



## Measuring Flare Gas Within the European Union Emissions Trading Scheme

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Figure 1: Typical offshore flare stack

**Flare gas is the name given to the surplus waste gas produced during the extraction of crude oil and the subsequent refining process. It is typically vented to atmosphere and burned in a flare stack (Figure 1). The process inevitably releases large quantities of carbon dioxide (CO<sub>2</sub>) to the atmosphere, which is a major contributor to global warming.**

Prior to the European Union Emissions Trading Scheme, the measurement of flare gas on oil and gas production facilities in the North Sea was driven mainly by statutory regulations that required operators to simply report emissions to the Environment Agency. Consequently, there was never an economic incentive to install metering equipment.

The Emissions Trading Scheme (ETS) was introduced in 2005 by the European Union as a part of its climate change policy and is about to begin its third trading period, which will run from 2013 to 2030.

The basic concept is that the European commission allocates Carbon credits (each credit is worth 1000 Kg of CO<sub>2</sub>) to participating countries, which effectively limits the amount of CO<sub>2</sub> that can be released to atmosphere. This limit or "cap" is then spread across the major industrial installations in each country. At the end of each year, installations are required to report their emissions and can either sell surplus credits, if they have emitted less than their allowance or buy credits from other installations,

if they have exceeded their target. As each trading period begins, the overall allocation is reduced further and the total output of industrially released CO<sub>2</sub> falls.

### Flow measurement compliance with ETS directives

Importantly, depending on the Industry and size of the facility, the Trading Scheme stipulates different levels of accuracy for the instrumentation used to measure both fuel gas and flare gas. For the oil and gas industry, flow meters used to report emissions from flares fall within the Tier 3 accuracy level which, means they must have a degree of uncertainty (accuracy) better than  $\pm 7.5$  percent of the measured value. (Dir 2003/87/EC-Appendix 2-2.1.1.3).

In addition, it is a mandatory requirement for the operator to submit a Monitoring Plan (Dir 2003/87/EC-Appendix 2-4.3) explaining how the operator intends to validate the instrumentation used to measure the flare gas emissions. So the operator must effectively prove that the flow meter is within its original specification. This would normally mean returning it to the manufacturer, which is not only inconvenient but extremely costly. For this reason, many operators are now being forced to review their existing arrangements in order to comply with the directive.

### Flare gas flow measurement

The main problem for operators in the offshore oil and gas industry is that measuring flare gas emissions is notoriously difficult. In fact, the EU commission recognized this and decided not to apply the same accuracy targets for flare gas as other important gas streams such as fuel gas, which, for Tier 3 is  $\pm 2.5$  percent. The problem is that not only can the gas be dirty and corrosive, but the variation in flow rates between the minimum and maximum flow can be enormous. Due to the fact that flare gas is effectively wasted gas under normal operation, the operators would hope for a very low flow rate indicating a stable process. During upset conditions, however, the operators can need to vent large quantities of gas to prevent over pressure within the system and this can result in extremely high flow rates through the flare stack.

The ratio between the minimum and maximum flow is known as the "turndown ratio," for example a flow range of 5 kg/hr to 500 kg/hr would mean a turndown ratio of 100 :1. A typical offshore flare system with a 12 inch NB pipe could have a flow range of 80 kg/hr to 50,000 kg/hr, i.e., a turndown ratio of 625:1.

There are very few flow measurement technologies capable of operating across wide turndown ratios. As an example, a

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Figure 2: FCI ST110 Flow Meter

conventional differential pressure (DP) measurement across an orifice plate operates over 5:1 turndown, an ultrasonic flow meter withstands a 40:1 turndown.

The other problem for the operators is maintaining accuracy over such a wide flow range. Generally speaking, all flow meters will perform with greater accuracy at the top of their range and the errors will increase as the flow rate falls. This makes the problem even worse because a flare gas flow meter will be operating in the lower 10 percent of its range for most of its life. Only under upset conditions, when the process becomes unstable, will it need to work at its maximum flow. Indeed the operators will be hoping this is a once a year occurrence.

All operators will have maintenance and calibration schedules in place for their instrumentation packages, but validating and testing flare gas meters is problematic. Ultrasonic flow meters have been traditionally used for flare gas metering and are installed within the pipe as "inline" devices, i.e. they comprise a short pipe section that installs between pipe flanges. Removal of an ultrasonic flow meter for testing, therefore, requires a plant shutdown, which is not ideal and results in lost productivity. Consequently, the only realistic means of testing is to perform a "zero check", whereby the flow meter is isolated and hopefully reads 0 kg/hr at no flow. This is not a functional test or a calibration check because the flow meter is not performing within its calibrated flow range, which means this form of testing is inherently unreliable.

