Technical Publication

Accurately Measuring LNG Tanker Boil-Off Gas For Process Efficiency and Environmental Compliance

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Figure 1. LNG Tanker

With the recent growth in demand and production of liquefied natural gas (LNG), there has been an increase in trade and the need to transport it globally via LNG tanker ships. This increase in LNG transport has driven the need for expansion of the tanker fleets with increased capacity, wherein the LNG ships are typically carrying up to 266,000 m³ around the world. The LNG tanker fleets are unique because LNG cargo generates waste gas, commonly known as boil-off gas (BOG). This waste gas can be used as fuel for the ships boilers and must be accounted for in order to comply with current marine propulsion regulations for energy efficiency. Accurate flow measurement of the BOG to the ships boilers is essential to tanker operators.

Ship Handling of LNG Cargo and Boil-off Gas (BOG)

In order to transport natural gas, it is economical to convert it to LNG. The conversion process involves cryogenically cooling the natural gas to -163 °C at atmospheric pressure, at which point the gas condenses to a liquid and is ready for transport. The refrigerated tanks on board the ship ensure the liquid gas remains cryogenic during storage. BOG results when the LNG within the ships storage tanks vaporizes due to subsequent ambient heat input to the tanks during transport. In the past LNG tanker ships used an onboard re-liquefaction plant to recycle the LNG vapor back to liquid and into the storage tanks.

BOG Problems

On January 1, 2013 the International Maritime Organization (IMO) implemented an amendment to the International Convention for the Prevention of Pollution from Ships whereby they added a new regulation to increase the energy efficiency for ships in order to reduce the CO_2 emissions. Though many ships have already implemented energy efficiency measures, it's now mandatory that they meet the new IMO regulation. LNG tanker ships are powered by steam turbines with boilers that are fueled by either methane, oil, or a combination of both. In recent years the ships are now using the LNG BOG that is produced during transport as fuel for the ships boilers.

The BOG is collected, heated to ambient temperature, odorized, compressed and then distributed to the boilers which power the steam turbines used for the ships propulsion. The flow measurement of the BOG to the ships boilers is a critical component because the IMO regulation requires low CO_2 emissions, which means they must accurately measure the amount of BOG they are using in their boilers for energy efficiency.

BOG Measurement Solution

The ST110 Series flow meter from Fluid Components International (FCI) meets the accuracy requirements for measuring BOG aboard tankers, at land terminals, storage facilities and points of distribution. This advanced air/gas flow meter combines powerful electronic features and an advanced flow sensor design to provide precision measurement, reliability and economy.

The ST110 flow meter (Figure 2) is designed with FCI's unique VeriCal In-Situ Calibration Verification System. Flow meters equipped with the VeriCal System (Figure 3) can perform periodic field functional testing and calibration verification of the flow meter's measurement performance without extracting the flow meter from the pipe or process to avoid shutting down the process for a lengthy period.

For BOG measurement, the ST110 flow meter with VeriCal features an internal purge tube that runs the length of the probe to the sensor and allows the operator to generate a known flow across the sensor element. The resultant signal output can then be compared to the factory baseline test certificate.

The ST110 Series' electronics can meet both current and future need for BOG measurement outputs, process information and communications. Whether the need is for 4-20 mA analog, frequency/pulse, alarm relays or digital bus communications

such as HART, FOUNDATION™ fieldbus, PROFIBUS or Modbus, it provides a solution.

For LNG operators, the ST110 flow meter features a graphical, multivariable, backlit LCD display/readout that can be read at locational times. It provides local information with a continuous display of all process measurements and alarm status, as well as service diagnostics.

Designed for complex gas measurements such as LNG and methane, the ST110 flow meter stores up to five calibration groups to support a broad flow range, differing gas mixtures, multiple gases, and obtains up over a 500:1 turndown. An on-board data logger with a removable 2-GB micro-SD memory card that stores 21 million readings is also included.

The ST110 can be calibrated to measure LNG, methane and other process gases. The insertion style ST110 flow meter features a thermal flow sensing element that measures flow from 0.25 to 1000 SFPS (0.07 NMPS to 305 NMPS) with accuracy of ±0.75 percent of reading, ±0.5 percent of full scale.

