MANUAL

NORTHERN GAS PIPELINE MEASUREMENT MANUAL

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1 INTRODUCTION AND SCOPE

This manual is designed to provide a technical reference for the operation and maintenance of the gas measurement and monitoring systems on the Northern Gas Pipeline (NGP).

The manual includes general detail of the overall measurement system and equipment, as well as the philosophies used to develop the site specific instructions:

- Validation and calibration of measurement equipment.
- Analysis of validation data.
- Adjustment of measured flow quantity.

Other aspects of the measurement process, such as billing, system auditing, and billing adjustments are not included in this document and are covered by the Pipeline Commercial Management Team and the Control Room. This manual is not intended to provide specific details of Gas Sales Contract terms and conditions.

1.1 SCOPE

This manual applies to all Jemena operated custody transfer metering facilities on the NGP extending from the Phillip Creek Compressor Station (PCCS) through to the Mt Isa Compressor Station (MICS). Table 1.1 and Figure 1.1 provide an overview of the measurement facilities currently maintained on the NGP.

Inspection and testing of both the fiscal and non-fiscal measurement equipment is addressed in this manual.

Table 1.1 NGP Metering Facilities

Location	Meter Type	Meter Runs	Pipe Dia. (mm)	Flow Computer	Temperature Transducer	Pressure Transducer	SCADA	Gas Chromatograph
Phillip Creek	Ultrasonic	Dual	200	☑	☑	☑	☑	☑
Mount Isa	Ultrasonic	Dual	200	☑	☑	☑	☑	☑

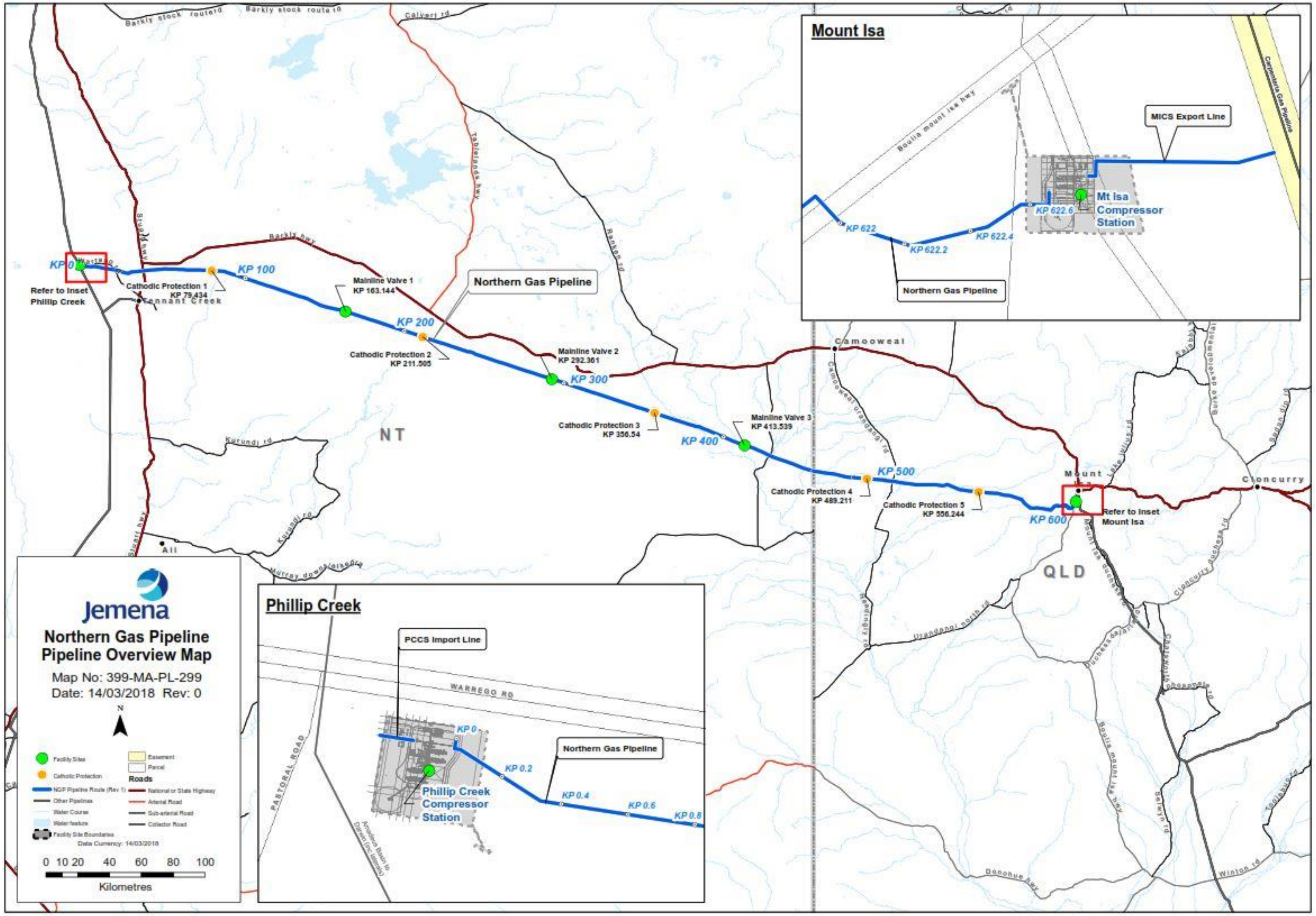


Figure 1.1 NGP Facility Overview Map

1.2 TERMINOLOGY & DEFINITIONS

1.2.1 TERMINOLOGY

Unless otherwise stated, all units and terminology used are in accordance with:

- Australian Standard AS ISO 1000-1998 "The International System of Units (The SI System) and Its Application" and regulations thereunder
- Commonwealth "Weights and Measures (National Standards) Amendment Act 2013 including Regulations
- Australian Gas Association publication "Metric Units and Conversion Factors for use in the Australian Gas Industry"

To ensure the technical integrity of various standards and software sourced internationally, conversion factors commonly used and accepted in the Australian gas pipeline industry are used.

