APPLICATION NOTE

Fast BTU Analysis and Full Speciation of Flare Gas Using a Single Gas Chromatograph Solution

Requirements for flare control devices

Gas flaring is a source of emissions that pollute the environment. Flaring releases greenhouse gases into the environment and further contributes to the problem of climate change. Hence, national and local government bodies are increasingly requiring process plants to monitor, report, and reduce emissions from their stacks and flares.

The 40 CFR Part 63 Subpart CC rule by the US Environmental Protection Agency (EPA) requires petroleum refinery owners or operators of a flare used as a control device for an emission point to meet the requirements of §63.670 rule regardless of the construction date of the flare. The regulation is part of the 1990 Clean Air Act that regulated emission standards for hazardous air pollutants (HAP) and is in addition to 40 CFR 60 Subpart Ja requirements.

40 CFR Part 63 regulations require determining the concentration of individual components in the flare vent gas within 15 minutes, or direct monitoring of the net heating value of the flare vent gas at standard conditions. Parameters that must be monitored include:

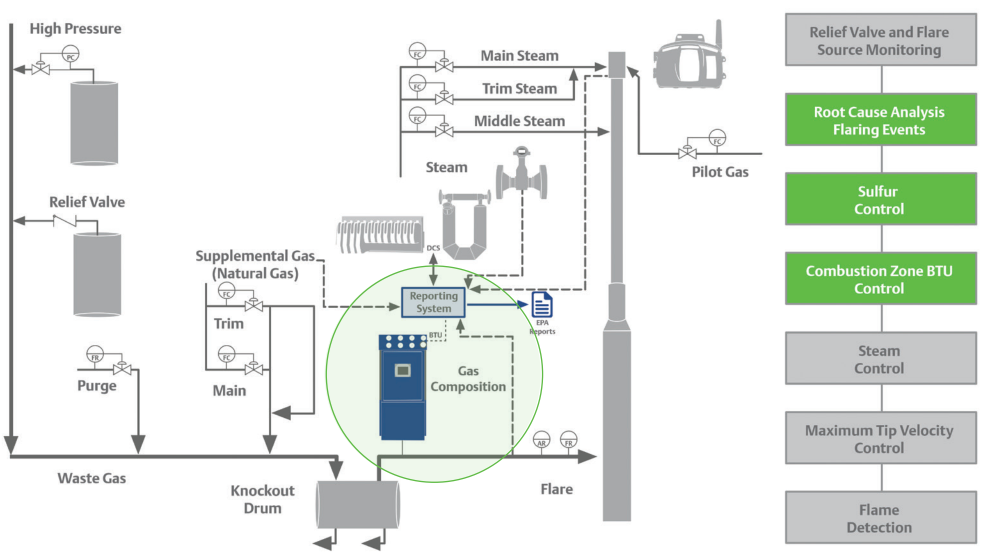
- BTU
- Net heating value in the combustion zone (NHV_{CZ})
- Net heating value dilution parameter (NHV_{dil})
- Vent gas composition

The Net Heating Value of the gas in the Combustion Zone (NHV_{CZ}) is of particular importance as it has a direct impact on combustion efficiency. The new rule mandates a $NHV_{CZ} \geq 270$ Btu/scf based on a 15-minute block average. If the NHV_{CZ} approaches 270 BTU/scf, operators must add fuel gas such as propane or natural gas. This may then require adding steam to the flare to burn the flare in an environmentally-sound manner.

Net heating value monitoring, which can be provided using either a gas chromatograph, a calorimeter or a mass spectrometer, helps indicate if the flare is at, above, or below the limits, allowing operators to save costs by avoiding wastful use of supplemental gas and steam. However, NHV reporting alone can't provide any information on why a problem may exist with flare levels.

Emissions typically consist of complex mixtures of inorganic and organic species, and compositions and concentrations vary over time as process conditions change. Measuring the concentrations of individual components is critical to identifying the source of the emission, locating the problem to a specific part of the plant. Therefore, full flare gas speciation and composition analysis, which can be achieved using a gas chromatograph or a mass spectrometer, is vital to compliance because it provides root cause analysis and allows plants to both monitor and control flare gas within the regulated 15-minute block.

