ESMER Wet Gas Meter

Technology Overview

ESMER Wet Gas Meter (**esmerWGM**) is designed specifically for wet gas metering applications.

esmerWGM provides high accuracy wet gas measurement using a conventional electro-mechanical skid aided by specialized real-time hydrodynamic and thermodynamic software.

esmerWGM comprises a standard venturi meter. The mass rate is calculated from the differential pressure equation assuming dry gas flow which is then corrected for over-reading due to the presence of the liquid phase.

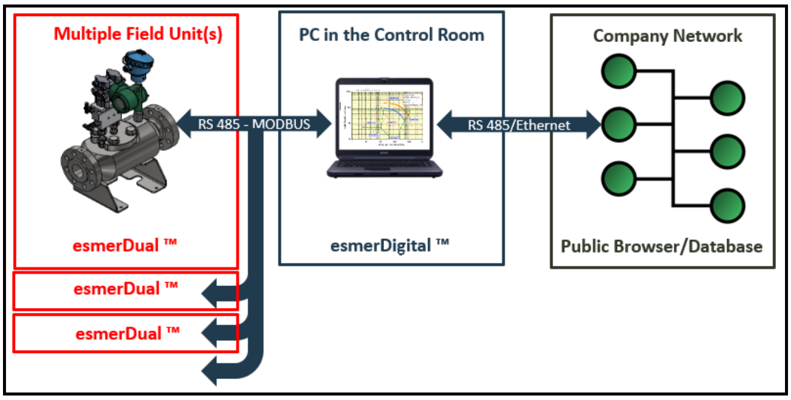
Liquid fraction required for the correction term is determined from pressure recovery analysis and the thermodynamic (PVT) calculation performed on-line

***esmerWGM* (Venturi) on an off-shore platform**

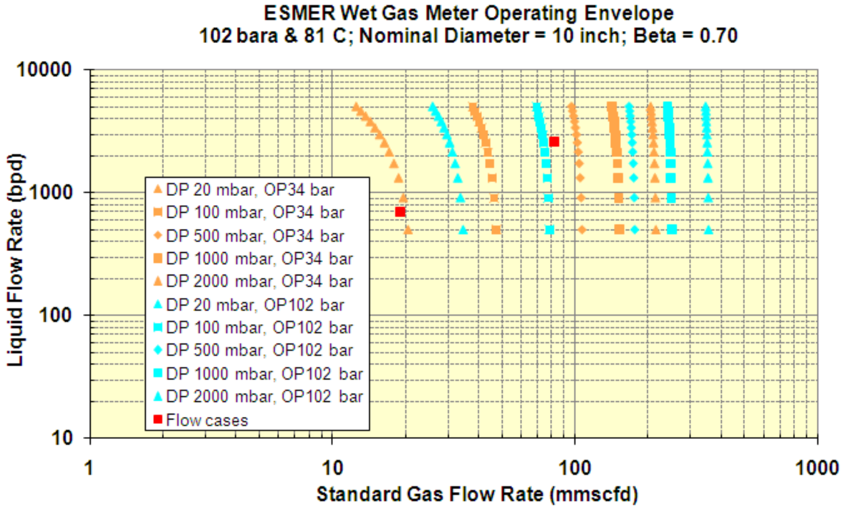
Electro - Mechanical System

esmerWGM field unit is available with the cone or venturi flow element designed as per ISO5167 standard. All models are connected to the pipeline for straight through flow. Models with the cone element are more compact and suited for applications with limited space. A multivariable transmitter is used for measuring DP,AP,RTD and share the same digital connectivity platform, electronics and software proprietary to PSL named ***esmerDigital*** ™ . The package implements different algorithms depending on the process conditions. Wet gas algorithms proprietary to Petroleum Software Ltd are described in detail in the following pages.

The low cost and digital implementation of the system renders an MPFM per well connected to the company network in the realm of reality. An equipment room is required for the Flow Computer assembly which comprises a small Exe enclosure housing the 24V power supply, the digital converters and a PC. For wiring, a single 24V power cable and a single RS485 digital cable is required between the Field Unit and the Flow Computer.



Specification



Each **esmerWGM** is built and calibrated to meet specific process and fluid requirements.

A sizing calculation will be made to suit given process conditions. An example is shown on the right.

Careful attention is paid to material selection to provide protection against corrosion.

esmerWGMs are quality tested by third party inspectors. We collaborate closely with TUV, Bureau Veritas, Lloyds to implement industry standards for testing and inspection during FAT testing of systems.

