METRA
Energie-Messtechnik
Member of Bopp & Reuther Messtechnik Group

Technical report

"Billing steam - a sensitive issue!"

Billing steam - a sensitive issue!

Water steam is of enormous significance, particularly in the energy sector. Small quantities of water steam can transport a large amount of heat and thus energy.

- Working medium in steam turbines
- For heating purposes
- Process steam

- Wet steam (water and steam content)
- Saturated steam (steam and temperature have a clear assignment)
- Overheated steam (no clear assignment of pressure and temperature)

The measurement of vaporous media still means interference of the pipework. The feasible, reliable measuring methods are limited to the measurement of the pressure differential and vortex separation. The growing demand for these billing measurements can be explained by the fact that the producer and consumer of the various material flows are not one and the same.

Due to the increasing devolution and decentralization of companies it is necessary to install meters at the relevant interfaces.

The demand for this type of billing measurements has increased considerably; the basic concept is, however, not very transparent, especially in terms of steam measurements. Questions about calibration, confidence range, measuring uncertainty and establishing respective measuring chains frequently arise.

Steam measurements cannot be calibrated!

A fact that is clearly defined in the calibration regulations (EO 22 Appendix A).

This is obviously a problem for both the producer and purchaser of steam. Naturally, both sides desire a precise, reliable and comprehensible measuring system. There are only a few methods that are generally suitable for steam applications.

The most important ones are:

- **Traditional pressure differential metering in accordance with DIN EN ISO 5167 (in short ISO 5167)**
- **Vortex meters**
- **Dynamic probe measuring**

Pressure differential in accordance with DIN EN ISO 5167:

METRA Energie-Messtechnik has been supplying steam flow and steam energy meters for 25 years. Based on our extensive experience in the field of steam measurements, we have ascertained that measurements according to the differential pressure method (orifices, nozzles, Venturi ISO 5167) are best suited for billing measurements and high quality balancing / check measurements.

Steam billing measurement using a Venturi tube in accordance with DIN EN ISO 5167
METRA Energie-Messtechnik Speyer, Germany
Medium: steam, mass flow 65 t/h, steam pressure 21 bar(abs), steam temperature 280°C

To substantiate this you have to put yourself in the position of a producer or purchaser of steam. The requirements placed on steam billing measurements from the operator's point of view are:

- Small measurement uncertainties with large measuring dynamics
- Large confidence range and high availability
- Verifiability on site, plausibility check
- Legal certainty and/or traceability to international standards of measurement

The requirements can only be met with standardized pressure differential devices (ISO 5167) and harmonized equipment technology. Apart from where a few minor amendments have been required, the pressure differential device standard ISO 5167 is valid worldwide. No other measuring method has been examined to such a degree; its performance has also been confirmed by conducting numerous calibrations at various test benches.

The popular and false opinion that pressure differential metering is only possible with low measuring dynamics and high measuring uncertainties is no longer valid. Even in traditional pressure differential measurements, modern equipment technology allows measuring ranges of up to 50:1 with a measuring uncertainty of 0.5% of the instantaneous value in terms of the mass flow rate and energy flow.

To realize such large measuring ranges with a minimum measuring uncertainty, the individual components and the test method of a pressure differential measurement chain must satisfy extensive requirements.

This ranges from the correct selection of the pressure differential device and the transducer technology (pressure differential, absolute pressure, temperature) to the steam flow or steam energy calculation unit.

Universal flow and energy meter ERW 700
(EC Type Examination Certificate DE-08-MI004-PTB004)
METRA Energie-Messtechnik Speyer

Correct evaluation and consideration of the inlet and outlet situation as well as the steam status (wet steam, saturated steam, overheated steam) are always essential for the correct design.

Choosing the right calibration institute is imperative for the quality of a steam measurement. The selection of the calibration institute is determined by the flow status during the actual application of the steam measurement (the Reynolds number ReD is the indicator for this).

A decisive advantage is that a current steam measurement can be verified easily. When selecting the correct pressure differential device in terms of its application, the wear and tear of measurement relevant parts over the years is not something which has to be considered. The appropriate transducer technology, e.g. pressure differential, temperature, absolute temperature or flow / energy calculation meter, can be easily checked on site using applicable standards.

Only when all the requirements described above are considered adequately is it possible to realize a reliable and comprehensible steam measurement that matches a calibrated measuring system.

