MEASUREMENT MANUAL

EASTERN GAS PIPELINE GAS MEASUREMENT MANUAL

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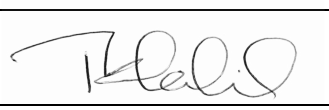
Fred Khalil	Metering Engineering Manager - Zinfra		12/11/2021
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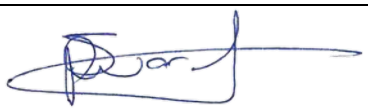
Sean Ward	General Manager – Asset Management – Gas Markets		16/11/2021

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DOCUMENT HISTORY

Revision	Date	Author	Description of Changes
15	4/07/2019	M. Blanchard Delgado	Change of billing period definition to gas day, and general review. Change of document number
16	12/11/2021	Santhosh Ananthakrishnan	Periodic review and update

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1 SCOPE AND GENERAL

1.1 SCOPE

This manual is to provide a technical reference for the operation and maintenance of the Jemena gas measurement and monitoring systems on the Eastern Gas Pipeline (**EGP**).

A typical gas measurement system consists of the following processes:

- Equipment specifications
- Equipment calibration
- Data acquisition
- Data transmission
- Data, storage, manipulation and computation
- Data validation
- Billing procedures
- Discrepancy resolution and billing adjustments
- System auditing
- Gas Sales Contracts or Agreements

This manual includes general details on technical aspects of the overall measurement system and equipment. Other aspects of the measurement process, such as billing procedures, system auditing, and billing adjustments are covered under separate procedures. This manual is not intended to provide specific details of Gas Sales Contract terms and conditions.

This manual includes the below:

a. Identifying each meter installed on various facilities in EGP
b. Australian standard or other standard to which each meter complies;
c. Meter testing or replacement philosophy;
d. Tolerance for error for meters;
e. Duration of review of the measurement manual;
f. Installation and commissioning of meters;
g. Meter testing methods and frequency;
h. Meter maintenance processes;
i. Correction factor calculation;
j. Calibration and traceability of meter test equipment;
k. Meter security (incl protection during transportation, installation, operation and unauthorised alteration of meter readings);
l. Process for estimated meter readings, reasons for estimation, and procedures for reconciling actual and estimated reading;
m. Procedures for meter failure, incorrect operation and meter bypass;
n. Competency for persons working on the meters and training programs to maintain skill levels of person, and
o. Record keeping (Incl Records of anomalies, complaints and actions and minimum period of record keeping).

Jemena is the measurement authority for the EGP. The scope of the manual applies to all Jemena owned and operated custody transfer facilities on the Eastern Gas Pipeline. Where Delivery or Receipt Point measurement equipment is owned or operated by a 3rd party, they shall be designed, installed and maintained in accordance with this manual.

1.2 PIPELINE DESCRIPTION

The Eastern Gas Pipeline (**EGP**) runs between Longford in Victoria (VIC) to Horsley Park in New South Wales (NSW) and consists of the two sections of pipeline as below

- PPL232 (Pipeline licence No. 232): This license is for the Victorian section.
- PPL26 (Pipeline licence No. 26): This licence is for the New South Wales section.

The VicHub (Victorian **PIPELINE** Licence No 247) is an interconnect **PIPELINE** situated at Longford that enables gas to flow bi-directionally between the EGP and the Victorian gas distribution network. There is no metering equipment owned by JEMENA in this pipeline.

2 METER SCHEME

2.1 METER IDENTIFICATION

The below sections details the meters installed on each facility in the pipeline. The “Location” column provides the location of the meter in the associated station on the pipeline. The station can be a metering station or a compressor station.

The map of EGP schematic can be obtained from the jemena website egp-map.aspx (jemena.com.au).

2.1.1 EASTERN GAS PIPELINE (EGP)

Table 1: EGP Meters (Owned and Validated by Jemena)