1.2.2 DEFINITIONS

AGA 3	American Gas Association Report No 3, Orifice metering of natural gas and fluids measurement. Part 3, natural gas applications ANSI / API 2530 August 1992, together with all appendices thereto.
AGA 7	American Gas Association Transmission Measurement Committee Report No. 7 Measurement of Gas by Turbine Meters Second Revision April1996 together with all appendices thereto.
AGA 8	American Gas Association report No 8 for calculation of super compressibility of natural gas Second Edition November 2003
AGA 9	American Gas Association Transmission Measurement Committee Report No. 9 Measurement of Gas by Multipath Ultrasonic Meter Second Edition April 2007
AGA 11	American Gas Association Transmission Measurement Committee Report No. 7 Measurement of Gas by Coriolis Meter October 2003
Calibration	To determine the accuracy of a measurement instrument
Calibration Gas	The gas used by a Gas Chromatograph to calibrate against known mole percentage values
Contract(s)	The various agreements for the purchase and transport of gas via the Northern Gas Pipeline
Control	A function of Jemena in monitoring the Pipeline via the SCADA system and in executing the necessary actions and directives to ensure the effective receipt, transportation and delivery of gas to the Purchasers.
GT Control	The place where gas transmission control occurs.
Custody Transfer	The transfer of responsibility for the care and keeping of the gas.

Delivered	Gas having left the pipeline at the delivery point/s specified in the relevant contract as the point of transfer of custody of the gas from Jemena to the relevant shipper.
Delivery Point	A defined location for gas to leave the pipeline
Energy	The volume of gas in standard cubic metres multiplied by the Gross Heating Value (GHV). Standard units are Gigajoules (GJ).
Energy Accounting	The determination of all quantities of gas added to or subtracted from and remaining in the Jemena Pipeline system each Gas Day and the determination of the energy content of all such quantities of gas.
Gas	Any naturally occurring mixture of one or more hydrocarbons in a gaseous state, and zero or more of the gases hydrogen sulphide, nitrogen, helium and carbon dioxide, and the residue gas resulting from the treating or processing of the natural gas.
Gas Day	Is the Gas day starting at 6am AEST and ending 24 consecutive hours later at 6am AEST.
Gas Used	Amount of gas calculated by Jemena to have been consumed by Jemena in normal pipeline operations such as fuel for heaters, venting and instrument gas consumption, and will include compressor fuel in later years.
Gigajoule (GJ)	10^9 Joules
GPA 2172	Gas Processors Association Standard 2172-84 (or subsequent revisions), and is the method used to calculate Gross Heating Value, Specific Gravity and Super compressibility of natural gas mixtures from compositional analysis.
Gross Heating Value(GHV)	**Higher Heating Value** (HHV) shall mean the energy produced by the complete combustion of one cubic metre of gas with air, at a temperature of 15 degrees Celsius and at an absolute pressure of 101.325 kPa, with the gas free of all water vapour, and the products of combustion cooled to 15 degrees Celsius, the water vapour formed by combustion condensed to the liquid state, expressed in MJ per standard cubic meter (MJ/scm).
Imbalance	Exists in relation to an agreement if there is a difference on any day between the quantities of gas received by the access provider at a receipt point/s for a facility user's account and the quantities of gas delivered to or on account of the facility user at the delivery point/s.
Input Quantity	The total of all gas received into the pipeline for a given Gas Day, as measured by the inlet meters.
ISO 6976	Natural Gas calculation of Calorific values, density, relative density, and Wobbe index from Composition.

Jemena Owned Gas	The quantity (in GJ) of gas in the pipeline equal to the difference between linepack and imbalance.
Joule	The energy expended or the work done when a force of one Newton moves the point of application a distance of one metre in the direction of that force.
Kilopascal(kPa)	One thousand pascals and is by definition a measure of absolute pressure. It is sometimes convenient for instrument calibration to use the term “kilopascal gauge” (kPag). This means that the gauge reads zero at atmospheric pressure.
Linepack	The calculated quantity of gas contained in the pipeline at a given point in time (which is necessary for physical operation of the pipeline, excluding System use gas).
Measurement Authority	The Pipeline Owner
Measuring Equipment	Includes but is not limited to the pipeline owner’s meters, temperature and pressure transmitters, flow computers and gas chromatographs.
Megajoule(MJ)	10^6 Joules
Month	A period extending from the beginning of the first day in a calendar month to the beginning of the first day in the next calendar month.
Off-specification Gas	Gas other than Sales Specification Gas
Output Quantity	The total amount of gas delivered by the pipeline in a given period as measured by the meters at pipeline outlet locations.
Petajoule(PJ)	10^{15} joules
Pipeline	The pipeline licensed under Pipeline Licence No. 30 pursuant to the Petroleum Act
Pipeline Controller	An employee of Jemena working at the Pipeline Control Centre in Melbourne
Pipeline Inlet	The location(s) at which gas enters the pipeline, specified in the relevant contract as the point of transfer of custody of the gas from the relevant supplier to the shipper and simultaneously and instantaneously from the shipper to the pipeline owner.
Pipeline Outlet	The location at which gas leaves the pipeline, specified in the relevant contract as the point of transfer of custody of the gas from the pipeline owner to the shipper.
Pipeline Owner	Jemena
Quantity	The quantity of gas measured in terms of its energy content.

Queensland Gas Regulations	Includes Gas Supply Act 2003, Petroleum and Gas (Production and Safety) Act 2004, National Gas (Queensland) Act 2008, Energy and Water Ombudsman Act 2006.
Received	Gas having entered the pipeline at the inlet receipt point specified in the relevant contract as the point of custody transfer from the supplier to the shipper.
Reconciliation	The process through which Jemena conducts an energy balance at the end of each Gas Day, and allocates any metering discrepancies in an agreed manner.
Sales Specification Gas	Gas, which meets all of the agreed requirements for content and properties as set out in Table 1.
SCADA	Supervisory Control and Data Acquisition and refers to the electronic means of receiving remote data and of sending remote control signals and data to pipeline facilities from the Melbourne Control Centre.
Shipper	An entity receiving transportation service on the pipeline pursuant to an effective Transportation Service Agreement (also known as the “facility user” or, in certain circumstances, “access provider” under the Pipeline Access Principles).
Specific Gravity	The density of dry gas divided by the density of dry air, both at 15° C and at a pressure of 101.325 kPa.
Speed of Sound	The speed of sound for a particular gas composition
Standard Cubic Metre of Gas	The unit of volume of gas free from water vapour, which would occupy a volume of one (1) cubic metre at a temperature of 15° Celsius and an absolute pressure of 101.325 kilopascals.
Standard Measurement Conditions	Defined as 101.325 kPa and 15° Celsius
Straightening vanes	Tubes found upstream of the metering device to induce laminar flow
Super compressibility	A factor expressing a deviation of a gas from perfect gas laws
Supplier	The party contracted by a shipper to supply gas at any of the pipeline inlets for transport in the Northern Gas Pipeline
System Use Gas	The quantity of gas used in the operation of the pipeline, including, fuel gas and lost or unaccounted for gas.
Terajoule(TJ)	10^{12} joules
Validation or "**Verification**	The process of periodically checking and servicing the measurement equipment to ensure that it continues to function within agreed levels of accuracy.