The example calculation below clearly shows that both the steam producer and the steam purchaser should have great interest in a precise and comprehensible steam measurement:

Example:

Steam measurement cost calculation

<u>Presumption</u>

Steam mass flow rate / hour	**=**	**80 t/h**
Steam price / ton	**=**	**25 €/t**
Operating period / year	**=**	**7,200 h/a**
Billed amount/Year		
80 t/h x 7200 h/a x 25 €/t	**=**	**€ 14.4 m**

<u>Steam measurement uncertainties and the resulting costs in euros</u>

Measuring uncertainty + - 5% > + - € 720,000 pa
Measuring uncertainty + - 3% > + - € 432,000 pa
Measuring uncertainty + - 2% > + - € 288,000 pa
Measuring uncertainty + - 1% > + - € 144,000 pa
Measuring uncertainty + - 0.5% > + - € 72,000 pa

Vortex meters:

Vortex meter technology is suitable for steam applications. The direct linear correlation between vortex separation and flow velocity in a specific Reynolds number range enables comparatively simple further processing of the signals. A steam measuring system consists of the vortex meter, the pressure and temperature transmitter and a flow or energy calculation unit. The application range is for temperatures ≤ 300°C and nominal widths ≤ DN 300.

However, further measures are required for a steam billing measurement. As with the previously described pressure differential measurement, the inlet and outlet sections are necessary as an integral part of the overall measurement. The vortex meter and the inlet and outlet section create a permanent unit (measuring section). A pressure and temperature measuring unit is integrated in the measuring section.

Only manufacturer specifications are available for the required inlet and outlet sections. Generally applicable inspections or even standards, as used for the pressure differential measurement, are not available. The international standard ISO 5167 should therefore be used as guidance when determining the necessary installation lengths. Factory calibration of the individual components (vortex meter, temperature, pressure) is definitely not adequate. The entire measuring system, consisting of the vortex meter measuring section, pressure and temperature measuring unit as well as the flow and energy calculation unit, must be tested under close-to-reality conditions at a suitable accredited test bench that mirrors the later working environment. The same applies as for the pressure differential measurement. Only the testing and interaction of the entire measurement chain enable a reliable statement about the expected measuring uncertainty.

Operating conditions which cannot be covered by the calibration, for example high medium temperatures, must be considered in a theoretical measuring uncertainty approach.

Steam billing measurement using vortex meters

METRA Energie-Messtechnik Speyer

Medium: steam, mass flow 50 t/h, steam pressure 16 bar(abs), steam temperature 230 °C

Dynamic probe:

Dynamic probe measuring is one of a number of pressure differential measurements. The advantages of dynamic probe measurements are obvious. The dynamic probe is inserted into the available pipe through a borehole in the pipework. Installation of the dynamic pressure probe in a pipe system is quite simple compared to other methods.

The flow-proportional pressure differential is detected via pressure vents in the probe and further processed as a flow rate and energy flow with the aid of pressure and temperature in combination with a calculation unit just the same as for a traditional pressure differential measurement (DIN EN ISO 5167).

The correlation between measured pressure differential and medium speed is quadratic as with all pressure differential methods. However, the comparatively simple assembly also has certain disadvantages:

Installation in existing pipework does not take into account manufacturing tolerances, surface quality, eccentricity or the method used to manufacture the pipe. The much acclaimed low loss of pressure is achieved at the price of a very small pressure differential signal and thus less measuring dynamics (approx. 3:1 in terms of the mass flow).

The inlet sections demanded by many dynamic probe manufacturers are very small for a pressure differential method. Doubts have also been expressed with regard to the following:

The diameter ratio (geometry ratio, probe / internal tube diameter, d/D) of these probes is very large. This means that the flow is actually not influenced.

Depending on the inlet fault, the standardized pressure differential measurement (ISO 5167) demands, e.g., an inlet section of 40xD - 50xD for orifices with a large diameter ratio (d/D = 0.7). With a smaller diameter ratio (d/D = 0.4), the demanded inlet section is reduced significantly to 7xD - 15xD.

Therefore, it can be concluded that a dynamic probe measurement with a considerably larger diameter ratio than 0.7 at least requires inlet sections of the same size. Due to the very small obstruction, the dynamic probe detects only a small part of the available flow profile. Faults or imbalances in the flow profile are not or only partially detected by the probe.

Conclusion:

Traditional pressure differential measurements in accordance with ISO 5167 are best suited for steam billing measurements. This method should be favoured if there is sufficient space.

It is still the only method which is traceable to international standards of measurement (ISO 5167). The large confidence range and the possible on-site plausibility check provide the operator with the required level of reliability.

The common incorrect opinion that pressure differential measurements can only be used for very small measuring ranges with a large measuring uncertainty is no longer applicable.

Test station (2-way pipe test loop) approved by PTB
METRA Energie-Messtechnik Speyer

The vortex meter method is also suitable for certain areas of application. This includes nominal widths of ≤ DN 300 and steam temperatures of ≤ 300°C.

In this regard, it is important that the complete measurement chain is considered and tested as a unit. Individual testing of the components is definitely insufficient.

Dynamic probe measuring is only partially suited as a billing measurement. The low measuring dynamics, uncertainties regarding the required straight inlet sections, a lack of traceability to international standards of measurement only allow the use of dynamic probes as a billing system in exceptional cases.

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