Location	Meter Description	Status	Custody Transfer	Meter Assembly	Meter Runs	Temperature Measurement	Pressure Measurement	Flow Computer	SCADA	Gas Chromatograph	Moisture Analyser	Sulphur Analyser
Longford Compressor Station	Longford Station EGP Meter	In Use	No	Ultrasonic	Single	√	√	√	√	√	√	√
	Longford Station ESSO Meter	In Use	Yes	Ultrasonic	Single	√	√	√	√	√		
	Longford Station TGP Meter	In Use	Yes	Ultrasonic	Single	√	√	√	√	√		
	Fuel Gas to Water Bath Heater Meter	In Use	No	Diaphragm	Single	√	X	√	√	√		
	Fuel Gas to Compressors Meter	In Use	No	Coriolis	Single	√	X	√	√	√		
Bairnsdale Meter Station	Bairnsdale Station Meters	In Use (Note 1)	Yes	Coriolis	Dual	X	√	√	√	X	X	X
	Bairnsdale City Gate Meter	In Use (Note 1)	Yes	Coriolis	Single	X	√	√	√	X		
	Fuel Gas to Heater 1 Meter	In Use	No	Diaphragm	Single	√	X	√	√	X		
	Fuel Gas to Heater 2 Meter	In Use	No	Diaphragm	Single	√	X	√	√	X		
East Gippsland Compressor Station	East Gippsland Station Meter	In Use (Note 1)	No	Ultrasonic	Single	√	√	√	√	X	X	X

Location	Meter Description	Status	Custody Transfer	Meter Assembly	Meter Runs	Temperature Measurement	Pressure Measurement	Flow Computer	SCADA	Gas Chromatograph	Moisture Analyser	Sulphur Analyser
	Fuel Gas to Compressor Meter	In Use (Note 1)	No	Coriolis	Single	√	√	√	√	X		
	Fuel Gas to GEA Meter	In Use (Note 1)	No	Coriolis	Single	√	√	√	√	X		
Mila Compressor Station	Mila Station Meter	In Use	No	Ultrasonic	Single	√	√	√	√	√	X	X
	Fuel Gas to Compressor Meter	In Use	No	Coriolis	Single	√	√	√	√	√		
	Fuel Gas to GEA Meter	In Use	No	Coriolis	Single	√	√	√	√	√		
Cooma MLV and Meter Station	Cooma Station Meter	In Use	Yes	Coriolis	Single	√	√	√	√	X	X	X
Michelago Compressor Station	Michelago Station Meter	In Use (Note 1)	No	Ultrasonic	Single	√	√	√	√	X	X	X
	Fuel Gas to Compressor Meter	In Use (Note 1)	No	Coriolis	Single	√	√	√	√	X		
	Fuel Gas to GEA Meter	In Use (Note 1)	No	Coriolis	Single	√	√	√	√	X		
Hoskinstown Meter Station	Hoskinstown Station Meters	In Use (Note 1)	Yes	Ultrasonic	Dual	√	√	√	√	X	X	X
	Hoskinstown Fuel Gas to Heater Meter	In Use (Note 1)	No	Rotary	Single	√	√	√	√	X		
Nowra MLV and Meter Station	Nowra Station Meter	In Use	Yes	Coriolis	Single	√	√	√	√	X	X	X
Bomaderry MLV and Meter Station	Bomaderry Station Meter	In Use	Yes	Ultrasonic	Single	√	√	√	√	X	X	X
Port Kembla Meter Station	Port Kembla Station Meters	In Use	Yes	Ultrasonic	Dual	√	√	√	√	√	X	√

Location	Meter Description	Status	Custody Transfer	Meter Assembly	Meter Runs	Temperature Measurement	Pressure Measurement	Flow Computer	SCADA	Gas Chromatograph	Moisture Analyser	Sulphur Analyser
	Fuel Gas to Heater 1 Meter	In Use	No	Diaphragm	Single	√	√	√	√	√		
	Fuel Gas to Heater 2 Meter	In Use	No	Diaphragm	Single	√	√	√	√	√		
Horsley Park Meter Station	Horsley Park Station Meters	In Use	Yes	Ultrasonic	Dual	√	√	√	√	√	X	X
	Fuel Gas to Heater 1 Meter	In Use	No	Diaphragm	Single	√	√	√	√	√		
	Fuel Gas to Heater 2 Meter	In Use	No	Diaphragm	Single	√	√	√	√	√		
	Fuel Gas to Heater 3 Meter	In Use	No	Diaphragm	Single	√	√	√	√	√		
Wilton Meter Station	Wilton JGN Station Meters	In Use	Yes	Ultrasonic	Dual	√	√	√	√	√	X	X
	Wilton APA Station Meters	In Use	Yes	Ultrasonic	Dual	√	√	√	√	√		
	Fuel Gas to Heater Meter	In Use	No	Coriolis	Single	√	√	√	√	√		
Smithfield Meter Station	Smithfield Station Meters	In Use (Note 1)	Yes	Ultrasonic	Dual	√	√	√	√	X	X	X

Note 1: These sites have live gas component downloaded to flow computers via SCADA.

Table 2 contains metering facilities not owned and not validated by Jemena, but connected to the Eastern Gas Pipeline (EGP).