Operating Envelope	Measurement Uncertainty
Gas: Depends on pipe diameter **Liquid:** Depends on pipe diameter **Water Cut:** 0 – 100% **GVF:** 98 – 100% **Pressure:** up to 150 bar **Temperature:** up to 120 ˚C	**Liquid flow rate:** +/- 10% (relative) **Gas flow rate:** +/- 5% (relative) **Water cut :** +/- 5% (abs) esmerWGM™ calibration will be tuned up to field conditions. Accuracy will depend on PVT data quality and flow rates. A specific accuracy target will be provided for each application.

Electro-Mechanics

Materials, Flanges, Schedule: Built to NACE and ASME standards. Materials selected as per customer request.
Meter sizes: 4" to 14"
Transmitters: DP/AP/ RTD/Water-cut
Certification: EEx ia IIB T4
Power Supply: 24 VDC / 110/220 VAC / 20 W

SIZE (600 ANSI)	L mm	H mm	W mm	WEIGHT kg
4"	1180	1293	623	180
6"	1669	1376	706	275
10"	2683	1528	858	520

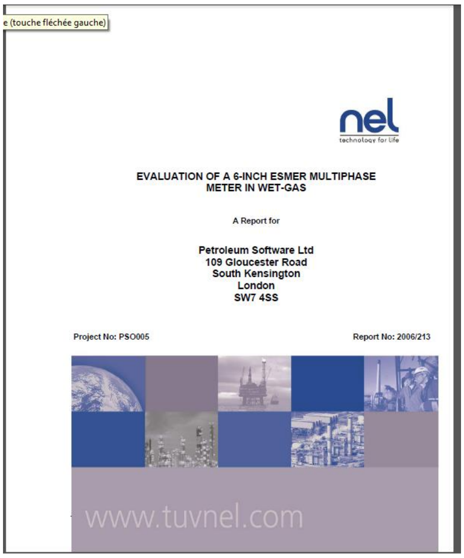
Flow Loop Calibration & Performance Evaluation

esmerWGMs are calibrated / tested in 3rd party wet gas flow loops. NEL UK flow loop is commonly used. NEL provides an independent performance report on request.

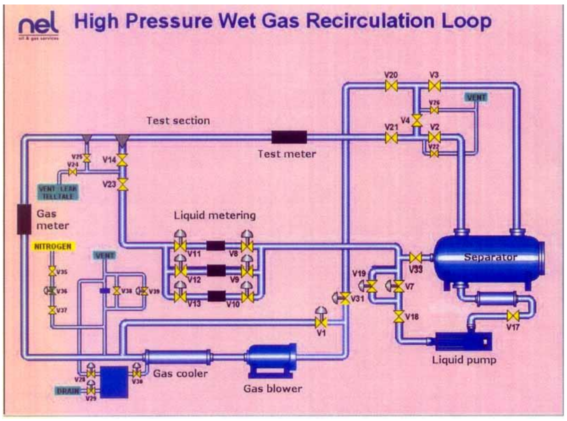
Some examples of NEL reports are:

EVALUATION OF A 6 inch ESMER MPFM IN WET-GAS
NEL Report 2013/432 August 2013

EVALUATION OF A 6 inch ESMER MPFM IN WET-GAS
NEL Report 2006/213 July 2006



NEL REPORT



NEL FLOW LOOP

ESMER calibrations are carried out under conditions which provide the best match against particular process conditions. Particular laboratories and calibration matrices will be recommended after a careful study of the process conditions and the operating envelope.

6" esmerWetGas – Venturi at NEL

Field Calibration & Validation

esmerWGM can be validated and recalibrated against a conventional gravity separator as per API 2566 guidelines

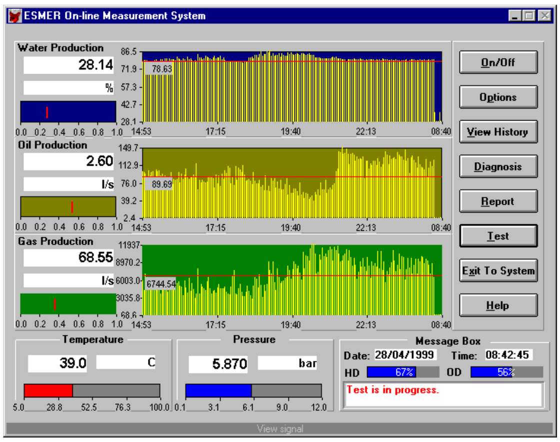
Flow Computer and Software

esmerWGM is founded on a user friendly Windows based software package named ***esmerDigital ™*** which handles all the data acquisition and measurement tasks.