Wobbe Index	The calorific value of the gas on a volumetric basis, at specified reference conditions, divided by the square root of the relative density of the gas at the same specified metering reference conditions.

2 GAS VOLUME MEASUREMENT

2.1 OVERVIEW

Jemena is the Measurement Authority for the NGP with responsibility for measurement and reconciliation of gas received and delivered on the NGP. Generally, Jemena owns, operates and maintains flow and gas quality measuring equipment at Receipt and Delivery Points on the pipeline. Where Delivery or Receipt Point measurement equipment is owned or operated by a 3rd party, they will be maintained in accordance with this manual and Jemena requirements or as otherwise agreed.

Monitoring of flow is achieved using the SCADA system, a communications link provides the Melbourne Control Room date from the onsite measurement equipment at each receipt and delivery points.

Measured flow is corrected for temperature and pressure to produce instantaneous volumetric and energy based flow rates at standard conditions and gas composition in the on-site flow computer. The on-site flow computer maintains an accumulated record of volume and energy passing through the meter. In conjunction with line pack calculations, the accumulated quantities are used for the daily reconciliation and balancing of the pipeline.

Shipper delivery points have Ultrasonic metering systems, which include compensation of energy flow for temperature and pressure.

The schematic shown below identifies and links the key repeated components.

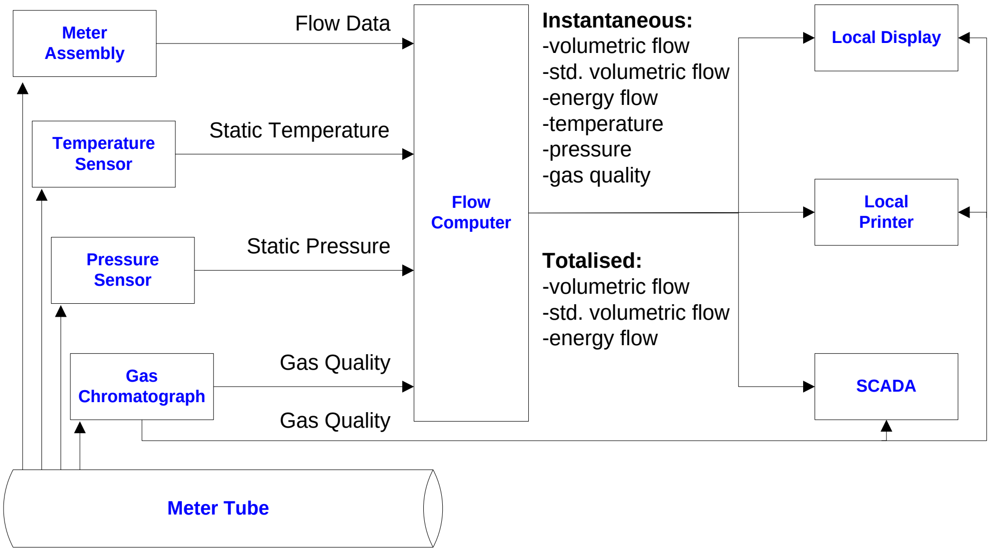


Figure 2.1 Measurement Facility Schematic

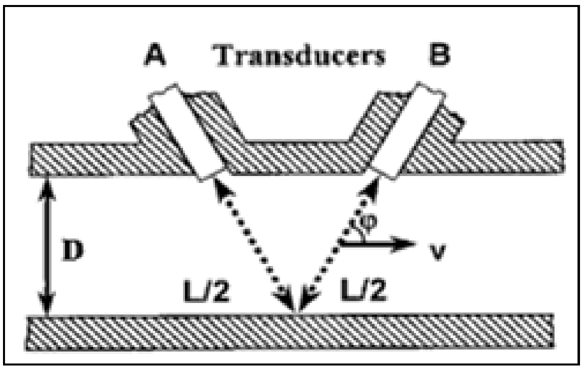
2.2 METER ASSEMBLY

The meter assembly measures dynamic flow properties for use in the calculation of volumetric and energy flow. Jemena uses Ultrasonic type meters on the NGP for custody transfer metering.

2.2.1 ULTRASONIC METERS

The Ultrasonic meter measures the difference in time taken for sound waves to travel in the gas stream between up and downstream-paired transducers. Ultrasonic sound pulses are launched in each direction (as shown in Figure 7), their time of transit is measured, and the difference can be related to the speed of flow in the pipe. Ultrasonic meters have several sound wave paths through the gas in the pipe. Algorithms are used to derive the average flow velocity and determine if swirl or turbulence is present. The actual volumetric flow rate is calculated from the average velocity and the internal diameter of the meter.

The Flow computer converts the actual volumetric flow rate to volumetric flow rate at Standard Conditions and Energy flow rate using inputs from pressure and temperature sensors and gas quality data.



D = Diameter of pipe

A & B = Transducers

L = Ultrasonic wave path distance

φ = Angle between pipe axis and acoustic path

V = Velocity of gas

Figure 2.2 Ultrasonic Meter Schematic

Ultrasonic meters are installed, operated and maintained as per the requirements of the American Gas Association (AGA) Report No. 9, latest edition, and the manufacturers installation, operating and maintenance manual.

Periodic checks, called validations, are carried out to confirm the accuracy and integrity of the meter set. This includes checks of the Automatic Gain and Level Control, correct ultrasonic pulse rate and velocity of sound. This data indicates if any of the ultrasonic paths are fouled, the meter is subject to external noise or any of the ultrasonic transducers are deteriorating. Monitoring of the measured velocity of sound will show if there is any change in a critical dimension or the reference clock has drifted. Checks and calibration of temperature and pressure transmitters are also carried out during a validation.

On-line diagnostics continuously monitor the performance of the meter. These diagnostic checks help to locate any metering discrepancies. Once identified, a discrepancy is investigated by Jemena field staff. Metered data validations will be initiated to prove metering at any site as dictated by the field investigation.

Where possible, delivery point meters will be operated in series with a nominated duty meter and stand-by meter.

- Sick Flowsic600 ultrasonic meters are used on the NGP metering facilities.

2.3 TRANSMITTERS, SENSORS AND RESISTANT TEMPERATURE DETECTORS

Transmitters, Sensors and Resistance Temperature Detectors (RTD) are mounted with each meter assembly depending on site requirements. They are used in the calculation of the correction factor which, converts the ‘gross’ metered flow to a net volume at standard measurement conditions.

2.3.1 STATIC PRESSURE TRANSMITTER

The static pressure transmitter is comprised of a simple diaphragm of which one side is exposed to pressure. The amount of pressure placed on this diaphragm provides a corresponding distortion, which can be measured to give a static pressure reading. The static pressure sensing lines are leak tested and the transmitter is calibrated across its range. The flow computer displays pressures are then compared to known test values.