Table 2 EGP Meters (Owned and Validated by 3rd Party)

Location	Status	Meter Assembly	Meter Runs
VicHub-EGP Meter	In use	Ultrasonic	Single
Orbost Meter Station	In Use	Ultrasonic	Dual
Bombala Meter Station	In use	Coriolis	Single
Albion Park Meter Station	In use (Note 1)	Ultrasonic	Dual
Tallawarra Meter Station	In Use	Ultrasonic	Dual

Note 1: The meter owned by Jemena Gas Networks.

2.2 APPLICABLE STANDARDS

All meters shall be designed and installed in compliance with the appropriate meter standards mentioned in Table 3 Meter Standards.

Table 3 Meter Standards

Meter Type & Associated Equipment	Applicable Standard
Orifice Plate Meter	AGA-3
Turbine Meters	AGA-7
Ultrasonic Meters	AGA-9
Coriolis Meters	AGA-11
Diaphragm Meters	AS 4647
Compressibility Factor of Natural Gas and Related Hydrocarbon Gases	AGA-8
Gas Chromatograph	ISO 6976 - Natural Gas: Calculation of Calorific Values, Density, Relative Density and Wobbe index from composition.

Additional standards that will be followed are noted in the Table 4 Additional Standards.

Table 4 Additional Standards

Standard Name	Standard Description
AS ISO 1000-1998	The International System of Units (SI) and Its Application
AS 1376 -1996	Australian Standard Conversion Factors
AS 4564 - 2020	Australian Standard Specification for general purpose natural gas
National Greenhouse and Energy Reporting (Measurement) Determination 2008 Chapter 2, Part 2.3 Division 2.3.6 Section 2.36.	All installed flow computers for metering purposes shall be compliant with the accuracy requirements as mentioned in this document.
National Greenhouse and Energy Reporting (Measurement) Determination 2008,, refer Chapter 2, Part 2.3 Division 2.3.6 Section 2.31.	All installed pressure transmitters for metering purposes shall be compliant with the transmitter accuracy requirements as mentioned in this document.

Standard Name	Standard Description
National Greenhouse and Energy Reporting (Measurement) Determination 2008 Chapter 2, Part 2.3 Division 2.3.6 Section 2.31.	All installed temperature transmitters for metering purposes shall be compliant with the transmitter accuracy requirements, as mentioned in this document.
National Greenhouse and Energy Reporting (Measurement) Determination 2008 Chapter 2, Part 2.3 Division 2.3.6 Section 2.37.	All installed Gas Chromatograph shall be compliant with the accuracy requirements, as mentioned in this document.
ASTM D1072	Standard Test Method for Total Sulphur in Fuel Gases by Combustion and Barium Chloride Titration
ASTM D1142	Standard Test Method for Water Vapor Content of Gaseous Fuels by Measurement of Dew-Point Temperature
ASTM D1945	Standard Test Method for Analysis of Natural Gas by Gas Chromatography
ASTM D3588	Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels
ISO 6326	Natural Gas: Determination of sulphur compounds
ISO 6974	Determination of composition and associated uncertainty by gas chromatography
ISO 6975	Natural Gas: Extended analysis – Gas chromatographic method

2.3 METER TESTING AND REPLACEMENT PHILOSOPHY

Table 5 Testing and Replacement Philosophy contains the testing and replacement philosophy for each meter type in EGP. This philosophy is applicable only for the meters classified as “Custody Transfer” meters in Section 2.1 Meter identification. A custody transfer meter is marked as “Yes” in the column “Custody Transfer” against the meter in the tables containing the meters for each pipeline.

Table 5 Testing and Replacement Philosophy

Meter Type	Testing or Replacement Philosophy
Ultrasonic Meters & Coriolis Meters	The Ultrasonic and Coriolis 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 (unrecoverable fault), once identified, will be replaced with a suitably calibrated meter of similar technology. The below monitoring will be performed on a continuous basis - For meters in Z configuration, deviation in opposite direction will be detected by continuous monitoring. The deviations beyond tolerance of 1.5% in Energy flow will be investigated. - Continuous Gas Unaccounted For (**GUF**) monitoring of the pipeline will be performed. GUF values beyond the acceptable tolerance will be investigated. This is expected to provide indications on meter deterioration.

Notes:

1. In the event of a malfunction (unrecoverable fault) of non-custody transfer meters, the meter will be replaced with a new meter with similar technology. This decision will be at the discretion of Asset Management.

