 1 s3.7; Vector Metering Requirements s2.7)

Metering maintenance is to be notified

For Vector, the metering owner will notify affected parties of any unscheduled maintenance, including what was tested, repaired, re-calibrated or replaced; and whether the testing found equipment to be accurate or inaccurate.

(Vector Metering Requirements s2.8)

For MDL, following any testing, the meter owner shall, if the testing was scheduled maintenance as defined in the Metering Operations Manual, advise the pipeline owners that such scheduled maintenance was carried out; otherwise the meter owner shall notify the pipeline owners what was tested and whether the testing found the equipment accurate or inaccurate.

(MPOC Schedule 1 s3.8)

7.2 Distribution[19] GMS testing

The basic provisions of NZS 5259 relating to GMS testing are:

All components of a GMS that may affect accuracy are to pass acceptance testing prior to installation

For meters, acceptance testing shall confirm identity, gas tightness, and accuracy of registration. The acceptance test comprises:

(a) identification test (NZS 5259 s3.4.5.1);

(b) external leakage test (NZS 5259 s 3.4.5.4);

[19] The standard also provides specific requirements for testing equipment and test areas in its appendices (Requirements of testing equipment and test area 2.3.5)

(c) accuracy of registration test (NZS 5259 s 3.4.5.6); and

(d) internal leakage test (NZS 5259 s 3.4.5.9).

For conversion devices, acceptance testing shall confirm identity and accuracy of conversion.

(NZS 5259 s1.2.4)

All components of a GMS that may affect the accuracy shall pass an acceptance test:

- before a new device is placed in service;
- if anything that may affect its accuracy has occurred; and
- before a device is returned to service if 12 months has elapsed since acceptance testing.

(NZS 5259 s2.3.1)

The acceptance test for meters comprises:

- identification test;
- external leakage test;
- accuracy of registration test; and
- internal leakage test.

(NZS 5259 s2.3.3.1)

The acceptance test for conversion devices comprises:

- identification test and
- accuracy of conversions test.

(NZS 5259 s2.3.4.1)

An as-found test may serve as an acceptance test if all the tests specified for an acceptance test were carried out and no repairs, maintenance or adjustment which would affect the calibration of the meter or conversion device have been carried out subsequently.

(NZS 5259 s2.3.7)

Meters and conversion devices removed from service are to be subject to as-found testing

(NZS 5259 s2.3.2)

The as-found test for meters comprises an accuracy of registration test.

The as-found test for conversion devices comprises an accuracy of conversion test.

(NZS 5259 s2.3.3.2 and s2.3.4.2)

NZS 5259 – **Table 2** Maximum permissible errors for meters (% of reading)

Meter capacity	**Range**	**Maximum Permissible Errors**	
		Initial	**In-service**
G16 and smaller ($Q_{max} \leq 25$ m^3/h)	$Q_{min} \leq Q < 0.1\ Q_{max}$	±3.0%	–6.0%, +3.0%
	$0.1\ Q_{max} \leq Q < Q_{max}$	±1.5%	±3.0%
Above G16 ($Q_{max} > 25$ m^3/h)	$Q_{min} \leq Q < Q_t$	±2.0%	±3.0%
	$Q_t \leq Q < Q_{max}$	±1.0%	±1.5%

NZS 5259 **– Table 3** Maximum permissible errors for conversions (% of conversion)

Conversion type	Maximum Permissible Errors			
	Initial		**In-service**	
	Reference conditions (1)	**Rated operating conditions (2)**	**Reference conditions (1)**	**Rated operating conditions (2)**
Electronic conversion device				
Temperature	±0.5%	±0.7%	±0.7%	±1.2%
Temperature and pressure	±0.5%	±1.0%	±1.0%	±1.3%
Temperature and pressure and compressibility	±0.5%	±1.0%	±1.2%	±1.5%
Fixed factor				
Temperature	±0.7%	±0.9%	±0.9%	±1.1%
Pressure	±0.7%	±0.9%	±0.9%	±1.1%
Altitude Meter pressure ≤ 100 kPa	±1.0%	N/A	±1.0%	N/A
Altitude Meter pressure > 100 kPa	±0.5%	N/A	±0.5%	N/A
Compressibility Meter pressure ≤ 500 kPa	±0.2%	N/A	±0.2%	N/A
Compressibility Meter pressure > 500 kPa	±0.25%	N/A	±0.25%	N/A
Calorific value	±0.5%	N/A	±0.5%	N/A

NOTE –

(1) Condition of use prescribed for testing the performance of a measuring device for inter-comparison of results of measurements.

(2) Values for the measurand (pressure, temperature, compressibility as applicable) and influence variables (ambient temperature, humidity, battery voltage, and so on) making up the normal operating conditions of the device.

(3) For temperature and pressure conversion MPEs are relative to absolute temperature and pressure.

(4) The estimated uncertainty of measurement of the test facility need not be applied to the MPEs.

(5) When fixed factors are used to convert the measured volume to the volume at standard conditions the combined MPEs shall not exceed ±1.5%.

8. GMS documentation

This chapter describes the basic requirements for GMS-related documentation on transmission and distribution systems.

8.1 Transmission GMS documentation

The basic provisions of MPOC Schedule 1 and the Vector Metering Requirements relating to GMS documentation are:

A metering operations manual is to be compiled and kept updated

The metering owner shall compile a 'Metering Operations Manual' and provide the pipeline owners a copy for approval prior to commissioning of any metering. As a minimum this shall include:

- design specifications for all devices and systems forming a part of the metering, as well as the metering as a whole;
- manufacturer's data for all devices, including their operating ranges;
- pre-installation test records and calibration certificates;
- maintenance plans;
- details of meter verification plans including the type and frequency of testing;
- details of fault detection and alarm systems;
- details of how and when the metering owner will respond to alarms, breakdowns and malfunctions;
- and, for Vector, a list of recommended spare parts and a hazardous area inspection dossier.