Accuracy of the Static pressure sensor and flow computer inputs are checked periodically as part of routine validations. The pressure sensors are mounted on each meter assembly. The static pressure is used in the calculation, which converts the ‘actual’ metered volumetric flow to a volume flow at standard conditions.

The transmitter transfers the sensor reading digitally via HART protocol. This increases metering accuracy by reducing uncertainties introduced by the isolating barriers and RTU A/D modules. For this reason HART communications is the preferred communications protocol for fiscal pressure transmitters.

- Rosemount 3051 series Smart Pressure Transmitters are used on NGP

2.3.2 TEMPERATURE TRANSMITTERS

The temperature transmitters are calibrated using a certified resistance device. A known resistance is placed on the input to the transmitter and the expected temperature is compared to that indicated on the flow computer.

Accuracy of the temperature transmitters are checked periodically as part of routine validations. The transmitters are mounted on each meter assembly. The temperature is used in the calculation, which converts the 'actual' metered volumetric flow to a volume flow at standard conditions.

The transmitter transfers the sensor reading digitally via HART protocol. This increases metering accuracy by reducing uncertainties introduced by the isolating barriers and RTU A/D modules. For this reason HART communications is the preferred communications protocol for fiscal pressure transmitters.

- Rosemount 644 series Smart Pressure Transmitters are used on NGP

2.3.3 RESISTANCE TEMPERATURE DETECTORS

The operating principle of the Resistance temperature detector is relatively simple. A platinum wire is fixed within a probe positioned mid-stream in the pipe. The resistivity of a conductor is proportional to its' temperature. Hence, variation in gas temperature can be inferred from the variation in the measured resistance across the platinum wire. Flow computers monitor the resistance across the platinum wire and convert it to temperature for use in flow calculations.

Accuracy of the RTD and flow computer inputs are checked periodically as part of routine validations of gas analysis and energy accounting equipment.

- PT100 RTD are used on NGP.

2.4 FLOW COMPUTERS

The flow computer performs three main functions:

- Computation of volume and energy flow-rate
- Calculation of flow Accumulation registers
- Data transfer

Each ultrasonic meter is connected to a local flow computer, which receives and records the instantaneous values for all primary measurement inputs, i.e. volume flow signals from the meter as well as pressure and temperature information from the transmitters. From these inputs and along with the gas analysis, the flow computer continuously calculates the following:

- Instantaneous corrected volumetric flow
- Cumulative corrected volumetric flow
- Instantaneous uncorrected volumetric flow
- Cumulative uncorrected volumetric flow
- Supercompressibility factor

All flow computers accumulate volume and energy totals and calculations done by the flow computers are in accordance with recognised industry standards.

Gas quality data electronically downloaded to each flow computer includes:

- Higher (Gross) Heating Value
- Relative Density
- Nitrogen Content
- Carbon Dioxide Content
- Hydrocarbon Components

- Meter specific data

Inputs manually programmed into the flow computers are:

- Site specific Atmospheric Pressure
- Contract Base Pressure
- Contract Base Temperature

SCADA outputs from the computer are:

- Pressure
- Temperature
- Flow Rate
- Energy Rate
- Accumulated Flow
- Accumulated Energy
- Specific Gravity
- Heating Value
- Gas component data
- Yesterday’s energy
- Yesterday’s volume
- Contract energy accumulator
- Contract volume accumulator

Flow calculations are carried out as per the AGA standard appropriate to the metering apparatus. Supercompressibility is calculated for the purpose of flow correction as per the requirements of the AGA Report No. 8, second edition 1992.

2.5 COMPUTATION OF CORRECTED GAS VOLUMES AND ENERGY

Calculation of volumetric flow is specific to the metering system being used.

In general, however, the meter assembly is measuring the flow.

Ultrasonic meters measure the volume/mass of flowing gas directly.

The measured, line flow rate (m3) is corrected to standard conditions (sm3) using a correction factor based on the gas composition and the flow temperature and pressure.

The energy based flow rate (GJ/day) used in the daily operation of the pipeline is established by multiplying the calculated standard flow rate (sm3/hr) by the calculated Gross Heating Value (MJ/sm3) of the gas, and adjusting the time scale.

2.6 MEASUREMENT UNCERTAINTIES

The uncertainties in the Jemena custody transfer measurement system have been estimated and the results of the calculations are presented in the 399-RP-JJ-002 “Calculation of Measurement Uncertainties”.

All ultrasonic meters, used on NGP, comply with the National Greenhouse and Energy Reporting (Measurement) Determination 2008 Chapter 2, Part 2.3 Division 2.3.6 Section 2.35.

The “Wholesale Market Metering Uncertainty Limits and Calibration Requirements Procedures” document, as produced in accordance with the requirements of the National Gas Rules 2008 (Version 18) where by AEMO (Australian Energy Market Operator), was adopted for the assessment and benchmarking of the performance of the Jemena measurement facilities.

On the basis of the calculations, all Jemena custody transfer facilities on NGP can be declared as compliant with the AEMO uncertainty requirements for the volume and energy flow categories.

3 SYSTEM USE GAS MEASUREMENT

3.1 FUEL GAS MEASUREMENT

Fuel gas is used on the NGP facilities to power the following equipment:

- Compressor Units
- Emergency Power Generators (GEA)
- Hot Oil Heater

The consumption of the fuel gas, as measured by the Coriolis meters, is processed and corrected in the flow computers. The resulting information on the volumetric and energy consumption is monitored and recorded on continuous basis via the Jemena SCADA facilities.

In accordance with the Petroleum and Gas (Production and Safety) Regulation 2004 the meters must be re-calibrated or replaced either when a malfunction or loss of accuracy of the meter is detected or every 10 years

Each Coriolis meter is connected to a local electronic flow computer, which receives a mass flow signal from the meter. Volume at standard conditions and energy flow rates through the meter are calculated from this signal and the specific gravity of the gas provided by a gas chromatograph. From these inputs and along with the gas analysis, the flow computer continuously calculates the following:

- Instantaneous corrected volumetric flow
- Cumulative corrected volumetric flow
- Supercompressibility factor.

3.2 UNMETERED SYSTEM USE GAS MEASUREMENT

There are three categories of measured or calculated gas consumption. Facility Use Gas (FUG) and System Use Gas (SUG), and station blowdown volumes, for PCCS and MICS facilities.

NGP also has two categories of estimated gas consumption, Unaccounted for Gas (UAG) and flared gas.

FUG is gas measured or unaccounted for within the contractual boundaries of the Nitrogen Removal Service Agreement (NRSA) equipment. From a metering perspective the GTE equipment, hot oil package and Residue Compressors come under this category. Fuel consumption for the hot oil and Residue compressors is directly measured and will in large part comprise the total of FUG.