2.4 TOLERANCE FOR ERRORS

2.4.1 OVERALL TOLERANCE FOR METERING

The overall acceptable tolerance of error for custody transfer meters is detailed in Table 6: Acceptable Tolerance of Error for Custody Transfer Meters. The validation checks shall ensure the meters operate within these tolerances.

Table 6: Acceptable Tolerance of Error for Custody Transfer Meters

Flow Range	Acceptable Error %
Flow < 25 m3/Hr	± 1.5%
Flow: 100 TJ/year to 1 PT/year	± 1.0%
Flow: > 1 PT / year	± 1.0%

2.4.2 TOLERANCE FOR TRANSMITTERS

The overall acceptable tolerance of error for transmitters is detailed in Table 7: Acceptable Tolerance of Error for Transmitters.

Table 7: Acceptable Tolerance of Error for Transmitters

Equipment	Acceptable Error %
Pressure Transmitter	± 0.1%
Differential Pressure Transmitter	± 0.1%
Temperature Transmitter	± 0.2%

2.5 REVIEW OF MEASUREMENT MANUAL

This measurement manual shall be revised if any of the below scenarios occur:

- If a new meter is installed, or proposed to be installed, which is not mentioned in this measurement manual;
- If there is an amendment of the American standard, or other applicable standard(s) referred to in this measurement manual;
- If an event (such as a significant development in the technical knowledge) relevant to the measurement manual becomes known; and
- If the operator of the Metering System becomes aware of a significant anomaly or likelihood of inaccurate measurement as mentioned in this measurement manual.

If none of the above scenarios occur, then this measurement manual will be reviewed in a 2-year period to ensure changes in regulation, technological advancement and operating procedures are captured.

2.6 INSTALLATION AND COMMISSIONING OF METERS

All meters shall be designed and installed in compliance with the associated AGA standards for the meter and details mentioned in this document. Industry and manufacturers best practices shall be taken into consideration for design and installation. Any deviation to the standard or this document for meter installation will require approval from the Principle E&I engineer.

The custody transfer flow meters shall be factory calibrated and certified prior to installation and commissioning. A Factory Acceptance Testing (**FAT**) shall be undertaken to verify the system is functioning as per design prior to transporting to site for installation. Site Acceptance Testing (**SAT**) shall be undertaken before the meter is placed into operation.

2.7 METER TESTING METHODS AND FREQUENCY

2.7.1 VALIDATION OVERVIEW

Validation is the process of ensuring the conditions of measurement equipment is in order, for it to function within agreed tolerances.

2.7.2 VALIDATION (TESTING) METHODS

A validation excel spreadsheet is used for the validation process. Jemena uses GOF, a proprietary software to perform meter validations. This software is "called" from the validation spreadsheet to calculate gas flow data in accordance with the AGA standards. The validation spreadsheets performs a comparison of the GOF calculated flows Vs the flow computer calculated flows and provides any discrepancies between the two readings. If the discrepancies are outside the acceptable tolerances for the meter, then appropriate action is taken to rectify the discrepancy.

Following is a typical list of relevant validation forms within the validation spreadsheet that is used to validate the meter installation:

- Test Equipment form
- Pressure Transmitter form
- Temperature Transmitter form
- Gas Chromatograph Tolerance Check Form
- Moisture Analyser Tolerance Check form
- Series Meter Comparison Form
- Ultrasonic Diagnostic Check form
- Ultrasonic Meter FC V’s GOF form

The details of the appropriate validation forms for each facility can be found under each facilities validation procedures.

2.7.3 FREQUENCY OF VALIDATIONS

The frequency of periodic validations is shown in Table 8 Frequency of Meter Periodic Validations for all facilities. These periods may be shortened due to gas quality or when Energy Accounting equipment are found to be outside of tolerances. They shall never be extended beyond the times noted in Table 8.

New meter assemblies requiring commissioning shall have measurement equipment validated within one week of initial operation and then continually validated for six weekly intervals for one year of service. After one year service, the validation frequency will be as per below Table 8.

Table 8 Frequency of Meter Periodic Validations (Meters Owned and Validated by Jemena)

