METHANE FROM FLARING TOOLKIT

Measure Efficiency: Active Laser Spectrometry

Summary

Active Laser uses a tuneable laser to monitor atmospheric pollutants, including methane. The laser is directed into the area of interest and back scatter creates by aerosols and pollutants negates the need for a reflector.

Systems can operate over large distances (up to 1km in real time) and differentiate between multiple plumes and sources, but may be limited for field applications because of the size and complexity of the equipment.

DIAL (Differential Absorption) is an example of this type of technology. DIAL emission measurements can be used to determined relative flare combustion efficiency and absolute quantification of emissions.

How it Works

A laser source of tuneable wavelength is transmitted over the measurement region. A small fraction of this light is scattered back by the aerosols and particulates that are present in the atmosphere; this is collected with a telescope and a fast, sensitive detector. There is no requirement to scatter off a feature, such as the ground or a mirror.

The extent of the absorption is known from accurate laboratory data and this enables the concentration, and spatial distribution, of the atmospheric pollutants to be determined. This is combined with wind information to provide emission data. When emission measurements are combined with data on the flow and composition of the hydrocarbons supplied to a flare, various aspects of flare performance can be determined including combustion efficiency.

Main Image Courtesy of the National Physical Laboratory UK

Advantages

- Direct measurement of the emissions from a flare with no assumptions about flare combustion efficiency or the operating conditions of the flare. The measurements can therefore be used to test and validate emission estimates and other methods. When calibrated against national gas standards the method can be fully

- Several different species relevant to flares can be measured simultaneously including methane, ethane and general hydrocarbons separately, and therefore measure the different levels of unburnt hydrocarbons in a flare's emission. This allows a direct calculation of the combustion efficiency of the flare if the composition and flow rate of the gas is known

- Measurements are range-resolved and can be used to produce a three-dimensional map of emissions. This means that the location of emissions and plumes can be mapped and spatially separate sources can be identified and quantified. It is possible for the system to differentiate between plumes

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This technique removes the need to access them directly. There is no requirement to scatter off a feature (the ground/ mirror etc.)

Limitations

- Requires expert operators and is usually deployed for periods of a few days or weeks. It therefore provides a short-term assessment of the emissions at the time of the measurements and is not yet suited to long-term continuous emission monitoring

- A typical measurement scan takes 10 to 15 minutes to complete, so any variations on a shorter timescale will not be captured

- Currently available systems such as the DIAL facility are very large (17m long, 2.5m wide, 4m high) can make access to some smaller sites difficult. The DIAL system is currently mounted on a heavy vehicle

- Although emission measurements can be made in most weather conditions, including rain and snow, there are some conditions where they are not possible, in particular very light winds (

- Quantitative data requires access to metered flow rates and/or meteorological data

Go Deeper

- [National Physical Laboratory UK: – DIAL for Remote Emissions Measurement]
- [National Physical Laboratory UK: Review article of Differential Absorption LiDAR]
- [National Physical Laboratory UK: Video of DIAL]

Case study

DIAL measurements on three flares at a gas processing facility

Flare measurements were performed at an onshore facility which receives gas from oil fields and treats it according to export specifications. The primary aim of this campaign was to determine the emission rates of methane, ethane and NOx from three flares on the plant.

The flow rate and composition of the gas to the flare was recorded during these measurements meaning that the flare combustion efficiency could be calculated using the following formula:

Combustion Efficiency (%) = [1 – (Carbon emitted/Carbon in flare gas)] x 100 Where carbon refers to the number of carbon atoms in hydrocarbon form.

This equation is valid under the following assumptions:

1. the gas in the flare plume had the same composition as the supplied gas;
2. there was not significant production of soot;
3. there was not significant production of carbon monoxide;
4. the combustion efficiency was similar during the methane, ethane and general hydrocarbon measurements.

Flare#1 – Enclosed Ground flare

This flare is part of the plant system to remove low pressure gas from the process stream under emergency conditions. The flare is continuously purged with nitrogen to prevent oxygen building up in the flare system. This flare burns continuously at low flow. This flare was measured ‘as found’

The measurements of this flare showed high levels of methane emission compared to the other species, with the flaring efficiency less than 50%. At this level the assumptions in the calculation of flare efficiency are not valid, particularly the final two assumptions.

The main reason for the low combustion efficiency was that the combustible part of the flare gas was approximately 50% of the volume, and this is further diluted by air drawn around the base of the flare.

Flare#2 Maintenance flare: Open Ground level flare

The maintenance flare is an open ground level flare. This flare is designed to receive gas during routine maintenance on the plant. This flare was measured under normal conditions, where only the pilot burners were lit (‘flare off’), and under an increased flow condition with the main burners were lit (‘flare on’).

In all cases the maintenance flare was measured with the DIAL measurement plane less than 20m downwind of the flare.

This flare showed higher levels of emission during the ‘flare off’ measurements. This suggests that there was a very low combustion efficiency and the possible presence of a leak.

The reported average flows during the ‘flare-on’ measurements were 90 Sm3 /hr. By combining the DIAL emission measurements with the gas composition analysed by the site, the maintenance flare efficiency was found to be 99.86 ± 0.02 % during the ‘flare on’ measurements. The destruction efficiency is defined as 1 minus the ratio of the amount of the species measured downwind of the flare to the amount of the species present in the flaring gas (expressed as a percentage).

The gas composition was not analysed during the general hydrocarbon measurements so the average composition measured during the ethane and methane measurements was used for this calculation.

Flare#3 – High Pressure flare

The high pressure flare is an elevated open flare designed to receive the full gas pipeline in the event of an emergency. Under normal conditions the flare is operated under a pilot gas or low flow conditions. This flare was measured ‘as found’ – with only pilot gas flow, and under increased flow flaring conditions.

For all species the high pressure flare ‘as found’ measurements were conducted with the DIAL measurement plane up to 20m downwind of the flare. For measurements of the flare under increased flow conditions the distance from the flare to the measurement plane was up to 100m. The difference between the ‘as found’ and actively flaring measurement distances is due to the physical size of the flare – measurements were not conducted through the visible part of the flame.

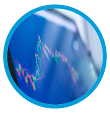
Measurements of the flare ‘as found’ were only taken for ethane and general hydrocarbon. The measurements showed that under this condition the emission of ethane and general hydrocarbon was approximately 50% of the ethane and general hydrocarbon flare throughput.

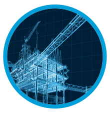
Measurements of the high pressure flare under increased flow conditions determined the combustion efficiency to be 99.73 ± 0.08 %

Flare	Indicative Flow rate SM3/hr	Combustion efficiency %	Methane Destruction efficiency	Ethane Destruction efficiency	General hydroc Destruction effi %
Flare #1	Not available	<50%			
Flare #2 ‘off’	Pilot only	<50 %			
Flare#2 ‘on’	~200	99.86 +/- 0.02	99.88 +/- 0.02	99.73 +/- 0.01	99.65 +/- 0.

Flare#3 ‘off’	Pilot only	<50%			
Flare#3 ‘on’	~4000	99.73 +/- 0.08	99.74 +/-0.09	99.64 +/- 0.07	99.69 +/- 0.

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