EMCO Wet Gas Metering Series WG-V for Gas Flow Measurement

Introduction

Wet gas flow measurement is becoming increasingly important in today’s oil and gas industry. Many high producing gas fields are exploited and some are facing the end of the production life time. Gas fields approaching the final stages and marginal fields have one thing in common: The natural gas is wet. The term wet means that the natural gas line also carry a relatively small amount of free liquid by volume.

Application

Well testing, hydrocarbon allocation metering, hydrocarbon sales metering, monitor critical factors such as water breakthrough.

Definition

The definition of wet gas is when the flow of gas and liquids has a Lockhart-Martinelli parameter $X$ in the range of $0 < X \leq 0.3$. The fluid of interest to be measured is the natural gas and not so much the hydrocarbon liquids.

Wet gas metering is a difficult application therefore a standard (dry) flowmeter cannot be used. The term “wet gas” is like a 2-phase flow measurement but with a maximum liquid volume of 10% and therefore a minimum of 90% gas volume (90% GVF – Gas Volume Fraction)
Measuring Principle

EMCO wet gas metering is based on the classical venturi tube according to ISO 5167-4 with single pressure tappings. A third tapping may be applied for liquid flow rate determination using the pressure loss ratio method. Calculating the differential pressure for the wet gas meter using the international recognized ISO standard 5167-1 is resulting in a higher differential pressure than a similar calculation for a dry gas. This over-reading has to be corrected for in computers using a number of algorithms. The magnitude of over-reading depends on the liquid volume fraction, the static pressure, the gas and liquid densities and the velocity. The mechanical design of the wet gas metering section is influenced by the choice of algorithm for over-reading correction.

Wet Gas Metering System

The system consists of a classical venturi tube in a metering section. Differential pressure transmitter(s), static pressure transmitter or multivariable transmitters, a thermowell and a temperature transmitter an instrument cabinet, a wet gas flow computer and an over reading correction algorithm and if required for liquid flow determination tracer dilution system.

Installation requirements

The metering section shall be mounted in a horizontal pipe run with pressure tappings pointing up wards. Length of in- and outlet pipe are not critical. An inlet length of 5 times inner pipe diameter and an outlet length of 2 times is sufficient. Impulse lines from transmitters to meter tube shall be sloped.
Flow pattern

The behaviour of wet gas flow will show different characteristics depending on gas velocity, gas pressure, liquid flow rate and pipe orientation. These combinations of gas and liquid are known as flow pattern or

There are different flow patterns depending on GVF.
Stratified (Smooth): Low gas velocities, Gas flow at the top, Liquid flow at the bottom.
Annular Mist: High gas velocities, Thin film of liquid around annulus of the pipe.
Stratified (Wave): Higher gas velocities produce waves on the liquid surface.
Liquid droplets are created and carried away

Mechanical Construction

Element type: Classical venturi tube, machined type
Sizes: DN 50 - 250 according to ISO 5167, 2” – 10” according to ASME, other sizes on request.
Beta (d/D): 0.4 ≤ β ≤ 0.75
Material: 22Cr Duplex (standard), AISI 316, 25Cr Duplex.
Process connection: Flanges to ANSI B16.5 or hubs for clamp connection
Pressure taps: ½”, ¾” or 1“ flanges or hubs.
Temperature tab: 1½” flanged.
Inlet cone: 21 or 10,5°
Outlet cone: 7 to 15°
Fluid Properties

Following wet gas condition must be fulfilled:

1. Lockhart-Martinelli parameter $X$: $0 < X \leq 0.3$

$$X = \frac{m_r}{m_g} \sqrt{\frac{\rho_g}{\rho_l}}$$

$$F_{rg} = \frac{v_g}{\sqrt{gD}} \sqrt{\frac{\rho_g}{\rho_l - \rho_g}}$$

$F_{rg}$ is proportional to gas velocity

2. Gas densiometric Froude number $F_{rg,th}$: $F_{rg,th} > 3$ The Froude no. in the throat.

3. Gas density to liquid density ratio at the tapping: $\frac{P_l}{P_i} > 0.02$

Gas density measured at plus pressure tapping.. $P_l$

GVF (gas volume fraction) 90 – 100 %

Velocity (or Fr g) has a significant effect on the over reading
Wet gas over-reading correction

Murdock has developed correlations for wet gas conditions based on his research on orifice plates that wet gas over-reading was depending on the Lockhart-Martinelli parameter. Later Chisholm found that the over-reading not only was related to the Lockhart-Martinelli parameter but also the gas to liquid density ratio. The most recent correction algorithm is a modification of the Murdock and Chisholm algorithm shown by R. de Leeuw that exponent in the density ratio is dependent on the gas Froude number. The Chisholm-de Leeuw correlation or simply the de Leeuw correlation is now widely used in the industry for wet gas over-reading correction.

8" 900 lbs EMCO wet gas venturi under calibration

Algorithms

Correction algorithms developed by R. de Leeuw is shown below.

\[ M_g \times P = \frac{M_g \times P}{\sqrt{1 + C \times X + X^2}} \]

Where \( C = \left( \frac{P_g}{P} \right)^n + \left( \frac{P_g}{P} \right) \)

\( M_g \times P \) = two phase flow
\( n = 0.41 \) for \( F_{lg} \) larger than 0.5 but smaller than or equal to 1.5
\( n = 0.606(1 - e^{-0.746 \times P_{lg}}) \)

For \( F_{lg} \) larger than 1.5

Pressure Loss Ratio Method

The pressure loss over the venturi tube is dependent on the \((d/D)\) ratio. For dry gas the pressure loss is 7 – 15 % of measured differential pressure for flow, but for wet gas the pressure loss increases due to the liquid load to much larger values. This finding can in some circumstances be used to determine the liquid load or wetness.

The pressure loss over a venturi tube is measured between an upstream tapping and a tapping placed in the venturi tube pipe section where full pressure recovery has taken place. Full pressure recovery is reached ca. 5 times inner diameter from the end of the outlet cone of the venturi tube.

The 3rd tapping or downstream tapping is normally placed 5 times inner pipe diameter from end of outlet cone.

The pressure loss ratio method is only applicable for velocities above 7-10 m/s.
Tracer Dilution Method

The Tracer Dilution Technique was developed to measure multiphase flow more accurately where phase separation is not available or possible and can equally be used for wet gas metering.

Tracers compatible with the liquid and/or gas flow are injected by a precision pump into the flow stream up-stream of the wet gas meter and diluted with the fluid.

Sampling is made down-stream and the dilution ratio makes possible to calculate the liquid flow rate. The tracer test results can then be compared with the wet gas flowmeter flow rate readings to verify the flowmeter readings. The results are used to validate the fluid composition or PVT data used in the flow computer software. Tracer dilution technique is not depending of fluid composition and therefore regarded as a reliable method of wet gas metering verification.

The distance between the injection and the sampling shall be larger than 150 times the inner pipe diameter.

PVT calculation

The static pressure transmitter and the temperature transmitter are used density correction.

Technical Data

Accuracy : 3 % gas flow
           10 % liquid flow

Maintenance

Wet gas metering systems require period check of fluid composition to ensure reliable flow rate measurement. The span of time between each check depends on required accuracy and how quickly the composition of the flow rate change. EMCO Controls can provide the initial start-up of the system as well as periodic flow check on site.

Notes :

Gas Void Fraction is gas area to total area

Gas Volume Fraction (GVF) is gas volume to total volume

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