Thermal Mass Flow Meter Improves Refinery Flare Gas Vent Monitoring Accuracy

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Introduction

To ensure the flow rate of combustible gases in a vapor header line connected to its incinerator were measured accurately, a major oil/gas began searching for a higher reliability instrumentation solution. Combustible toxic vapours result during the refining process at the plant and must be captured for safe disposal. Incorrectly measuring the rate of vapor flow in the header line during the refining process could result in an improper mix of toxic waste gases that would fail to combust in the facility's incinerator. If these gases are not properly incinerated, there is a risk of their accidental release into the environment resulting in costly government fines and a potential plant shut-down.

The Problem

Releasing combustible vapors and dangerous toxins into the atmosphere can result in emergency plant shutdowns. Such plant closures, which are often mandated by various government agencies, can be expensive and time consuming to remediate. The lost production time and the cost of restoration can impact profits and makes this process critical to the plant's safe and effective continuous operation.

The company's process engineers at the refinery determined they were experiencing a highly variable vapor density. Vapors in the header line included a mix of Paraxylene, Benzene and other combustible toxic gases. This gas mixture led them to conclude that mass (rather than volumetric) flow rate was the most important parameter to consider in the incineration process and to assist in plant's mass balance calculation.

In the header lines, the variable flow rate ranged from just 0.5 to 150 SCFM (0.8 to 240 NCMH). The low end of this range (0.5 SCFM) in this process required a highly sensitive mass flow sensor to recognize the presence of gas. The pressure range in the process varied from 0 to 50 psig [0 to 3.4 bar (g)] at temperatures from 68 to 149°F (20 to 65°C).

For process engineers, it is generally a complex challenge to measure multiple variable gas mass composition accurately, which can typically require the use of multiple flow meters. The cost of installing and maintaining multiple flow meters, however, along with cost of keeping different spare instrument items, led the plant's instrumentation team to consider another option.

Fluid Components International (FCI), a manufacturer of mass flow meters, was contacted by the instrumentation team to discuss the development of a highly intelligent flow transmitter to handle the task. There are two major types of mass flow meters (1) thermal and (2) Coriolis, and FCI offers both types of instruments.

In this application, the instrument team chose a thermal mass flow meter, which applies the thermal dispersion principle and measures mass flow rate directly. Many other flow sensing technologies measure mass flow indirectly, which requires separate devices to measure process temperature and pressure along with a flow computer to calculate the actual mass flow rate.

These flow meters also can be designed with no moving parts to wear or break, which means they require little or no maintenance. Moreover, they have a broad flow range, detecting a very low flow rate to a much higher flow rate up to a turn down ratio of 1000:1. For this reason, a single meter can be applied in an application to measure wide flow ranges reliably - instead of using multiple flow meters in series to support an application over the same wide flow range.