Location	Meter Description	Meter Assembly	First Yearly Requirement (Weekly)	Continuous Requirement (Weekly)
Longford Compressor Station (Note 2)	Longford Station EGP Meter	Ultrasonic	6	6
	Longford Station ESSO Meter	Ultrasonic	6	6
	Longford Station TGP Meter	Ultrasonic	6	6
Bairnsdale Meter Station	Bairnsdale Station Meters	Coriolis	6	12
	Bairnsdale City Gate Meter	Coriolis	6	12
Cooma MLV and Meter Station	Cooma Station Meter	Coriolis	6	12
Hoskinstown Meter Station	Hoskinstown Station Meters	Ultrasonic	6	12
Nowra MLV and Meter Station	Nowra Station Meter	Coriolis	6	12
Bomaderry MLV and Meter Station	Bomaderry Station Meter	Ultrasonic	6	12
Port Kembla Meter Station (Note 2)	Port Kembla Station Meters	Ultrasonic	6	6
Horsley Park Meter Station	Horsley Park Station Meters	Ultrasonic	6	12
Wilton Meter Station	Wilton JGN Station Meters	Ultrasonic	6	12
	Wilton APA Station Meters	Ultrasonic	6	12
Smithfield Meter Station (Note2)	Smithfield Station Meters	Ultrasonic	6	6
Albion Park Meter Station (Note 1, 2)	Albion Park Station Meters	Ultrasonic	6	6

Note 1: The meter owned by Jemena Gas Networks.

Note 2: In these stations validation checks are performed 6 weekly.

2.8 METER MAINTENANCE

Maintenance procedures as defined by the meter manufacturer should be carried out during the scheduled validation process if any of the validation or diagnostics checks result in out of tolerance. Due to the wide range of meters installed on various pipelines, the maintenance procedures are site specific and are based on manufactures guidance and history of the equipment.

2.9 CORRECTION FACTOR CALCULATION

The meter assembly measures actual flow. The Pressure and Temperature Transmitters and Resistance Temperature Detectors (**RTD**) are mounted with each meter assembly.

Each meter is connected to a local flow computer (**FC**), which receives and records the instantaneous values for all primary measurement inputs, i.e. volume flow signals from the meter, pressure, temperature and Gas Chromatograph data.

The correction factor calculation is implemented in the flow computer. The flow computer performs temperature and pressure compensation of the measured flow (Actual) to produce instantaneous volumetric and energy based flow rates at standard conditions using the gas composition data from gas chromatographs. AGA calculation standards relevant to the type of meter are implemented in the flow computer to perform these calculation for e.g. AGA9 for USM. All flow computers accumulate volume and energy totals.

The below typical data are transferred to SCADA from the flow computer:

- 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

The equipment specification varies between various facilities, however the schematic shown in Figure 1 identifies and links the key repeated components.

