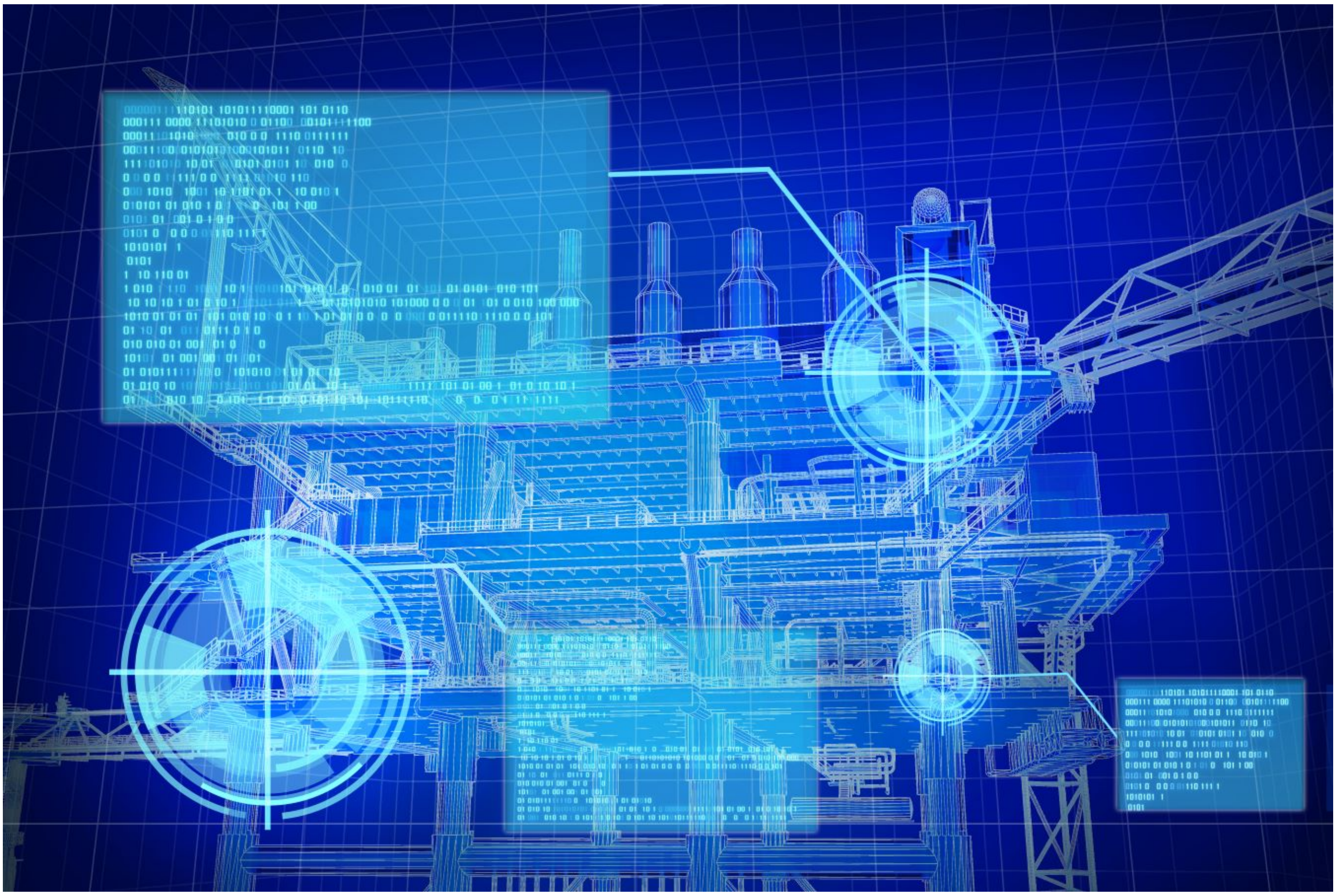
METHANE FROM FLARING TOOLKIT



Measure Efficiency: Calculated performance

Can I measure flare efficiency? > Measure Efficiency: Calculated performance

Summary

Measured flare data from existing equipment is used to calculate flare (NHV$_{CZ}$) or combustion zone net heating value dilution parameter (NHV$_{dil}$). With this, the flare combustion/destruction efficiency (CE/DE) can then be inferred indirectly using equations derived from previous empirical studies. A high flare CE/DE is required to ensure sufficient destruction of VOCs sent to the flare.

Follow the link to the right of this page to access an online calculation tool

How it Works

- Vent Gas' NHV is calculated from its components' NHV values or alternatively, obtained from a calorimeter.