Figure 1- Typical Flare System with 40 CFR 63.670 Controls



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Flare gas analysis using gas chromatography

Emerson offers gas chromatograph solutions with concurrent analytical trains that **deliver fast NHV reporting/BTU analysis within 1-minute cycle time, as well as full composition of the flare gas within the EPA's 15-minute requirement using a single analyzer.** This ensures reliable monitoring and control of the flare and full compliance with regulations using one device with a single installation and communication point, reducing the scope of analyzers and overall solution cost.

Rosemount™ 700XA and 1500XA Gas Chromatographs are both capable of performing BTU measurement within a 1-minute cycle time. Rosemount 700XA GC is ideal for a simple standalone flare gas stream, while the Rosemount 1500XA Gas Chromatograph can monitor multiple flare gas streams.

	Emerson Solution
Fast BTU Cycle Time	**1 Minute** by Rosemount 700XA or 1500XA GC
Full Analysis Cycle Time	**Within 15 Minutes*** by Rosemount 1500XA GC

* stream dependent

The Rosemount 1500XA Gas Chromatograph can also measure the full, speciated composition of hydrocarbons, H_2S, H_2, and CO along with optional benzene detection. It can calculate and record the individual component concentrations present in the flare vent gas within 15 minutes. Custom solutions that measure, calculate and record operators' specific flare compositions are also available.

Table 1 - Flare Control Solution Using Rosemount 1500XA Gas Chromatograph. Custom Solutions That Measure Specific Flare Compositions Are Also Available.

Stream components	Units	Measured range	
		Min.	Max.
Hydrogen Sulfide (H_2S)	PPM	3	300
Nitrogen/Oxygen	Mole%	0	20
Carbon Monoxide	Mole%	0	20
Hydrogen	Mole%	0	60
Methane	Mole%	0	100
Ethane	Mole%	0	30
Ethylene	Mole%	0	30
Acetylene	Mole%	0	10
Propane	Mole%	0	20
Propylene	Mole%	0	20
Isobutane	Mole%	0	10
n-Butane	Mole%	0	10
Butenes	Mole%	0	10
1, 3 Butadiene	Mole%	0	5
Isopentane	Mole%	C5+ = 0–5	
n-Pentane	Mole%		
Net BTU Saturated	Mole%	0	2000

Prove full compliance while saving costs

Rosemount gas chromatographs enable operators not only to to satisfy the entire 40 CFR Part 63 regulations under the 15-minute requirement, but also meet the rule's specified daily calibration requirements.

The Rosemount 1500XA Gas Chromatograph's repeatability has an extremely low relative error rate that's far below the 40 CFR Part 63 requirements. Analysis, calibration, or validation cycles can be configured to run automatically via Emerson's exclusive, onboard MON2020 software which delivers embedded expert knowledge, helping less experienced technicians interpret diagnostics to resolve process upsets more rapidly. In addition, Rosemount Gas Chromatogrpahs:

- Require no shelter, enabling significant overall total costs savings
- Use up to four clocks, allowing multiple streams to run simultaneously
- Are 100% chamber tested – guarantees the Rosemount 1500XA Gas Chromatograph will work reliably and repeatedly over full temperature range of 0 °F to 130 °F (18 °C to 55 °C), while the Rosemount 700XA Gas Chromatograph has a wide ambient temperature range of -4 °F to +140 °F (-20 °C to +60 °C) without impact on its analytical performance.
- Fully compatible with modern Ethernet networks and DCS communication, allowing access to actionable data either locally or remotely.

Rosemount 700XA Process Gas Chromatograph

Rosemount 1500XA Process Gas Chromatograph

What to consider before choosing a flare monitoring technology

Before a process plant can select a flare monitoring system, they must decide what measurement technology to use. The approved measurement methods include a **mass spectrometer,** a **gas chromatograph (GC),** and **calorimeter**.

From a cost/benefit and performance standpoint, no process plant should leave out consideration of the gas chromatograph in its planning of measurement systems as it provides the ideal, balanced choice that delivers full compliance and performance while reducing OPEX and CAPEX cost.