Even though these devices have limitations, in the past they performed well enough to satisfy the needs of the operators. With the introduction of the carbon trading scheme, however, a completely new approach is required that is dependable.

### Thermal Flow Meters... The Next Generation

The ETS directives have completely changed the way we look at flare gas measurement and a new industry standard is required to address the issues of accuracy and field testing. Fluid Components International (FCI), with over 40 years of experience supplying thermal mass flow instrumentation for the oil and gas industry, has designed its new ST110 flow meter (Figure 2) specifically to meet the new challenges set down in the Emissions Trading Scheme.

### Thermal Mass – Principle of Operation

The ST110 flow meter's sensor element comprises two PT1000 RTD's, which are placed within 316 stainless steel thermowells. The active RTD is preferentially heated with a constant current heater, whereas the reference RTD is allowed to rest at the ambient temperature (Figure 3).

At zero flow the differential temperature between the two RTD's is at a maximum. When flow occurs this "Delta T" is reduced due to the cooling effect on the active RTD. This cooling effect is a function of both the velocity and density of the gas. The flow meter therefore senses mass flow directly without the need for additional temperature and pressure corrections. There are no moving parts and the simplicity of the constant current heater design means this technology is extremely reliable and repeatable.

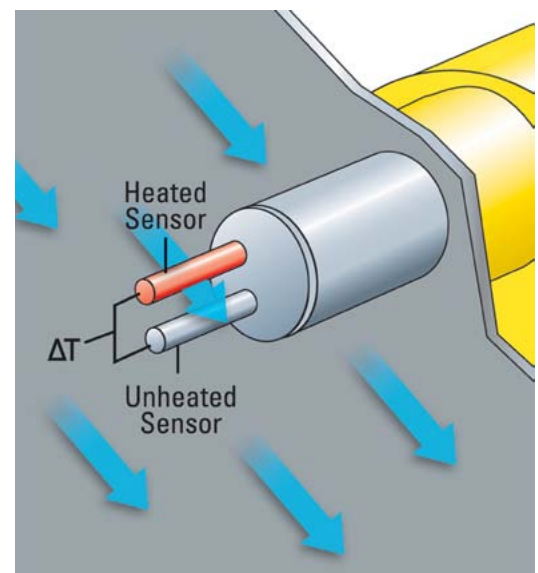


Figure 3: Thermal mass flow sensor element

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The transmitter can express the flow rate in mass units, e.g. kg/hr or standardised volume, e.g., Sm<sup>3</sup>/hr and communicates 4-20 mA via HART, FOUNDATION™ fieldbus, PROFIBUS, or Modbus.

### Turndown Ratio versus Accuracy

Thermal flow meters are inherently sensitive at low flow rates, and this means they are capable of extreme turndown ratios. The ST110 flow meter is unique in its ability to measure gas flow rates with a turndown of 1000:1. It uses a special split range multiple calibration system (SR2x™) developed by FCI engineers specifically for flare gas applications. It has an accuracy statement of ±0.75 percent of reading plus 0.5 percent of the calibrated full scale with a worst case accuracy of ±5 percent of reading. So, even at the low end of a 1000:1 turndown, the ST110 flow meter complies with the ETS directive and is within the target ±7.5 percent accuracy requirement.

### Testing and Validation of Thermal Flare Gas Flow Meters

Until now, validating the calibration of a gas flow meter has been extremely expensive because it meant either installing a second reference flow meter in the pipe line or removing the meter from the pipeline altogether and returning it to the manufacturer. The latter option could also mean purchasing a spare meter to use while the first unit was offsite as well as paying the costs of the additional testing and shipping.



Figure 4: ST110 Flow Meter with packing gland

The ST110 flow meter's sensor features a flanged compression packing gland (Figure 4) that connects to an isolation ball valve. Under normal operation, the sensor is inserted through the valve to the pipe centerline and the gland is tightened to a torque setting of 85 lb/ft. During calibration tests, the gland is loosened to 35 lb/ft, and the sensor is wound back through the valve using the guide rods into the packing gland.

