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WHITE PAPER: FLARING

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Flaring and the implications on pollution - focusing on biogas flaring from landfill, sewage and anaerobic digestion sites.

What is Flaring?

Flaring is the combustion of gas for destructive purposes. Flaring is used to reduce the harmful effects of releasing methane (CH_4) and carbon dioxide (CO_2), known greenhouse gases, into the atmosphere. Typical values of biogas are in the region of 35 – 60% CH_4, 25 – 35% CO_2, 0-1% oxygen with an assumed nitrogen balance. The values vary between sites depending on a myriad of factors, such as, the age, composition and management of waste on landfill sites and the feedstock and production rate on AD sites.

Why Flare?

Flaring is typically undertaken when engines are unavailable to generate power from the gas whatever its source. In a fracking situation, flaring is used whilst the gas well is being optimised and as a safety feature to burn the gas rather than to detrimentally release it directly to atmosphere where the warming effect of CH_4 is deemed to be 21 times more potent than CO_2.

So Flaring rather than burning to produce power is seen as the last resort for use of the productive qualities of the gas derived from anaerobic or methogenic sources. Effectively, flaring is seen as literally burning money when it can be utilised in other plant systems for making money rather than wasting it. For every hour a $2000m^3hr^{-1}$ rated flare is operating – operators are losing out on around 3mW of power generation that could be sold on to the National Grid.

Of course, sometimes flaring is inevitable, for example, older landfill sites were the CH_4 values are too low to be utilised in power or heat generation. These types of site will continue to burn off the methane until the levels become too low for combustion. On AD sites flaring is only used as a back-up for periods of engine

When is emissions monitoring for flaring required?

Monitoring requirements will be set out within the sites EPR permit. Flares will usually require testing at least once per calendar year, once operational, providing the flare has operated for more than 10% of the year (876hrs). For new sites, the operator may be required to monitor the flare after commissioning to show the emission limits can be attained. The standard suite of pollutants to be measured are Oxides of Nitrogen (NOx), Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs) as well as oxygen and moisture content for referencing results to standard conditions. Some AD site flares will require testing for additional pollutants such as sulphur dioxide (SO_2), hydrogen chloride (HCl) and hydrogen sulphide (H_2S) but individual permits should be checked thoroughly prior to any sampling campaign.

The emission limit values (ELV's) are dictated by the date the flare was originally commissioned with the main difference being the requirement for a lower ELV for Carbon monoxide for Flares commissioned after 31/12/2003. The following table is taken from the Environment Agency's Technical Guidance Note 05:

Table 2.1 Emission standards for enclosed landfill gas flares

Determinand	Emission standard mg/m^{3*}	
	Flare commissioned before 31 December 2003	Flare commissioned after 31 December 2003
Oxides of nitrogen as NO_2	150	150
Carbon monoxide	100	50
Total volatile organic compounds as carbon	10	10

* At STP (273K (0˚C), 101.3 kPa), dry gas, 3 per cent oxygen.

Maximum Uncertainty

Something that is often misunderstood when assessing flare emissions for permit compliance is the overall uncertainty allowed under LFTGN05. This guidance, written for landfill flares but applicable to any flare running on biogas, allows an overall uncertainty to be attached to the result when assessing compliance. This overall uncertainty differs from the measurement uncertainty stated within the test houses MCerts reports. Measurement uncertainty is calculated and reported to ensure the monitoring methods for the different pollutants fall within the uncertainties of the corresponding monitoring standards and allow the quality of results produced by the test house to be quantified. These uncertainties must be within the values stated in the standards in order to achieve MCerts and UKAS accreditation on the resultant reported figures. For example, the NOx monitoring result must be within a 10% uncertainty in order to comply with BS EN 14792.