Calorimeter. Widely used as a BTU or Wobbe Index analyzer, but can't provide full speciation of concentrations of the flare's individual components needed for process control and identification of the emission's source. Two types of calorimeter are used for flare applications: residual oxygen measurement (higher cost, higher accuracy) and flame (temperature limitations, noise). Flame design calorimeters can be general purpose and are inexpensive, but they require a shelter. For explosion-proof flame design calorimeters that do not require a shelter, the prices are approximately double that of general-purpose calorimeters.

Due to the low cost, ease of maintenance and BTU analysis time of less than 60 seconds, plants may assume that the calorimeter is the obvious choice, but this is not necessarily the case. The lower-priced calorimeters are temperature sensitive and need to be in a temperature-controlled shelter, which is costly. In addition, they do not measure hydrogen (H_2), a critical component of accurate reporting of the net heating value of vent gas (NHV_{VG}). Lower heating value (instead of higher heating value) is calculated using the value of 1212 BTU/scf for Hydrogen as recommended by EPA. This provides a better indication of flare performance and reduce wasteful increase of supplemental gas and steam to burn the flare in an environmentally-sound manner. High-end, premium calorimeters are far more temperature stable and can measure H_2.

Mass spectrometer. The mass spectrometer provides individual component concentrations within the flare and can measure BTU and record a full analysis cycle in seconds. However, it is typically expensive, complex, and can be difficult to maintain. In addition, it requires a calibration gas for every component to be analyzed as well as a multi-component blend. Between initial costs and ongoing maintenance expenses, the mass spectrometer has a high cost-to-function ratio.

A mass spectrometer is also susceptible to drift over time and must be frequently calibrated, which can significantly increase trips to the field. In addition, the process to calibrate a mass spectrometer is more complex than calibrating a GC due to the measurement principles of each instrument. Stringent EPA calibration guidelines must be followed to prevent contamination of a mass spectrometer and formation of unidentified ions during subsequent analysis.

Gas chromatograph. Falls in price between the mass spectrometer and calorimeter, but unlike a calorimeter, **a GC provides fast BTU analysis within 1-minute cycle and full speciation of flare gas under the 15-minute requirement using one analyzer.** Accurate gas composition analysis is critical to NHV reporting and enables operators to maintain key set points, minimizing use of supplemental gas or steam necessary for clean flare combustion. Not only do gas chromatographs analyze and data-record the individual component concentrations under the 15-minute requirement, but they also exceed the quality assurance requirements outlined in Table 13 of 40 CFR Part 63 and calibration requirements in Subpart CC 63.671,Section A, Paragraph 4.

Separately, a gas chromatograph can also measure hydrogen (H_2) under 1 minute, for which plants can get fuel credit. And with its full compatibility with modern Ethernet networks and DCS communication, a GC permits a high level of automation and actionable data and enables operators to satisfy the entire 40 CFR Part 63 requirements using one device.

In addition, a GC provides the ability to be placed outside (32°F–130°F/0°C–55°C) or in a cabinet for harsher environments, allowing it to be near the sample point. This ensures the sampling system time requirement of ≤ 5 minutes is met, providing significant cost savings in sample tubing, heat trace, and shelter costs. Unlike the mass spectrometer, Emerson Gas Chromatographs can be used without a shelter. Since the cost of a shelter can be five times the cost of the instrument, this can translate into additional cost savings and reduction of expenses associated with running long sample lines.

Table 2 - Advantages and Limitations of Three Technologies for 40 CFR Part 63 Requirements

	Gas Chromatograph	Calorimeter	Mass Spectrometer
Price	$$	$	$$$
Actionable information	Yes	No	Yes
Ease of maintenance	Easy	Very easy	Difficult
Reliability	High	High	Low
Calibration complexity	Low	Low	High
Requires shelter	No	Yes	Yes
Fast BTU cycle time	1 min	< 1 min	< 1 min
Full analysis cycle time	< 15 min	Not available	< 1 min*

* Inaccurate due to interferences

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