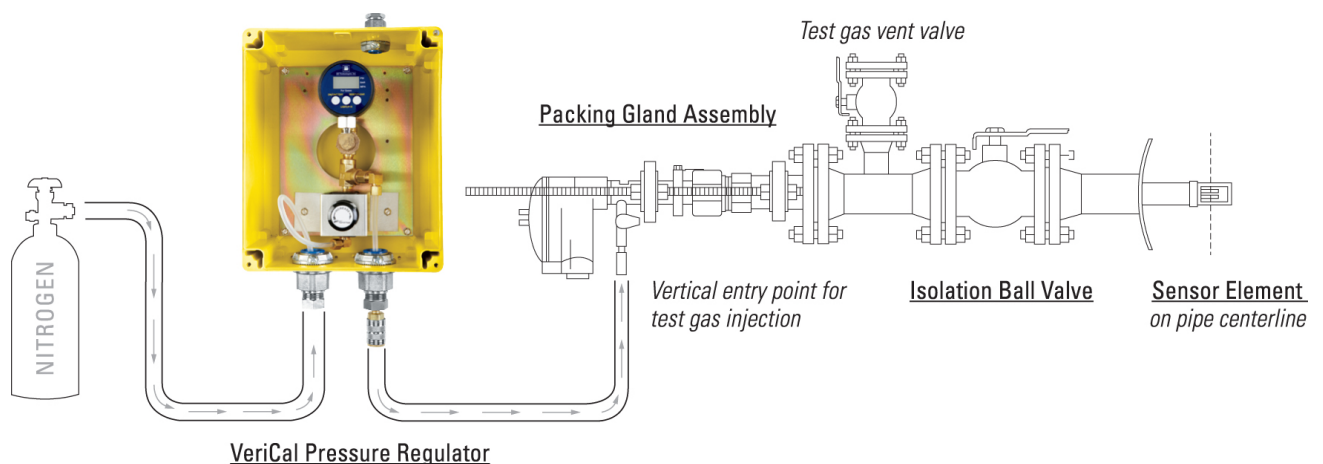


Figure 5: ST110 Flow Meter with VeriCal In-Situ Calibration System



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The key advantage of the ST110 flow meter is its unique ability to be functionally tested and calibration verified without being removed from the pipeline. The patented technology known as VeriCal™ is a true “wet” in-situ calibration verification system. It is comprised of a specially modified sensor element with a separate nitrogen test gas supply, pressure regulator and sonic nozzle (Figure 5).

Inside the sensor rod is a small bore pipe (2 mm – 3 mm diameter) that enters the rod just beneath the sensor’s electrical enclosure via a non-return valve and isolation valve. It extends through the body of the probe and opens at the face of the sensor element between the two thermowells. The test gas flows through the inner pipe and out across the sensor element. The sensor detects the flow and the transmitter outputs a flow reading.

It is important that the sensor is fully recessed into the packing gland. The sensor is now in a controlled environment and will be reading zero flow. The test gas is then injected at increasing flow rates, typically steps of 25 psi, and the corresponding signal outputs are recorded. One key consideration is the integrity of the flare pipeline. The nitrogen test gas should not be allowed to enter the pipeline during testing. This means the ball valve needs to be closed after the sensor is retracted, and the vent valve opened to release the test gas to atmosphere.

Each ST110 flow meter is calibrated at the FCI facility, which is traceable to the U.S. National Institute of Science and

Technology (NIST). In addition to the main calibration certificate, the factory performs a baseline VeriCal test. The results of this test form the basis of all further checks by the customer. The operator can then compare its in-situ recorded test results to the baseline factory test and verify that the instrument has not drifted and remains within specification (Figure 6).

Many operators also require data on the leak rate through the packing gland during the VeriCal test procedure when the sensor is being retracted and re-inserted. The procedure takes approximately 30 minutes, which is the time it takes to crank the sensor out and again when it is re-inserted. Our testing showed the leak rate was <10 cc/hr, which was considered negligible.

Typically, the operators repeat these tests monthly for the first six months to gain confidence in the system and thereafter once per year. This historic data allows the operator to prove that the flow meter is within the factory specification and so forms a part of the Monitoring Plan stipulated in the ETS directive. There are now two major operators in the U.K. North Sea that are using this system. For the first time they are capable of performing wet in-situ validation of their flare gas flow meters. ■

| Date       | 02/06/2012   | Date       | 05/08/2012 |             | Date       | 01/09/2012 |             |
|------------|--------------|------------|------------|-------------|------------|------------|-------------|
| Media      | Nitrogen     | Media      | Nitrogen   |             | Media      | Nitrogen   |             |
| Cal Group  | 1            | Cal Group  | 1          |             | Cal Group  | 1          |             |
| Technician | Factory Test | Technician | Ben Smith  |             | Technician | Ben Smith  |             |
| PSIG       | Kg/Hr        | PSIG       | Kg/Hr      | Deviation % | PSIG       | Kg/Hr      | Deviation % |
| 0          | 0            | 0          | 0          | 0.00%       | 0          | 0          | 0.00%       |
| 25         | 511          | 25         | 521        | 2.00%       | 25         | 516.11     | 1.00%       |
| 50         | 760.3        | 50         | 771.7      | 1.50%       | 50         | 754.5      | 0.75%       |
| 75         | 975.8        | 75         | 970.9      | 0.50%       | 75         | 970.9      | 0.50%       |
| 100        | 1195.7       | 100        | 1197.45    | 1.75%       | 100        | 1186.1     | 0.80%       |

Figure 6: Typical VeriCal data from in-situ testing