- A higher NHV contribution/adjustment is applied for hydrogen (~1212 BTU/SCF @ 60F 1 atm) as H_2 was found to promote better destruction in the flare
- The NHV_{CZ} or NHV_{dil} is then determined depending on the type and size of flare – volumetric average of the flare constituent's NHV (air, steam & vent gas). Equations are listed below
- NHV_{CZ} is most commonly used for elevated flares with the exception of air-assisted flares and small steam-assisted flares (< 9") which uses NHV_{dil}
- From past , the higher the NHV_{CZ} or NHV_{dil}, the higher the flare CE/DE and vice versa

Equations:

NHVcz - US EPA regulatory requirement is 270 BTU/scf

$$NHVcz = \frac{Qvg\ x\ NHVvg}{(Qvg + Qs + Qa, premix)}$$

Where:

NHV_{cz} = Net heating value of combustion zone gas, Btu/scf.

NHV_{vg} = Net heating value of flare vent gas, Btu/scf.

Q_{vg} = Cumulative volumetric flow of flare vent gas, scf.

Q_s = Cumulative volumetric flow of total steam, scf.

$Q_{a,premix}$ = Cumulative volumetric flow of premix assist air, scf.

NHV_{dil}- US EPA regulatory requirement is 22 BTU/ft^2

$$NHVdil = \frac{Qvg\ x\ Diam\ x\ NHVvg}{(Qvg + Qs + Qa, premix\ Qa, parameter)}$$

Where:

NHV_{dil} = Net heating value dilution parameter, Btu/ft^2.

NHV_{vg} = Net heating value of flare vent gas, Btu/scf.

Q_{vg} = Cumulative volumetric flow of flare vent gas, scf.

Diam = Effective diameter of the unobstructed area of the flare tip for flare vent gas flow, ft. determine the diameter as

$$Diam = 2\ x \sqrt{Area/\pi}$$

Q_s = Cumulative volumetric flow of total steam, scf.

$Q_{a,premix}$ = Cumulative volumetric flow of premix assist air, scf.

$Q_{a,perimeter}$ = Cumulative volumetric flow of perimeter assist air, scf.

Advantages

- Able to use existing equipment

- Quick to implement once required data is collected

- Suitable to be applied for elevated flares of variable size and designs

- Can be done remotely from outside process boundary as only involves workbook calculations

- Method can be integrated directly to distributed control system

Limitations

- Cannot be applied if required input data for calculations is unavailable

- Calculation method depends significantly on input data quality, ie: flow meter ranges and measurement errors.

Go Deeper

- [USEPA Technical Report]
- [TCEQ Study]

Case study

A study was done to identify the impacts of steam/air assist as well as turn-downed vent gas flow rates on an elevated flare's CE/DE. The study involved varying the steam/air and vent gas flow rates while directly measuring the VOC emissions from the flare stack to calculate CE/DE. This calculated CE/DE values were then validated by comparing against separate results obtained from the following installed technologies:

1. Hyper-Spectral Imaging
2. Passive and Active Fourier Transform Infrared

The NHV_{CZ} or NHV_{dil} of the flare is able to be calculated for each test cycle using the vent gas composition as well as the steam/air flow rate to assess the relationship between NHV_{CZ}/NHV_{dil} and the flare's CE/DE.

Example Data – Steam Assisted Flare > 9'' Diameter

#	Vent Gas (lb/hr)	Steam (lb/hr)	Vent Gas Composition	Calculated NHV_{CZ} (BTU/SCF)	Measured
1	920	0	1:4 Natural Gas to Propylene Vol Ratio Diluted with N2	355.8	>99
2	2342	1000	1:4 Natural Gas to Propylene Vol Ratio Diluted with N2	208.9	90
3	2342	2000	1:4 Natural Gas to Propylene Vol Ratio Diluted with N2	147.9	68

4	920	1000	1:4 Natural Gas to Propylene Vol Ratio Diluted with N2	127.6	35

**Dilution with N2 to target vent gas NHV of 356 BTU/SCF. Conditions for volume is at 60°F & 1 atm*
**From TCEQ test series S3 & S4*

Example Data – Air Assisted Flare

#	Vent Gas (lb/hr)	Air (lb/hr)	Vent Gas Composition	Calculated NHV_{dil} (BTU/ft^2)	Measured
1	900	20,000	1:4 Natural Gas to Propylene Vol Ratio Diluted with N2	30.0	>99
2	900	90,000	1:4 Natural Gas to Propylene Vol Ratio Diluted with N2	6.9	78

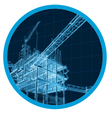
**Dilution with N2 to target vent gas NHV of 356 BTU/SCF. Conditions for volume is at 60°F & 1 atm*
**From TCEQ test series A3, 24'' diameter of flare tip*

Observations

- As steam/air flow is increased or vent gas flow is decreased, the flare's NHV_{CZ} & NHV_{dil} will decrease
- The higher the flare's NHV_{CZ} or NHV_{dil}, the higher the measured CE and DE

Can I measure flare efficiency?

Measure Efficiency: Predictive Feedback and Control



Measure Efficiency: Flare Simulations

Measure Efficiency: Drone equipped with single methane sensor

Measure Efficiency: Aerial measurement of flare efficiency

Measure Efficiency: Extractive method for determining flare efficiency