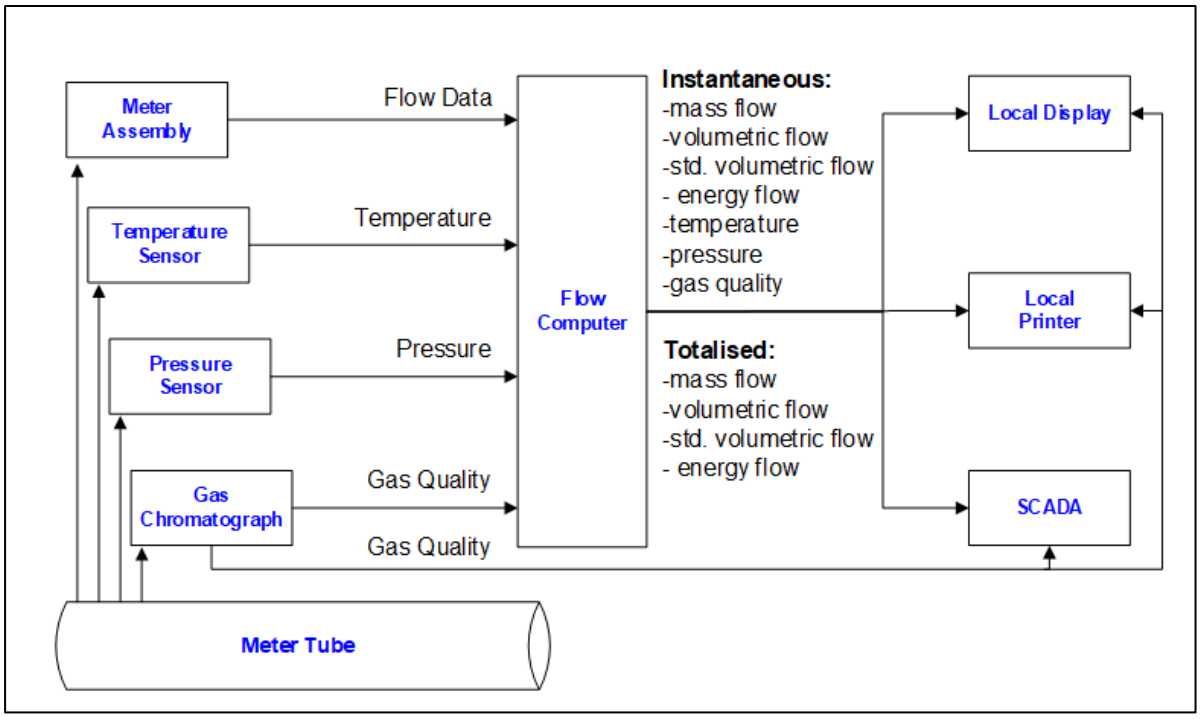

Figure 1: Measurement Facility Schematic

2.10 3RD PARTY DATA TRANFER REQUIREMENTS

Jemena shall require at a minimum the below data to be transferred from 3rd party owned and operated meter installations to Jemena's SCADA.

- Metering Pressure
- Metering Temperature
- Meter Frequency
- Actual, Standard and Energy Flow Rates
- Today's Actual, Standard and Energy accumulation
- Yesterday's Actual, Standard and Energy accumulation
- Contract Actual, Standard and Energy accumulation
- Non-resetting Actual, Standard and Energy accumulation
- Gas Chromatograph data, If installed
- Sulphur Analyser data, If installed
- Moisture Analyser data, if installed
- Meter Configuration (Single, Series, Parallel)
- Selected Duty Meter, if redundant meters are installed
- Validation status of installed meters
- Selected Duty GC, if multiple GCs are installed or manual values can be entered.
- GC calibration mode, communications failure, out-of-range and Malfunction alarms.
- Selected Duty regulator, if multiple regulators are installed
- Master & Slave Clock register for communications watchdog purposes
- Isolation valve status
- Jemena flow permissive command

Notes:

1. The flow information is required for individual meter runs and for the overall station in both forward and reverse direction, if configured in the 3rd party control systems.
2. Jemena's permissive command shall be configured in the 3rd party control systems to open/close the flow isolation valve in the event of off-spec gas or in an emergency to stop flow. The Jemena flow permissive signal will have the below two states
    - State 0 = NO FLOW
    - State 1 = FLOW

    When the permissive is set to "NO FLOW", the isolation valve will close and will remain closed until the permissive is set to "FLOW" by Jemena. It is then, the responsibility of the 3rd party to initiate an open command, upon restoration of the Jemena flow permissive. Jemena will not have the ability to open the isolation valve.

    If a communications link failure occurs the Jemena flow permissive will remain in the last state. If isolation is required Jemena control room will contact 3rd party control room to perform isolations following an agreed process.

    Jemena SCADA will transport clock value in the Slave clock register to Master clock register at a set time (e.g. every 5 Sec). On communications failure, this value in the Slave Clock register will remain unchanged and a communications failure alarm can be configured in the 3rd party control systems and can be used to mask the Jemena flow permissive signal to shut down the isolation valve.

The hardware requirements and the communications architecture to implement this data transfer shall be discussed with Jemena SCADA manager. A communications interface specification shall be developed that will contain the requirements of hardware, power, installation, communication redundancy, communication protocols, communication address. data set and acceptance testing for the interface. This document will be accepted by both parties before implementation.

2.11 CALIBRATION AND TRACEABILITY OF METER TEST EQUIPMENT

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

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

Some other equipment may also be used.

The equipment is periodically checked and its accuracy verified by NATA accredited laboratories. Appropriate calibration certificates will be obtained and stored in ECMS after the verification process.

The frequency of re-calibration shall be as detailed in Table 9 Calibration Period of Validation Instruments.

Table 9 Calibration Period of Validation Instruments

Validation Instrument	Examples of Instruments Used		Re-Calibration Period Required
	Brand Name	Catalogue No	
Multifunction Calibrator	Beamex Advanced Calibrator	MC6	Every 12 months
	Druck Unimat Calibrator	TRX II	
	Druck Modular Calibrator	DPI610 IS	
	Druck Advanced Modular Calibrator	DPI620	
Hydraulic Dead Weight Tester	Ametek	PK II	Every 36 months
Function Generator		TG550	Every 12 months
Crystal Digital Test Gauge		3KPSIXP2	Every 12 months
Mercury in Glass Thermometer	AMA		Every 5 years
Delta Ohm Digital Thermometer		HD9215	Every 12 months
Time Electronic Decade Box			Every 12 months
Digital Multimeter	Fluke	45	Every 12 months
Certified RTD			Every 12 months

2.12 METER SECURITY

2.12.1 PHYSICAL SECURITY

All Jemena's remote and un-manned facilities are fenced and under regular remote surveillance by Jemena personnel or external security company. Site security system alarms are configured in the SCADA system. This ensures that any unauthorised access to site is immediately alarmed in the Melbourne Control Centre.