The metering owner shall keep the manual up to date and reissue it as required.

(MPOC Schedule 1 s2.22 and Vector Metering Requirements s1.22)

The meter owner is to keep records of all testing

All records of pre-installation calibration testing of primary meters are retained by the metering owner for the life of the meter.

(MPOC Schedule 1 s3.2 and Vector Metering Requirements s2.1)

The metering owner shall retain records of all testing for not less than 5 years and provide, for MDL, the pipeline owners and for Vector the affected parties, with copies on request.

(MPOC Schedule 1 s3.9 and Vector Metering Requirements s2.9)

8.2 Distribution GMS documentation

The basic provisions of NZS 5259 relating to GMS documentation are:

Records are to be kept for all GMS components and complete systems

The records for the GMS components shall include:

- the suitability of all gas meters, conversion devices, regulators, filters, flow conditioning devices, flow restrictors, temperature measurement elements and pressure measurement elements
- acceptance testing, installation, operating conditions and maintenance of the components of the GMS
- information for each type of regulator used including the ranges of operating conditions for which it is suitable and its performance over those conditions
- the results of acceptance and as-found tests
- the date and details of all maintenance

In relation to each complete GMS, records shall be kept detailing all inspections, maintenance and changes to components. This shall include:

- The identity, location and date of installation of each installed component
- Periodic maintenance test results, including time, date, operator
- The next scheduled date for maintenance
- The next scheduled date for test or replacement

NZS 5259 1.2.8, 2.2.6, 2.6.1 and 2.6.2

A record of the factor is to be kept where a fixed factor is applied

NZS 5259 2.7.3.2

There is to be documented procedures for the conversion of volume to energy

NZS 5259 2.7.5

Competency of persons involved in critical GMS activities is to be described and documented

NZS 5259 1.2.9 and 2.8

Management policies to ensure safe management and operation are to be recorded and reviewed

NZS 5259 2.1.5

Records of testing procedures and test results are to be kept

NZS 5259 2.3.3, 2.3.4 and 2.3.9

The results of monitoring the on-going performance of meters and conversion devices for accuracy are to be documented

NZS 5259 2.5 including 2.5.3.6

9. Auditing

The two transmission codes do not have any specific GMS audit requirements. Both codes have a general right for any participant to request an audit if that participant has a concern about any aspect of the application of the respective operating codes. In practice this right is seldom exercised.

The Gas (Downstream Reconciliation) Rules 2008 have auditing provisions intended to ensure that allocation participants comply with the Rules. Event audits can be commissioned for instances where there is a particular issue that needs investigating, such as abnormally high levels of unaccounted-for gas. In such a case, it is likely that the auditor would want to examine the installation and maintenance records of GMSs that could be contributing to the problem.

Laboratories that undertake GMS testing are subject to audit to achieve their International Accreditation New Zealand accreditation, but this has a relatively narrow focus and does not extend to the design and installation of meters or other activities undertaken by technicians in the field.

NZS 5259 s2.10 provides that: *'Requirements for audit and review in order to verify compliance with this standard shall be described, documented, and implemented.'* NZS 5259 Appendix C provides an extensive audit checklist. It is for the documents that reference the Standard to specify how often, and by whom, an audit should be conducted.

Large Station	A defined term in the MPOC and VTC essentially referring to a station with a maximum design flow rate of more than 5,000 scm/hr.
ICP	An installation control point, being the point at which a consumer installation is deemed to have gas supplied.
Open Access Transmission Information System (OATIS)	The web-based system by which the gas transmission businesses of MDL and Vector interact with the pipeline users to operate their open access regimes. Many of the documents referred to in this document can be found on either the Vector public pages of OATIS, known as the Vector Information Exchange (Vector IX), or the MDL public pages, known as the Maui Information Exchange (Maui IX).
Small Station	A defined term in the MPOC and VTC essentially referring to a station with a maximum design flow rate of less than or equal to 5,000 scm/hr.
Points of transfer	Where gas moves from one system to another, including from gas producer to transmission system; from transmission system to a major user or distribution network (gate station), or from distribution system to end user (ICP)
Time of Use (ToU)	Refers to gas measurement systems that record the gas quantities that have passed during fixed time intervals, such as every hour or every day. These quantities are recorded on a data logging device.
Welded Party	A defined term in the MPOC meaning the owner of assets that are physically connected to the Maui pipeline at a Welded Point.
Welded Point	A defined term in the MPOC. A Welded Point may be a location where physical assets owned by another party interconnects with the Maui pipeline (a Physical Welded Point), or a location where a gas trading market is located on the Maui pipeline (a Notional Welded Point).

Appendix A Governance of this Document

Gas Industry Co wishes this document to accurately reflect the views of industry participants on what the requirements for gas reconciliation are and how they are managed. It is also necessary to provide arrangements that allow any participant to propose changes, to have that proposal considered and for a new version of the document to be issued if required. These arrangements are described in this Appendix.

Proposing changes

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.

Processing proposed changes

On receiving a request to change the document, Gas Industry Co will discuss it with the proposer and seek comment from industry experts before making any changes.

Issuing a revised document

Gas Industry Co will decide whether the document should be changed or not but, regardless of its decision, it will maintain a register of all proposed changes together with a summary of any issues arising. When reissued, the document will be given a revision number and a table of revisions will be included in the document.