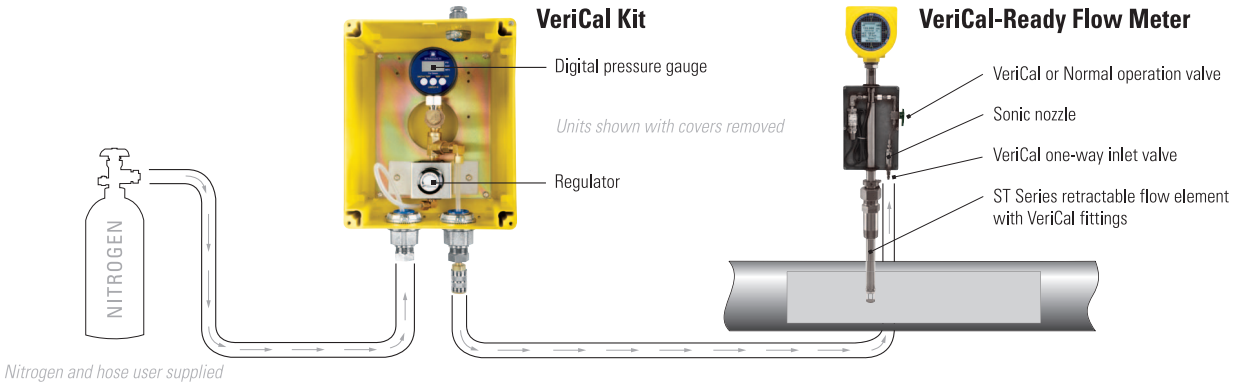
Designed for demanding oil/gas industry applications, the ST110 flow meter operates at up to 850°F (454°C) and is available with both integral and remote (up to 1000 feet [300 meters]) electronics versions. The ST110 includes system wide agency approvals for hazardous environments, and a rugged, NEMA 4X/IP67 rated 316 stainless steel enclosure. Approvals include SIL-1, ATEX, IECEx, FM and FMc.

Figure 2. ST110 Air/Gas Flow Meter

Thermal Dispersion Technology

The ST110 flow meter's precision flow sensors are designed with thermal dispersion constant current technology, which places two thermowell protected platinum RTD temperature sensors in the process stream (Figure 4). One RTD is heated while the other senses the actual process temperature. The difference in temperature between the two sensors is measured and is directly

Figure 3. VeriCal In-Situ Calibration System



proportional to the mass flow rate of the fluid. This technique supports direct mass flow measurement and does not require the addition of temperature and pressure sensors for mass flow computations.

Conclusions

At this time, FCI flow meters are operating successfully in LNG BOG applications aboard tankers and at land terminals. The ST110 flow meter's accuracy, reliability, rugged design and certification to global industry standards makes it ideal for the LNG industry. In addition, thermal mass flow meters feature a unique no moving parts design that requires virtually no maintenance with low operating and lifecycle cost over a long life.

The combination of accurate performance, low maintenance and long life offers distinct advantages over other flow measurement technology solutions. With 50 years' of experience in the oil/gas industry, FCI's thermal flow meters are designed with this industry in mind and are especially well suited for its rugged operational environment.

With the demand and production growing for natural gas worldwide, FCI's thermal mass flow meters are helping the oil/gas industry and the shipping industry provide cleaner energy solutions by helping to reduce the greenhouse gasses that are a cause of global warming. FCI is committed to helping industry protect the environment through more reliable monitoring of air/gas quality for sustainable best industrial process practices. ■

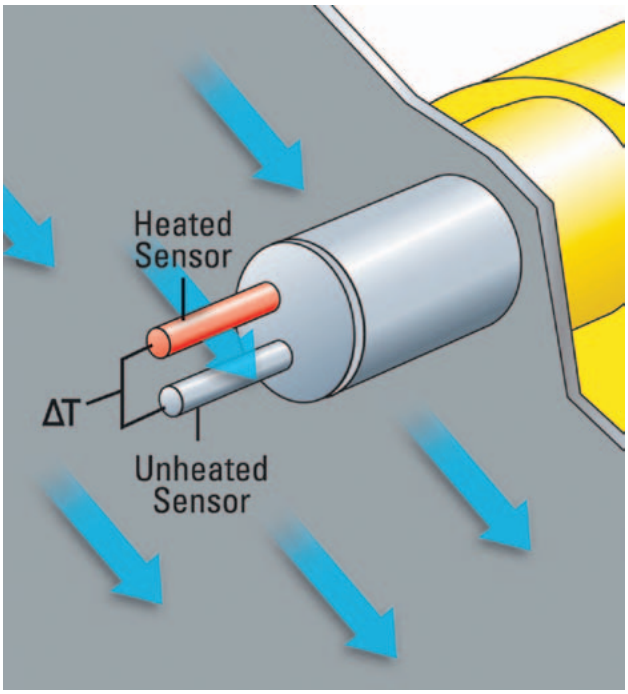


Fig 4. Thermal Dispersion Technology Principle of Operation