Flared and blown down gas will on occasion be material.

If system blowdown occurs, where a part or the whole of PCCS or MICS plant is shut in and vented, the station control system (SCS) will calculate the released inventory and add it to a station vented accumulators, and will be categorised as SUG and/or FUG, dependent on what portion of the station has been blown down.

If station flaring occurs at PCCS, this will appear in SUG, as an increase in UAG. Flaring can release material quantities of gas, and where this occurs continually for periods exceeding tens of minutes, this will appear as UAG.

Note that there are no unaccounted for calculations required for FUG.

SUG is gas measured or unaccounted for within the contractual boundaries of the Gas Transportation Agreement (GTA). This includes PCCS export compressors, PCCS GEA and balance of plant, unaccounted for gas in the NGP pipeline, gas flared, and all MICS consumption. All fuel gas users are directly measured.

Unaccounted for gas in the NGP is calculated using all gas consumers who are metered, the inlet and outlet custody transfer meters, and the change in linepack on the pipeline. UAG under normal circumstances is merely metering uncertainty and should net to zero over an extended period, especially as there is only one inlet and one outlet custody transfer metering skid of identical construction.

4 GAS QUALITY MEASUREMENT

4.1 GENERAL

Gas entering the inlet of PCCS must meet the specifications as defined in Schedule 4 of the Power & Water Corporation (PWC) Nitrogen Removal Services Agreement (NRSA), restated below in Table 4.1.

Gas exiting the Residue Compressors must meet alternate gas quality specifications under the PWC Gas Transportation Agreement (GTA), see table 4.2.

Jemena monitor the gas quality to ensure it meets these specifications.

4.2 NRSA RECEIPT SPECIFICATIONS

NGP gas quality limits that apply to gas receipted from the AGP, into PCCS, are stated in Table 4.1 below. Jemena is contractually obligated to flow, on behalf of its Shippers, only gas that meets the specification. It is the Shipper's responsibility to ensure that gas to be transported meets this specification at its Receipt Point(s).

Under the NRSA, Jemena is obligated to notify all Shippers if receipted gas is not meeting specification, and despite Jemena's best endeavours, Jemena cannot accept the gas. If Jemena does not notify shippers within 2 hours, Jemena is deemed to have accepted the gas, and accepts all liability for doing so, including damage to equipment.

If off specification gas is observed at PCCS inlet, immediate action is required to notify shippers, before any detailed assessment of acceptability under our best endeavours obligations is undertaken. Production can continue provided a breach of GTA gas specifications at the exit of the plant has not occurred. An immediate assessment of the capability of PCCS to process the off specification gas should occur, and if any risk of equipment damage is possible, the gas should not be accepted.

Table 4.1 NRSA Gas Quality Requirements

Item	Limits	
Gross Heating Value	Minimum	33.00 MJ/sm^3
	Maximum	42.00 MJ/sm^3
Wobbe Index	Minimum	44.00 MJ/sm^3
	Maximum	51.00 MJ/sm^3

Hydrocarbon Dewpoint	Maximum	2.0^{O} C at 3500 kPag
Water Content	Maximum	80.00 mg/sm^3
Oxygen	Maximum	0.20 mol%
Nitrogen	Maximum	11.00 mol%
Carbon Dioxide	Maximum	0.90 mol%
Total Inerts	Maximum	12.00 mol%
Hydrogen Sulphide	Maximum	10.00 ppm(wt)
Total Sulphur	Maximum	50.00 mg/sm^3
Mercury	Maximum	0.20 mg/sm^3
Solid Particulate Size	Maximum	10.00 Microns
Methanol	Maximum	1.00 mg/sm^3
Glycols	Maximum	1.00 mg/sm^3
Radioactivity	Maximum	8000.00 Bq/sm^3
Oil	Maximum	20 ml/TJ

4.3 GTA RECEIPT SPECIFICATIONS

Gas quality limits that apply to gas blended from the exit of the Residue compressors, which is blended with PCCS bypass gas, and is receipted into the Export compressors and hence into the NGP, has a different gas quality limit to the inlet from the AGP.

This interface, at the suction of the Export compressors, represents a boundary between the NRSA gas specification and the GTA specification. Gas receipted at this boundary must conform to the GTA specification, which is stated in Table 4.2 below.

If gas presenting at this interface breaches the GTA specification, Jemena must inform the NRSA shipper, that gas present at the inlet to the GTA breaches the GTA specification. This is a commercial process which occurs in parallel with Jemena taking action at site.

In practice this means that blending of GTE processed gas with PCCS bypass gas must always remain within the GTA limits. Gas entering from AGP is measured by the PCCS inlet GC and gas exiting the NRU is measured by the NRU outlet GC. Gas blending calculations are then used for the GTA gas quality.

As with the NRSA, Jemena is obligated to notify all Shippers if GTA receipted gas is not meeting specification, and despite Jemena's best endeavours, Jemena cannot accept the gas. If Jemena does not notify shippers within 2 hours, Jemena is deemed to have accepted the gas, and accepts all liability for doing so, including damage to equipment.

If off specification gas is identified at the GTA receipt point, it should immediately be sent to flare and not injected into the NGP. Gas cannot be accepted at the MICS delivery point if outside the GTA limits. In parallel commercial notifications should occur.

Table 4.2 GTA Gas Quality Requirements

Item	Limits

Gross Heating Value	Maximum	42.30 MJ/m^3
Wobbe Index	Minimum	46.0 MJ/sm^3
	Maximum	52.00 MJ/m^3
Hydrocarbon Dewpoint	Maximum	2.0^O C at 3500 kPag
Hydrogen Sulphide	Maximum	5.7 mg/sm^3
Total Sulphur	Maximum	50 mg/ sm^3
Water Content	Maximum	Dewpoint 0^o C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m^3)
Oxygen	Maximum	0.20 mol%
Total Inert Gases	Maximum	7.0 mol%
Oil	Maximum	20 mL/TJ

CONTAMINANTS

1. The gas shall not contain materials, dust, and other solid or liquid matter, waxes, gums, gum forming constituents, and unsaturated or aromatic hydrocarbons to an extent which might cause damage to, or interfere with the proper operation of, pipes, meters, regulators, control systems, equipment or appliances or which might cause the gas to be harmful or toxic to persons having contact with it in normal work operations or usage;
2. unsaturated or aromatic hydrocarbons to an extent that causes unacceptable sooting; or
3. other substances to the extent that they cause damage to, or problems in operation of, pipelines or appliances or that cause the products of combustion to be toxic, or hazardous to health, other than substances that are usually found in natural gas combustion products.