The maximum uncertainties (stated in LFTGN05) are listed below:

Table 5.5 Apply maximum values for measurement uncertainty when assessing compliance of emissions from enclosed flares

Determinand	Method Description	Typical Uncertainty (percent)
Nitrogen oxides	Extractive NDIR and chemiluminescence BS EN 14792: 2005	30
Carbon monoxide	Extractive NDIR BS EN 15058: 2006	20
Total volatile organic compounds	Flame ionisation detection (BS EN 12619 : 1999)	40
Hydrogen chloride	Integrated method with ion chromatography (BS EN 1911) (BSI 1998)	60
Sulphur dioxide	Integrated method with ion chromatography (ISO 11632) (ISO 1998)	30

For example, if a flare had a NOx result of 200mgm^{-3} with a measurement uncertainty of ±10mgm^{-3} then it would appear to be non-compliant based on the ELV's stated in Table 2.1, above. However, when assessing compliance, a maximum uncertainty of 30% can be attached to the monitoring result - giving a range of 140mgm^{-3} to 260mgm^{-3}. As the lower end of this range is below the 150mgm^{-3} limit value then the result will be deemed as compliant.

Other provisions required for flare operation are a minimum operating temperature of 1000°C and a retention time of 0.3 seconds. These conditions are required to ensure sufficient temperature and combustion time in order to fully destruct the components within the fuel gas. If these conditions aren't met, emissions can vary dramatically. For example, if the retention time is too short then the fuel gas doesn't have time to fully combust leading to unburnt gases being emitted to atmosphere and, more than likely, a failure on the VOC result.

Flare set-up and implications on exhaust emissions

Although flare systems are relatively straight forward, the set-up and operation can have a significant effect on the emissions produced. Flares with a below optimal set up can actually emit pollutants in the region of 100 fold the ELV's. Optimal set up of the flare achieves a balance between the fuel flow to the flare and the oxygen ingress, usually controlled via louvres, creating optimum combustion within the stack. Where this is not achieved, the emissions can be very high. For example, a flare that is restricting the oxygen ingress below optimum values will see very high values for CO and VOC's. The CO is the best indication of the combustion efficiency and once the correct CO values have been reached the NOx and VOC values will usually be compliant with ELV's. It should be noted that small variations (mm's) in the position of the louvres can have a huge effect on the pollutant levels emitted.

Practicalities of Monitoring Flares

Flare stacks vary significantly in size and design but they all pose serious health and safety implications for emissions monitoring personnel. Working at height has always been inevitable as the sample points for testing have to be above the combustion zone. With flue gas temperatures of around 1000°C it is not safe to have personnel located at the sample positions during flare operation. Access to the sample point can be achieved via scaffolding but the flare must be isolated while the monitoring equipment is positioned to ensure personnel do not come into contact with high temperature flue gases.

Until recently, this has been the only method of successfully testing flares. Our naturally innovative nature coupled with a relentless drive to improve health and safety lead us to undertake Phoenix, our project to engineer out the requirement for working at height when testing flares.

Phoenix

In a major development we have applied to patent our Phoenix Mast system which allows emissions monitoring of Flare systems without the requirement for scaffolding or working at height. Phoenix can be operated from ground level and meets the requirements for testing under MCerts and UKAS.

Another major benefit of the system is that it doesn't require the flare to be isolated in order to carry out the monitoring. This removes any issues with stopping and restarting the flare and also saves significant time in waiting for the flare to reach the required combustion temperature. This opens up the possibility of monitoring flares in situations where previously it was impossible, for example in Hydraulic Fracturing (Fracking) where Flares are used to burn off excess methane or during initial installation phases. It is impossible to switch the flare off even temporarily in this situation because of Environmental and Health and Safety concerns. Prior to this exciting innovation, emissions from live Fracking flares could only be calculated or assumed compliant, Phoenix offers the opportunity to do emissions measurements on live flares. The importance of optimum flare set-up is even more crucial in the case of Fracking flares where the correct temperatures must be achieved in order to reach effective destruction through good combustion and ensure pollutant release is minimised as far as practicable. An assumed destruction efficiency of 98%, though sounding efficient, could still be contributing to VOC emissions hundreds of fold higher than the emission standards of 10mgm^{-3} listed above.

The Phoenix mast system has been independently witnessed by the Environment Agency and causes quite a stir on the sites we attend where it is used.

For more information...

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