External contractor access to these facilities are controlled by induction processes and permit to work system.

2.12.2 SOFTWARE SECURITY

Flow meters used for custody transfer application(s) are protected by a password and only accessible through special software. Additionally, a parameter write lock in the Signal Processing Unit (**SPU**) of the meter prevents unauthorised changes to the meter configuration.

Temperature and pressure transmitters are not password protected but the risk of unauthorised alteration is minimised by adherence to Jemena's standard permit to work system.

2.12.3 TRANSPORT AND STORAGE

Transport and storage of all metering equipment shall be in accordance with manufacturer's instruction and Jemena's transportation requirements as defined by the project.

Meters shall be firmly secured during transport and measures shall be taken to avoid mechanical damage. A detailed inspection of the meter shall be performed by Jemena personnel or Jemena authorised external contractor prior to installation of the meter. Site Acceptance testing will be performed to ensure that meter performance has not been degraded due to the transportation process.

2.13 ESTIMATED METER READING & METERING CORRECTIONS

If the metering facilities are out of service or registering inaccurately so that the quantity of gas delivered during a period cannot be ascertained or computed from the readings from these facilities, the gas Delivered during such period will be determined upon a basis of the best data available, using any one of the following methods:

- By using the registration of any check or standby metering equipment, if installed, and accurately registering; or
- By correcting the error if the percentage of error is ascertained by calibration, test or mathematical calculations; or
- By estimating the quantity of deliveries during the preceding periods of demand under similar conditions when the metering facilities were registering accurately.

2.14 PROCEDURES ON METER FAILURE, INCORRECT OPERATION AND METER BYPASS

If the event of a meter failure or incorrect operation or if a meter is bypassed for maintenance purposes, an estimation of meter reading as per Section 2.13 Estimated Meter Reading & Metering Corrections will be performed, if a standby meter is unavailable.

The failed meter will be repaired and re-instated in service. A validation will be performed on the re-instated meter to ensure the meter performance is within acceptable tolerance of errors. On successful validation, the meter will be placed in operation.

2.15 TRAINING AND COMPETENCY REQUIREMENT

The field technicians performing meter validations will be suitably trained to perform the activities required to complete validations following the facility appropriate procedures. The staff will have to demonstrate competency in the required validation procedures, applicable equipment, and understanding of hazards before they are allowed to perform validations.

The validations are performed by an field technician and witnessed and checked by another field technician. This is recorded in the validation spreadsheets as shown in the Figure 2 Validation Witness Record. This process ensures that new field technicians will be trained by performing validations with experienced field technicians. This also provides an opportunity to perform site

specific knowledge transfer and assess the competency of the field technicians before they are allowed to train other field technicians.

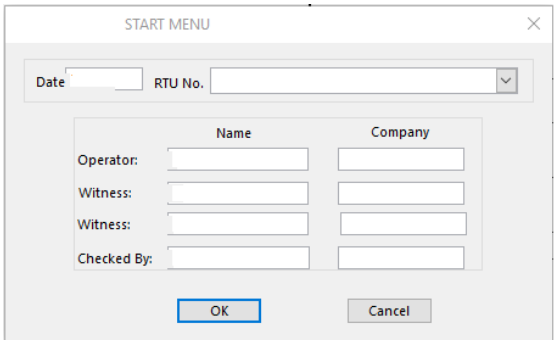

Figure 2 Validation Witness Record

In addition to the above, the field technicians will perform additional formal training sessions for e.g. Workplace inductions, Site specific induction, Manual handling etc.

Training covering the new meter installation shall be included after commissioning of any new meters. This training should be provided by the commissioning, project engineers or meter vendors and attended by field technicians working on the facility. A copy of the training records will be stored in ECMS.

2.16 RECORD KEEPING

All validation documents will be kept as records in Jemena's enterprise content management system (ECMS). Anomalies and complaints will be recorded in the validation documents as much as possible to ensure that consolidated records are maintained. If anomalies and complaints are present in other documents for e.g. email, they will also be kept as records.

All records will be kept for a duration of minimum 5 years from the date of creation.

3 GAS QUALITY MEASUREMENT

Gas entering the pipeline must meet certain specifications before it is transmitted through the pipeline. Jemena monitors the gas quality to ensure it meets these specifications. The natural gas specification must comply to the Australian standard AS 4564-2020 Specification for General Purpose Natural Gas.