4.4 ON SITE ANALYSIS

Gas Chromatographs that sample line gas and separate the inert and hydrocarbon components to C6+ and C9+ are used to analyse the gas stream. Gas composition, specific gravity, heating value and Wobbe Index of the gas are determined.

The table below lists the properties measured and calculated from the on-site analysis.

Table 4.3 Output from Onsite Analysis

Measured On-Line	Calculated On-Line
Hydrocarbon breakdown to C6+	Gross Heating Value
Hydrocarbon breakdown to C9+ (PCCS)	Specific Gravity
Carbon Dioxide	Wobbe Index
Nitrogen	Hydrocarbon Dew Point
Gas Temperature	
Moisture Dew Point, Total Sulphur & Mercaptans (Periodic gas sampling / laboratory analysis)	

Live monitoring of the gas quality is enabled via the SCADA system. Output from the on-site measurement equipment is linked to the Melbourne Control Room. Alarms are triggered should the measured or calculated gas properties approach the limits specified.

4.4.1 CHROMATOGRAPHS

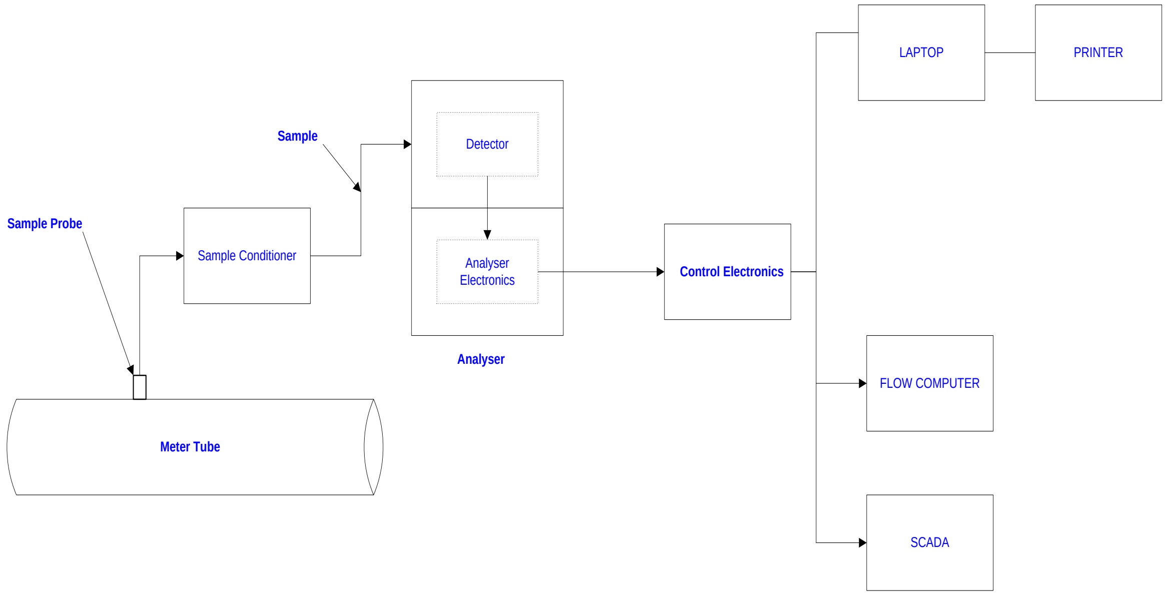
A small gas sample is retrieved from the pipeline at nominal intervals of 3 – 6 minutes. The sample is separated into its basic components and is analysed by the C6+ gas chromatograph, returning the following:

- Hexane Plus (C6+)
- Propane (C3)
- I-Butane (I-C4)
- N-Butane (N-C4)
- Neo-Pentane (Neo-C5)
- I-Pentane (I-C5)
- N-Pentane (N-C5)
- Nitrogen (N2)
- Methane (C1)
- Carbon Dioxide (CO2)

The C9+ chromatograph system analyses for the following components:

- Hexane (C6)
- Propane (C3)
- I-Butane (I-C4)
- N-Butane (N-C4)
- Neo-Pentane (Neo-C5)
- I-Pentane (I-C5)
- N-Pentane (N-C5)
- Nitrogen (N2)
- Methane (C1)
- Carbon Dioxide (CO2)
- Ethane (C2)
- Nonane+ (C9)
- Octanes (C8)
- Heptanes (C7)

Table 4.4 Gas Chromatograph System



Component analysis, in general terms, is achieved by passing the sample gas through a separation system. A thermal conductivity detector located at the outlet of the separator senses the change in conductivity as each component elutes from the column and outputs an electrical signal, proportional to the quantity and concentration passing across the sensor.

A microprocessor calculates the gas composition concentrations, Specific Gravity (real), Compressibility Factor, Higher Heating Value (real; dry basis), and the Wobbe Index. The basis of these calculations ISO 6976. These figures are supplied to the flow computers for correcting the meter data to standard volume conditions and calculating energy.

The chromatograph automatically calibrates itself every 24 hours using a reference gas custom-blended to be similar to the gas being transported. This reference gas is supplied with a certification of analysis. The certified mole% of each gas is entered into the chromatograph to allow self-adjustment on calibration. The spare calibration gas bottles are maintained to ensure a timely replacement of the empty bottles.

In addition, the chromatograph is checked as part of routine validations of metering equipment

Hydrocarbon Dew Point is calculated in the C9 + Gas chromatograph. The calculations are based on two empirically derived equations of state (Redlich Kong Soave and Peng Robinson) to predict the hydrocarbon dewpoint from the gas composition. The algorithms return the hydrocarbon dew point maximum temperature (cricondentherm) and the temperature at 4 other pressures.

- Rosemount Model 370XA (C6+) and Rosemount Model 770XA (C9+) are used on NGP.

4.4.2 OFF SPECIFICATION GAS

Off specification gas is gas, which does not meet the required standards

If a Shippers receipt gas does not meet specification Jemena may exercise its right to terminated receipt of gas from the Shipper.

Jemena will immediately notify the Shipper and the Shipper’s Supplier of such action.

The Shipper can recommence supply when they can prove to Jemena that receipt gas has been returned to within specification levels. Jemena will assist the Shipper, as is practicably possible, in proving of the gas quality of the Shippers receipt gas.

Once Jemena is satisfied that the Shipper's receipt gas is within specification then Jemena will recommence receipt of gas for that Shipper.

Any time the Shipper requires Jemena will carry out check calibration or other tests to prove the accuracy of its equipment in relation to off specification gas. If Jemena's equipment is found to be correct then the shipper shall bear associated costs for the testing of equipment.

5 METER CALIBRATION

All Ultrasonic meters, installed on NGP, must be flow-calibrated prior to their installation on site. This flow calibration must be adequate for the meter for the conditions where the meter will be installed. The Calibration certificates for these flow meters must be available for verification.

