Wet Gas Metering

Flow solutions for the oil & gas industry



1. Product Overview & Principle of Operation

McMenon applies some 75 years of differential pressure flow metering experience to wet gas measurement.

Its systems use a venturi tube and established correction algorithms to provide corrected gas flow readings.

Wet gas contains a small liquid fraction but is treated as a single-phase measurement application when only the gas flow is required.

The gas volume fraction (GVF) is typically at least 90-95%.

Product highlights

- Robust venturi construction with low pressure loss and minimal wear.
- Handles entrained liquids without blockage or damage.
- Available in a wide range of materials.
- Suitable for extremes of pressure and temperature.

Areas of application

- Marginal oil and gas field development
- Process and allocation metering
- Well management and well testing
- Production optimisation

2. Understanding Wet Gas Measurement

As many of the most economically attractive gas fields are already on stream, more marginal fields are being developed, including gas condensate fields. Gas is the primary resource in these fields, with small quantities of hydrocarbon liquid present in the stream.

Separating the phases for well testing may be impractical or uneconomic. This creates a need for meters that measure the gas flow while accounting for the effect of the liquid phase.

Why correction is required

Liquid in a gas stream causes a differential pressure (DP) meter to indicate a flow rate higher than the true gas flow rate. This over-reading increases as the liquid volume fraction (LVF), the ratio of liquid volume to total volume, increases.

The venturi tube is well suited to wet gas metering because liquid can pass through it without blockage or damage. Its readings are less affected by liquid than those of many other primary elements.

Established correction algorithms

Murdock developed the original correction algorithm for orifice plates. Chisholm modified it to account for gas density, and De Leeuw developed a correlation for wet gas measured using venturi tubes.

These correlations use the Lockhart-Martinelli parameter, a dimensionless number that expresses the liquid content in terms of the pressure drops that would occur if the liquid and gas phases flowed separately through the meter restriction.

Configuration and updates

The algorithms require liquid density and LVF data, supplied by the user and entered during start-up. The configuration can be updated periodically if the LVF or density changes.



3. System Components & Computer Options

Component	Function
Venturi tube	Flow sensing
Integral RTD element	Temperature sensing
McMenon multivariable transmitter	Measurement of differential pressure, static pressure and temperature
Flow computer, display and retransmission module	Wet gas correction and corrected flow readouts/signals

SpiritIT Flow-X series

The Flow-X module can be used in several enclosures. The Flow-X/S and Flow-X/K are single-module enclosures that provide onboard wiring terminals and remote I/O connectivity through 37-pin D-sub connectors, respectively.



PLC version

The PLC version is suited to more demanding applications, including sites with multiple wet gas metering systems and those requiring Profibus-DP, Modbus, DeviceNet, CANopen or Ethernet communications. It can be supplied in a wall-mounted enclosure or for rack or panel mounting.



A package tailored to the application

McMenon can supply anything from a meter and transmitters to a complete system incorporating a distributed control system (DCS). It can also work with client-nominated tracer-dilution suppliers to add measurement of the flow rates of individual liquids in the stream.

4. System Capability & Liquid Correction

Level	Description	Device
1	Flow element	Venturi + RTD
2	Field device	MVTx / DPTx / TTx / PTx
3	Remote computer - basic	SensyCalG - wet gas version
4	Remote computer - advanced	AC 500 PLC
5	Remote computer - advanced, with liquid flow rates	AC500 PLC + tracer-dilution inputs
6	Full DCS	AC800 DCS

Factors affecting over-reading

If uncorrected, a venturi meter will over-read the gas flow rate when liquid is present. The degree of over-reading is affected by operating pressure, the Lockhart-Martinelli parameter (X) and the gas Froude number (Frg).