The Contracts for services on the pipelines state the acceptable gas quality limits that apply to gas to be transported. 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). If the limits mentioned in facility specific Contracts differ to the Australian standard then the Contract limits will take precedence to the Australian standards.

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 Centre. Alarms are triggered should the measured or calculated gas properties approach the limits specified. On facilities, where a Gas Chromatograph (**GC**) is not installed on-site, Gas Quality information shall be sourced from a Gas Chromatograph at another location proven to be representative of the gas passing through the meters in this facility.

3.1 ON SITE ANALYSIS

Gas Chromatographs 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.

Moisture analysers are used to continuously sample the gas stream to establish its water dew point.

Sulphur analysers are used to continuously monitor the sulphur component of the gas.

3.1.1 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)
- Ethane (C2)

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)

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 is GPA 2172 or 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 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 four other pressures.

All gas chromatographs are factory tested and calibrated with use of the gravimetric methods in accordance to Australian legal units of measurement.

3.1.2 SULPHUR ANALYSER

The analysers utilise a Flame Photometric Detector to identify sulphur constituents in process gas. They operate by detecting characteristic light waves emitted by combustion of sulphur in the flame cell. Individual components are eluted from separation columns into the flame cell. The GC's resolve the sulphur compounds into Hydrogen Sulphate (H2S), Carbonyl Sulphite (COS), Tertbutyl Mercaptan (TBM) and Tetrahydrothiophene (THT).

The analysers are validated by testing the equipment with use of the gas of known composition. The calibration gas bottles are supplied by NATA accredited laboratories. The gas is prepared with use of gravimetric methods traceable to recognised national standards to achieve predetermined composition. Appropriate certificates are provided with the bottles for traceability purposes. The certified composition of the calibration bottles in form of the composite mole percentage values is entered into the Validation Spreadsheet for the specific locations of the chromatographs.

The calibration gas contains small quantities of H2S, COS, TBM and THT, blended in methane with traces of Propane, Ethane and Nitrogen.

3.1.3 MOISTURE ANALYSER

The Moisture Analyser draws a continuous sample stream from the gas flow and provides an indication of water content. An analogue output signal and alarm is provided.

The analysers covers the overall range from 0 to 100ºC (32ºF to 212ºF); analyser performance is immune to changes in sample gas, sensibility of 0.1 ppmv or 1% of reading, whichever is greater.

The analogue output of the analyser is connected to the SCADA system and is alarmed and monitored.

The moisture analyser(s) are calibrated as part of routine verifications of gas analysis and Energy Accounting equipment.

4 REFERENCE AND LOCAL CONDITIONS

4.1 REFERENCE CONDITIONS

The standard reference conditions utilised by Jemena for the gas measurement is as below. These standards are also Industry accepted reference conditions within Australia.

Measurement Reference Temperature	15°C (288.15K)
Measurement Reference Pressure	101.325 kPa (abs)
Standard Gravitational Acceleration (gs) at sea level and 45 latitude	9.80665 m/s
Density of Air at standard temperature and pressure	1.2255 kg/m3

4.2 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”.

4.2.1 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.

4.2.2 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

5 ABBREVIATIONS AND DEFINITIONS

Term / Abbreviation	Definition
AGA	American Gas Association
AS	Australian Standard
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 transport of gas via the Eastern 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.
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
ECMS	Enterprise Content Management System
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.
FAT	Factory Acceptance Test
FC	Flow Computer

Term / Abbreviation	Definition
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.
GC	Gas Chromatograph
GEA	Gas Engine Alternator
Gigajoule (GJ)	10^9 Joules
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).
gs	Standard gravitational acceleration
JGN	Jemena Gas Networks
Melbourne Control Centre	The place where gas transmission control occurs.
HP	High Pressure
ISO	International Organisation for Standardisation
Joule (J)	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.
K	Kelvin
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.
kg	Kilogram

Term / Abbreviation	Definition
LP	Low Pressure
Megajoule(MJ)	10^6 Joules
ml	millilitre
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.
NATA	National Association of Testing Authorities
Petajoule(PJ)	10^{15} joules
Pipeline	The pipeline licensed under Pipeline Licence No. pursuant to the Petroleum Act
ppmv	Parts per million volume
Qmax	highest flow rate at which the meter can still maintain an accuracy
Qmin	lowest flow rate at which the meter can still maintain an accuracy
Qt	Transitional Flowrate
Quantity	The quantity of gas measured in terms of its energy content.
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.
RTD	Resistance Temperature Detector
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).
SI	International System of Units

Term / Abbreviation	Definition
Terajoule(TJ)	10^{12} joules
USM	Ultra-Sonic Meter