The Jemena Policy for the maintenance of metering equipment will specify flow meters replacement and/or re-calibration intervals. The replacement/re calibration intervals will be in accordance with the Jemena Engineering Assessments, relevant Australian and International Standards, and meter manufacturers recommendations.

Ultrasonic type of flow meters are equipped with extensive self-diagnostic capabilities, which, in combination with the regular meter validations, allow detection of any loss or drift of accuracy over time. The malfunctioning meter, once identified, is to be replaced with a suitably calibrated one.

6 VALIDATION

Validation is the process of ensuring the accuracy of the gas quality and energy accounting equipment and shall be performed periodically at each metering facility. The validations purpose is to assess the conditions of measurement equipment in order for it to function within agreed tolerances.

6.1.1 VALIDATION DOCUMENTS

The follow documents provide the site specific instructions and detail required for validation on the NGP:

- 399-RP-VC-001 Validation Spreadsheet
- 399-RP-JJ-002 Calculation of Measurement Uncertainties
- 399-PR-VC-001 Ultrasonic Meter Run Verification
- 399-PR-VC-002 Gas Chromatograph / Data Transmission Verification
- 399-PR-VC-004 Calibration Gas Identification and Traceability Functions

6.1.2 COMMISSIONING AND CONTINUAL PERIODIC VALIDATIONS

New meter assemblies requiring commissioning shall have measurement equipment validated within one week of initial operation and then continually validated as prescribed in Table 6.1 below. Additional validation can be performed and frequencies may also be shortened or extended at Jemena's discretion.

Table 6.1 Validation Frequencies and Detail

Location	Meter Type		Validation Number

		Period (weeks)	51	52	53	54	55	56	58	62	63
Phillip Creek (NT)	Ultrasonic	13	☑	☑	☑	☑	☑	☑	☑	☑	☑
Mt Isa (QLD)	Ultrasonic	13	☑	☑	☑	☑	☑	☑	☑	☑	☑

6.1.3 OWNERS AND REPRESENTATIVE RESPONSIBILITIES

Representatives of each of the parties having a direct interest in the accounting of quantities of gas passing through a given meter are given at least 48 hours' notice in writing of the proposed date and time of the tests so that they may witness the tests.

Witnesses are given the opportunity to attend the site to witness the validation and sign the report to signify their attendance. Remarks can be made on the report to raise any concern.

In the event that any or all of the invited witnesses do not attend, the test results will nevertheless be deemed to be an accurate statement of current performance and shall be accepted by all parties.

In the event that validations have to be re-scheduled, the new schedule would be at a date and time agreed by both operations staff and affected witnesses.

One copy of each of the completed test reports will be forwarded to the relevant parties within 14 days of the test being completed. A copy of each report is filed on the Jemena document management system (ECMS).

In the event of equipment failure, damage or accuracy drift, the Pipeline Owner may conduct interim validations without witnesses but shall, where possible, give prior notice to the relevant parties that an interim validation is to be undertaken.

In any case, all interested parties will receive full written details of the validation results, and any adjustments made as a result of the findings, including changes to manually programmed input data in flow computers.

Any party may request that a validation be conducted between scheduled dates. In the event that the equipment is found to be within specified tolerances, the requesting party is required to pay the costs of conducting the extra validation.

Where possible, any maintenance will be done during a scheduled validation to be witnessed by all parties.

6.2 VALIDATION SPREADSHEET

An Excel Spreadsheet is used to assist in the validation process and ensure that the process is consistent across all sites. Below is a list of all relevant validation forms within the spreadsheet, each form will contain the relevant validation tolerance for the test. Following each test, the relevant form is printed and signed for acceptance that the information entered is correct.

- VAL 51 – Test Equipment
- VAL 52 – Ultrasonic Diagnostic Check
- VAL 53 – Pressure Transmitter Tolerance Check
- VAL 54 – Temperature Transmitter Tolerance Check
- VAL 55 – Ultrasonic Meter Flow Computer V's GOF Check
- VAL 56 – Gas Chromatograph Tolerance Check
- VAL 62 – Meter Comparison Check
- VAL 63 – Data transfer check

Note: GOF is proprietary software that is "called" from the spreadsheet to calculate gas flow data in accordance with the AGA standards.

6.2.1 VAL 51 TEST EQUIPMENT

A list of certified test equipment used during a validation detailing the model number, serial number, date of last certification and accuracy of each piece of validation equipment.

6.2.2 VAL 52 ULTRASONIC DIAGNOSTIC CHECK

Ultrasonic Diagnostic Check is used to assess ultrasonic meter operational status. Data accessible via a computer is used as key indicators of meter performance, and the nature of problems affecting that performance. There are five main indicators of meter performance:

- Sample rate - used to determine that all ultrasonic pulses sent by the emitting transducer are being collected by the receiving transducer. The Sample rate for all Jemena ultrasonic meters is 15 Hz with a tolerance of + or – 1 Hz.
- Velocity of sound (VOS) - is output as an average value of all pulse paths in the meter (m/s). The VOS calculated by the meter is compared against that calculated from gas quality, pressure and temperature using VOS calculated using proprietary software. This comparison is then used to determine whether there is any performance faults with the meter. A tolerance of 1.5 m/s is set for VOS comparison.
- Stability - this measures the status of Axial Path, Swirl Path, Flow and Swirl. A value up to 4 represents correct functioning.
- AGC Levels - or automatic gain control levels, is an output from each transducer. The ultrasonic meter relies on the transit time from when one transducer emits an ultrasonic pulse until when the receiving transmitter “hears” that pulse. Certain devices commonly used on standard meter stations can produce ultrasonic noise such as pressure regulators. In these noisy environment gain levels increase to enable the detection of each transmitted pulse. The meter automatically adjusts the gain of each transducer to achieve optimal metering capability.
- AGC Limits - are also outputs from each transducer. The limits are adjusted automatically by the Signal Processing unit and are defaulted to a maximum level.

The AGC characteristics are best represented as a ratio of AGC limits to AGC levels. A ratio of 3:1 is a minimum requirement, with ratios of up to 10:1 being typical

6.2.3 VAL 53 PRESSURE TRANSMITTER

The Pressure Transmitter form is used to validate the accuracy of the Pressure transmitter.

The type of pressure calibrating equipment to be used for the pressure test is selected either Dead Weight Tester (DWT) or electronic pressure calibrator. If the DWT is selected the oil temperature and hydraulic head are entered to give a corrected "required kPa".