Fig 1: GF90 Gas Mass Flow Meter

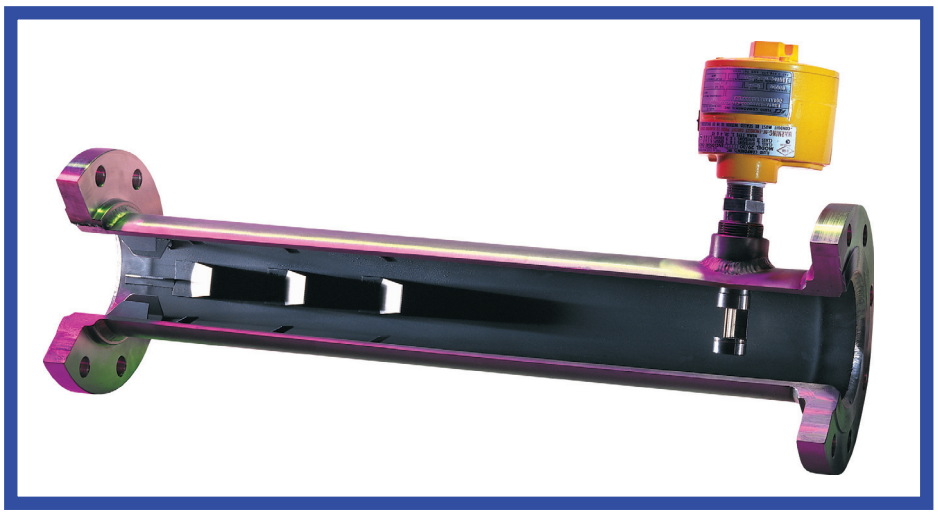

Fig 2: Vortab Meter Run Flow Conditioner Configuration

The Solution

In their flare gas vent monitoring application, the refinery's process engineers chose FCI's highly intelligent GF90 microprocessor-based flow meter (Fig 1). When networked with a densitometer, this flow meter accepts a process input signal and selects a flow calibration curve that precisely matches the waste gas vapor composition in the line connected to the facility's incinerator.

The instrumentation team at this facility set the densitometer cutovers at 35, 50 and 75 percent. FCI's GF90 flow meter automatically changes to a flow calibration curve stored in its intelligent transmitter that is appropriate to the gas composition at each of these different cutover settings. A signal is then sent via the plant's distributed control system that adds the necessary amount of natural gas to the toxic gas vapors for optimal incineration.

In this application, the accuracy of the flow meter was enhanced with the use of a Vortab flow conditioner that was also provided by FCI (Fig 2). This tab-type flow conditioner, which is then inserted in the process piping, features a series of tabs that create a highly predictable flow profile with little or no pressure loss. The tabs create vortices that eliminate swirl and other process distortions that are often caused by inadequate straight pipe runs and due other flow disturbances such as elbows, "T"s, valves, etc.

Thermal mass air/gas flow meters, such as the GF90 model chosen for the vapor header line application, support a broad variety of gas flow measurement tasks in the oil/gas, chemical, wastewater, general process and pollution monitoring industries. The flow meter chosen by the refinery's engineers is compatible with four popular communication buses: HART, Ethernet, Profibus and MODBUS.

The GF90 flow meter selected by the refinery team features a standard flow accuracy in this application that is ±1% of reading +0.5% full scale over a flow range of 0.25 to 1600 SFPS (0.08 to 488 NMPS). It operates at pressures of up to 1000 psig (69 bar[g]) at temperatures ranging from -100 to +850°F (-73 to +454°C). Repeatability is +0.5% of reading or better.

The GF90 flow meter's intelligent electronics are addressable via a built-in LCD display and keypad or through its RS-232C serial port. The LCD and keypad allow the refinery's process engineers to perform in-field programming to change zero, span, switch points and units to measurement or to perform instrumentation verification, troubleshooting and other critical functions. The serial ports also support access to computers or ASCII terminals.

The flow meter's smart transmitter features two independent analog signal outputs that are field programmable. Analog outputs may be: 4-20 mA, 600 ohms maximum load; 0-10 Vdc, 5000 ohms minimum load; 0-5 Vdc, 2500 ohms minimum load; and 1-5 Vdc, 2500 ohms minimum load.

Dual alarm switch points are designed into this type of flow meter. The switch points are field programmable to alarm at high, low or windowed flow. They are also programmable at high, low or windowed process temperature.

An auxiliary input terminal is available to the plant's engineers for connecting the flow meter to external signal sources that provide real-time compensation for complex applications. Through this terminal, composition analyzers, pressure and temperature transducers, densitometers and other devices perform signal correction for high accuracy within close tolerances. The terminal also permits remote switching between the calibration groups.

Conclusion

With the installation of the first FCI GF90 mass flow meter supporting the vapor header line application at this facility, the company has experienced no further problems with this process over the past year. The process team has installed seven more flow meters on other vapor lines at the facility. The company plans to utilize this same solution at several other locations for similar applications.