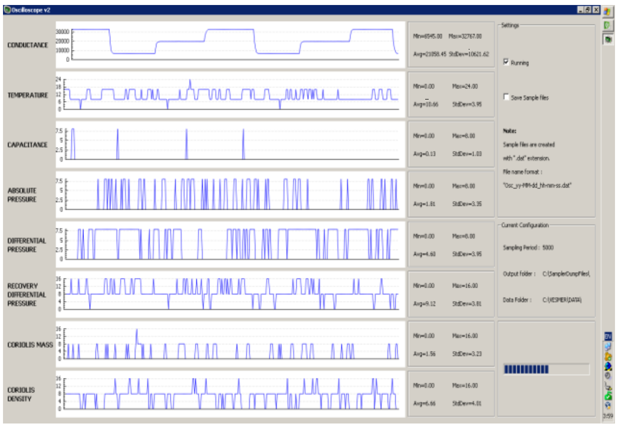
Measurements are displayed in real-time strip charts and saved in a database. Diagnostic and reporting functions are available.

Measurements can also be transmitted in analog or digital form via Ethernet and serial ports under a number of protocols.

- **Hazardous Area:** Embedded PC in Class II 2G EEx d IIB T6 Exd Enclosure
- **Safe Area:** Industrial PC in IP55 Rack Mount Enclosure
- **Software:** **esmerDigital** running under Windows
- **Communication:** RS232/RS485/Ethernet/MODBUS



esmerDigital OPERATOR'S CONSOLE



esmerDigital DIAGNOSTICS

Hydrodynamic and Thermodynamic Wet Gas Flow Models

esmerWGMs can be configured for use under a variety of fluid and flow regimes by means of a combination of hydrodynamic and thermodynamic models. Flow models are fine tuned against process conditions in the field by proprietary methods.

esmerWGM software executes the following calculation steps to predict true gas and liquid flow rates:

1. Apparent gas mass gas flow rate is determined from the Bernoulli equation:

$$\dot{m}_{g(tp)} = C_d E \varepsilon A_d \sqrt{2\rho_g \Delta p_{tp}} \qquad (2a)$$

where $\dot{m}_{g(tp)}$ is the apparent gas mass flowrate determined by the meter from the two-phase flow differential pressure.

C_d is the discharge coefficient of that meter from a dry gas flow calibration.

E is the velocity of approach factor $\left(1/\sqrt{1-\beta^4}\right)$

ε is the gas expansibility factor.

A_d is the minimum cross sectional area through the meter.

Δp_{tp} is the measured two-phase differential pressure.

β is the square root of the ratio of the minimum flow cross sectional area through the meter to the inlet cross sectional area.

2. Apparent gas mass flow rate calculated by the Bernoulli equation will over predict the actual gas rate due to the presence of the liquid phase which is not accounted for in equation 2a. Actual gas mass flow rate can then be determined by means of the Correction Factor:

$$\dot{m}_g = \frac{\dot{m}_{g(tp)}}{\text{CorrectionFactor}} \qquad (3a)$$

Where the over-reading Correction Factor is given by the de Leeuw correlation:

$$\dot{m}_g = \frac{\dot{m}_{g(tp)}}{\sqrt{1 + CX + X^2}}$$

where

$$C = \left(\frac{\rho_l}{\rho_g}\right)^n + \left(\frac{\rho_g}{\rho_l}\right)^n$$

and $n = 0.41$ for $0.5 \le Fr_g \le 1.5$

$$n = 0.606\left(1 - e^{-0.746\, Fr_g}\right) \text{ for } Fr_g \ge 1.5$$

Where, X (the Lockhart-Martinelli Parameter) is defined as:

$$X = \frac{\dot{m}_l}{\dot{m}_g}\sqrt{\frac{\rho_g}{\rho_l}}$$

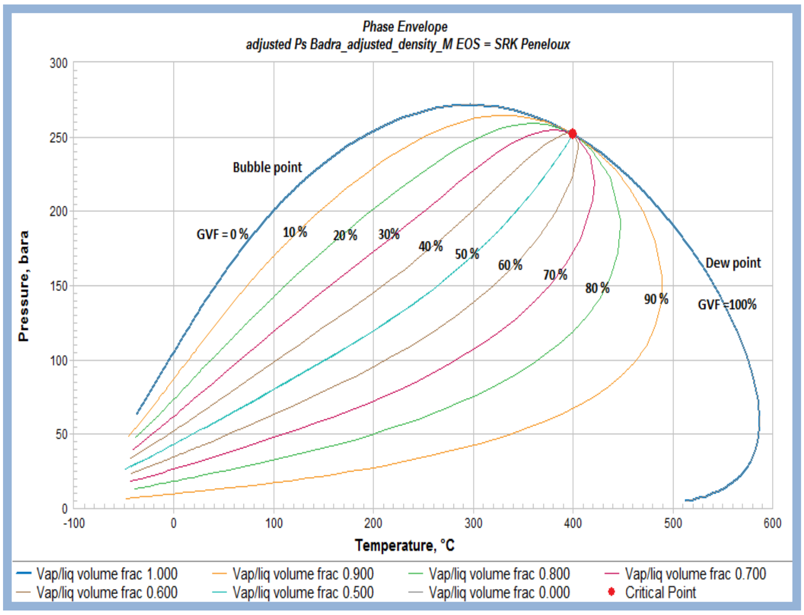
Where. Froude number is defined as:

$$Fr_g = \frac{U_{sg}}{\sqrt{gD}}\sqrt{\frac{\rho_g}{\rho_l - \rho_g}}$$

Where, U_{sg} is gas superficial velocity.