Pressures are applied across the pressure transmitter and then viewed on the flow computer and entered into the "As Found kPa" table. Once all pressures are applied and entered into the "As Found kPa" table they are automatically compared to "Required kPa" and an error shown. This error is then compared to the acceptable variance to determine whether the transmitter is within tolerance.

If the transmitter is found to be within tolerance the "As Found kPa" values are copied into the "As Left kPa" table and the transmitter tolerance check is completed.

If the transmitter is found to be out of tolerance a transmitter calibration is carried out. Once completed, all pressures are reapplied and entered into the "As Left kPa" table.

It the transmitter does not calibrate correctly it will be replaced.

6.2.4 VAL 54 TEMPERATURE TRANSMITTER

The Temperature Transmitter report is used to validate the accuracy of the Temperature transmitter.

The Temperature transmitter is calibrated across its range using a decade box. Different resistances are applied to simulate an RTD at different temperatures. The corresponding temperature can be viewed in the flow computer. This value is then entered into the "As Found °C" table.

Once all Temperatures are dialled and entered into the "As Found °C" table they are automatically compared to the "Required °C" and an error shown. This error is then compared to the acceptable variance to determine whether the transmitter is within tolerance.

If the transmitter is found to be within tolerance the "As Found °C" values are copied into the "As Left °C" table and the transmitter tolerance check is completed.

If the transmitter is found to be out of tolerance a transmitter calibration is required. Once completed, all temperatures are reapplied and entered into the "As Left °C" table

The transmitter is replaced if it cannot be calibrated to within tolerance.

6.2.4.1 RTD Probes

Both the RTD to be validated and NATA a certified RTD are placed in the same water bath and their resistances measured. These resistances are entered into the "As Found RTD" table and the variance is automatically calculated. This variance is then compared to the variance limit to determine if the RTD is functioning correctly. If the RTD is found to be within tolerance the “As Found RTD” values are copied to the “As Left RTD” table and the RTD check is completed.

If the RTD being is found to be out of tolerance then the RTD is replaced and the new RTD compared to the NATA certified RTD in the water bath. The resistance of the new RTD and NATA certified RTD are entered into the “As Left RTD” table.

6.2.5 VAL 55 ULTRASONIC METER FC V’S GOF

Ultrasonic meter FC V’s GOF check is used to determine if the flow computer is correctly calculating the actual and standard flow accumulators, energy flow accumulators and the Supercompressibility (Fpv). The check also confirms that the correct numbers of pulses are being recorded.

Once pulses have been injected into the flow computer, the actual, standard and energy flow rates along with the FPV automatically calculate. These calculated values are compared to the flow computers calculated values and a percentage variance determined.

6.2.6 VAL 56 GAS CHROMATOGRAPH TOLERANCE CHECK

Gas Chromatograph tolerance check is used to determine the Gas Chromatographs operational status

The Gas chromatograph is placed on the calibration gas and let run for three cycles to insure all line gas is purged from the system. The data from the GC Report is entered into the validation spreadsheet is compared to the calibration bottles certified known SG, HV and compressibility to give a total variance.

The variance is then compared to the allowable tolerance to determine if the GC readings are within the set tolerances. If the SG, HV and compressibility are found to be within tolerance, the validation is completed. If the SG, HV and compressibility are found to be out of tolerance, a calibration is required. Once the calibration is complete, data from the GC Report is entered into the validation spreadsheet to ensure the variances are within tolerance.

6.2.7 VAL 62 METER COMPARISON

A meter comparison check is used to determine the variance in standard flow rate over a set period of time between two meters. This check can only be carried out on sites where the metering facilities can be arranged to allow a series configuration of the two metering runs.

6.2.8 VAL 63 DATA TRANSFER CHECK

A Data transfer check is used to determine if the data that is constantly being transferred to and from meter stations is being done correctly.

The comprehensive data transfer check is performed for the sites, equipped with gas chromatographs. For these sites the flow of gas composition information from the Gas Chromatograph through the Flow Computer into the SCADA is checked for correctness and accuracy.

6.3 CALIBRATION OF THE VALIDATION EQUIPMENT

A standard set of equipment for the meter validations comprises the following items:

1. Multifunction Calibrator
2. Hydraulic Dead Weight Tester
3. Mercury In Glass Thermometer
4. Resistance Decade Box
5. Certified RTD (Resistance Temperature Detector)

Some other equipment may also be used.

The equipment is periodically checked and its accuracy verified by the NATA accredited laboratories. Appropriate calibration certificates are obtained in the verification process.

The instruments and gauges, used for the validation of gas flow meters, must be verified in accordance with the following schedule.

Table 6.2 Re-calibration Schedule

Validation Instrument	Examples of Instruments Used		Re-calibration Period
	Brand Name	Model No.	
Multifunction Calibrator	Beamex Advanced Calibrator	MC6	12 Months
NitroPak Calibrator	Ralston	NPAK	12 Months
Digital Test Gauge	Crystal	XP2i	12 Months
Hydraulic Dead Weight Tester	Ametek	PK II	36 Months
PT100 Simulator	Beamex	RTS24	12 Months
PT100 RTD	WIKA	TR40	12 Months
Mercury in Glass Thermometer	AMA	-5 to 50 ^{o}C	5 Years

7 REFERENCE AND LOCAL CONDITIONS

7.1 VALIDATION SPREADSHEET

In order to be able to equate flows at differing pressures and temperatures, a common reference needs to be established. Defining the base conditions and converting all volumes to these “standard conditions” achieves this. Industry accepted reference conditions within Australia are:

- Measurement Reference Temperature - 15°C (288.15K)
- Measurement Reference Pressure - 101.325 kPa (absolute)
- Standard Gravitational Acceleration (gs) (at sea level, 45 latitude) - 9.80665 m/s

7.2 LOCAL CONDITIONS

The local gravitational acceleration and atmospheric pressure at each site varies. A universal strategy must be established for determination of the local conditions to allow conversion to “Standard Conditions”

7.2.1 LOCAL GRAVITATIONAL ACCELERATION

Local gravitational acceleration at each site is calculated in accordance with equation 3-A-10 of AGA3-1992. The local gravity is dependent on the latitude and elevation of the site.

7.2.2 LOCAL ATMOSPHERIC PRESSURE

Local atmospheric pressure is also calculated for each site. It is calculated using the following equation and is dependent on the elevation only.

$$P_{local} = 101.325 - \frac{h * density\ air * gs}{1000}$$

h = elevation (m)

density air = 1.2255 kg/m^3

gs = 9.80665 m/s^2

Table 7.1 Local Reference Conditions

Site	Latitude	Elevation	Local Gravity (m/s^2) AGA3 ref.	Local Atmospheric Pressure
Phillip Creek (NT)	19.445	308	9.7851	97.623
Mt Isa (QLD)	20.787	366	9.7857	96.926