Lockhart-Martinelli parameter

$$X = \frac{m_l}{m_g}\left[\frac{\rho_g}{\rho_l}\right]^{1/2}$$

m_l: liquid mass flow rate
mg: gas mass flow rate
ρg: gas density
ρl: liquid density

Gas Froude number

$$Fr_g = \frac{v_g}{gD^{1/2}}\left[\frac{\rho_g}{\rho_l - \rho_g}\right]^{1/2}$$

υ_g: superficial gas velocity
g: gravitational acceleration
D: upstream pipe diameter
ρg: gas density
ρ_l: liquid density

5. De Leeuw Correction

The De Leeuw correlation applies to venturi meters measuring a gas stream containing hydrocarbon condensate. The over-reading ratio (φ) is the ratio of the uncorrected gas flow rate to the true gas flow rate.

$$\phi = \frac{Q_{\text{uncorrected_gas}}}{Q_{\text{real_gas}}}$$

$$= (1 + CX + X^2)^{1/2}$$

Correction algorithm

$$Q_{\text{real_gas}} = Q_{\text{uncorrected_gas}} / (1 + CX + X^2)^{1/2}$$

$$C = (\rho_l/\rho_g)^n + (\rho_g/\rho_l)^n$$

n = 0.41 for 0.5 ≤ Frg ≤ 1.5
n = 0.606 (1 - $e^{-0.746Frg}$) for Frg > 1.5

Gas and liquid density inputs

The gas and liquid densities must be supplied to McMenon for the initial system configuration. If either value changes significantly, the client must update the system accordingly.

Uncorrected gas mass flow rate

$$Q_{\text{uncorrected_gas}} = C_{\text{gas}}\, \varepsilon \pi d^2 \sqrt{\frac{2\rho_{\text{gas}}\Delta P}{4\sqrt{(1-\beta^4)}}}$$

Symbol	Definition
Cgas	Venturi discharge coefficient in dry gas, determined through calibration
ε	Gas expansibility in the venturi, as defined by ISO 5157-1
d	Venturi throat diameter, corrected for temperature
ρgas	Gas density at upstream conditions
ΔP	Raw differential pressure measured by the transmitter
β	Ratio of venturi throat diameter (d) to pipe diameter (D)

6. Wet Gas Meter System & Installation

Parameter	Specification
Fluid	Wet gas with a Lockhart-Martinelli parameter of 0.0-0.3; higher values indicate greater liquid content
Liquid volume fraction	5-10%
Flow regime	Mist flow
Pipe orientation and velocity	Horizontal pipe run; typically 15 m/s or higher to keep liquid suspended in the gas
Primary element	Classical venturi tube with a machined convergent, designed and constructed as a single-phase meter to ISO 5167:2022
Correction	Wet gas correction by a separate flow computer or PLC using the correlation algorithm
Uncertainty target	±10%
LVF input	Estimated or determined empirically on site for use in the De Leeuw algorithm

Pressure tapping and temperature measurement

Single pressure tappings are provided at the standard upstream and throat locations in accordance with ISO 5167. An additional downstream tapping measures pressure after full recovery, allowing the total pressure loss to be determined.

Changes in overall pressure loss can indicate significant LVF variations and the need to retest or re-estimate the LVF used in the correction algorithm. An RTD element is located 5D downstream of the venturi, in accordance with ISO 5167, to provide the temperature input.

7. Instrumentation, Applications & Testing

Transmitter options

McMenon differential pressure, pressure and temperature transmitters are supplied fitted to the meter assembly.

Dual DP transmitters, set to different ranges, can be supplied for greater flow turndown.

Multivariable transmitters can replace separate DP, pressure and temperature transmitters where required.



Applications

- Development of marginal oil and gas fields
- Process metering where gas contains hydrocarbon liquid, water or both.
- Allocation metering for individual well control
- Well management.
- Well testing to reduce capital expenditure when evaluating new wells.
- Production optimisation.



Certification, testing & documentation

McMenon wet gas meters undergo stringent testing and are supplied with comprehensive certification and documentation. Material traceability certificates support the quality and suitability of the materials used to manufacture the flow elements.

McMenon offers material testing, and the complete meter can optionally be tested on water, gas or wet gas. McMenon has used the UK National Engineering Laboratory (NEL) wet gas test facilities.

Project-specific data dossiers include meter bore calculations, welding qualifications, drawings, NDE certificates and procedures, material certificates and quality plans.



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