Hence, it is seen that a-priori knowledge of the liquid fraction is required in order to apply the wet gas correction.

esmerWGM determines the liquid fraction by compositional modelling of the fluid stream by means of an equation of state and performing a flash calculation at line pressure and temperature.



Calibration Inputs

- Fluid composition and PVT information.

Outputs

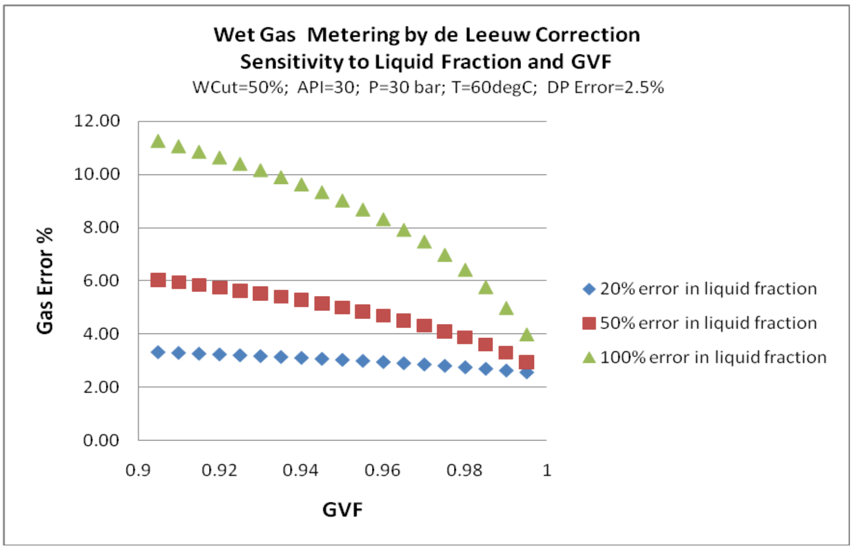
The following outputs are provided:

- Gas flow rate (mass or volume)
- Liquid flow rate
- Water fraction (option)
- Pressure
- Temperature

Sensitivity of Accuracy to Liquid Fraction and Pressure

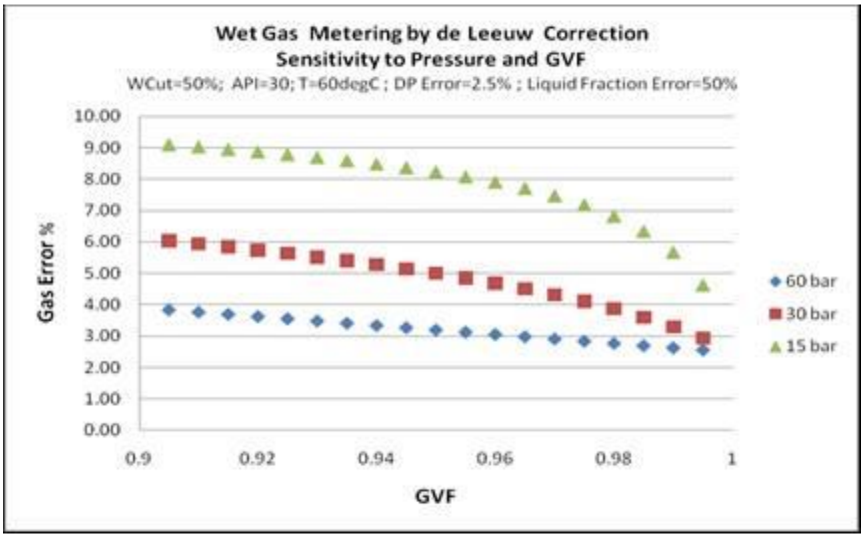
Liquid Fraction Error

As shown in the chart on the right, the wet-gas correction error (ie liquid fraction error) is relatively small. For example, at 30 bar and GVF=0.98, an increase in the liquid fraction error from 20% to 100% results in the doubling of the wet gas total measurement error from 3% to 6%.



Pressure and GVF Effect

The correction term is however quite sensitive to pressure. For example, consider the chart on the right. Under same measurement conditions and error margins, reducing the pressure from 60 bar to 15 bar results in increasing the error in the wet gas measurement by a factor of three.



esmerMPFM

Petroleum Software Ltd

http://www.petroleumsoftware.co.uk