Best Available Techniques (BAT) Reference Document for the

Refining of Mineral Oil and Gas

Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control)

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drawbacks are summarised in Table 3.99. Calculation methods cannot be considered measurements and will not be described in this section.

Method EN 15446: 2008: conventional VOC 'sniffing'
This method was originally developed as a support for the implementation of a LDAR programme (see Section 4.23.6.1) for the detection and ranking of leaking equipment pieces to be repaired. The first step is the detection ('sniffing') which is achieved using hand-held VOC analysers measuring the atmospheric VOC concentration adjacent to the equipment, as shown in Figure 3.37. The most frequently used measuring techniques are the flame ionisation (FID) and the photo-ionisation (PID), calibrated to operate in the range of 10 – 100 000 ppmv. The probe is characterised by a 'response factor' which takes into account the sensitivity to the actual VOC mixture measured compared to a reference gas, and a 'response time' defined as the time needed to register 90 % of a concentration step change. Both factors greatly influence the results and have to be optimised according to the EN 15446 standards

Figure 3.37: Leak concentration measurement

Figure 3.38: Bagging of a leaking valve

For mass flow quantification, the second step proposed by the standard method consists of bagging the source component as shown in Figure 3.38. This bagging is the only step of this method allowing for a direct measurement at the source of emission. However, as bagging is an extremely burdensome operation and is not always possible, mathematical correlation curves can be derived from statistical results obtained from a sufficiently large number of previous measurements of both leak concentration (Step 1) and mass flow (Step 2) made on similar components. Very few refineries have developed such correlation curves corresponding to their own set of components, related VOC leakage mixtures, and concentration measurement skills and real practices. Alternatively they use generic curves from the literature based on extensive measurement campaigns carried out on US facilities in the 1950-1980s and 1990s.

Optical gas imaging techniques (OGI)
Optical imaging uses small lightweight hand-held cameras which enable the visualisation of gas leaks in real time, so that they appear as 'smoke' on a video recorder together with the normal image of the component concerned. This technique is primarily used to easily and rapidly locate significant VOC leaks e.g. on process components, storage tanks fittings, pipeline flanges or vents. Most current commercial OGI cameras fall under one of these two categories.

- *Active systems* where the image is produced by a back-scattered IR laser light reflected on the component and its surroundings. The laser wavelength is optimised to be absorbed by the VOC concerned.
- *Passive systems* based on the natural IR radiation of the equipment and its surroundings. The contrast of the VOC image is based on the plume IR absorption and the heat radiance difference between the plume and its background. An optical filter selects the optimal IR wavelength according to the VOC nature.

Detection limits are related to the minimal thermal gradient for visualisation, and will depend on the gas temperature, the distance from the source, and the wind speed. Although these are higher than achieved by 'sniffing', OGI technology can more efficiently identify the main fugitive emission sources. The mass emission rate is still not directly quantified. Specific work is being done in order to propose and validate appropriate OGI emission factors based on comparison with EN 15446 quantification on the same set of components in an actual unit. In addition, the US API also developed OGI leak/no-leak factors.

Figure 3.39: An OGI videocamera

Figure 3.40: Typical visualisation of gas leak

Differential absorption lidar (DIAL)

DIAL is a laser-based technique using differential adsorption LIDAR (light detection and ranging) which is the optical analogue of radio wave based RADAR. As shown in Figure 3.41, the technique relies on the back-scattering of laser beam pulses by atmospheric aerosols, and the analysis of spectral properties of the returned light collected with a telescope. As each molecule present will absorb and re-emit a typical light, the returned beam acts as an optical signature of the concentration of most molecules present between the DIAL source and the reflecting particulate. By sampling the returned light pulse rapidly according to time, it is possible to distinguish how far each sample of the light pulse has travelled and, thus, locate it with the precision of a few meters in optimum conditions.
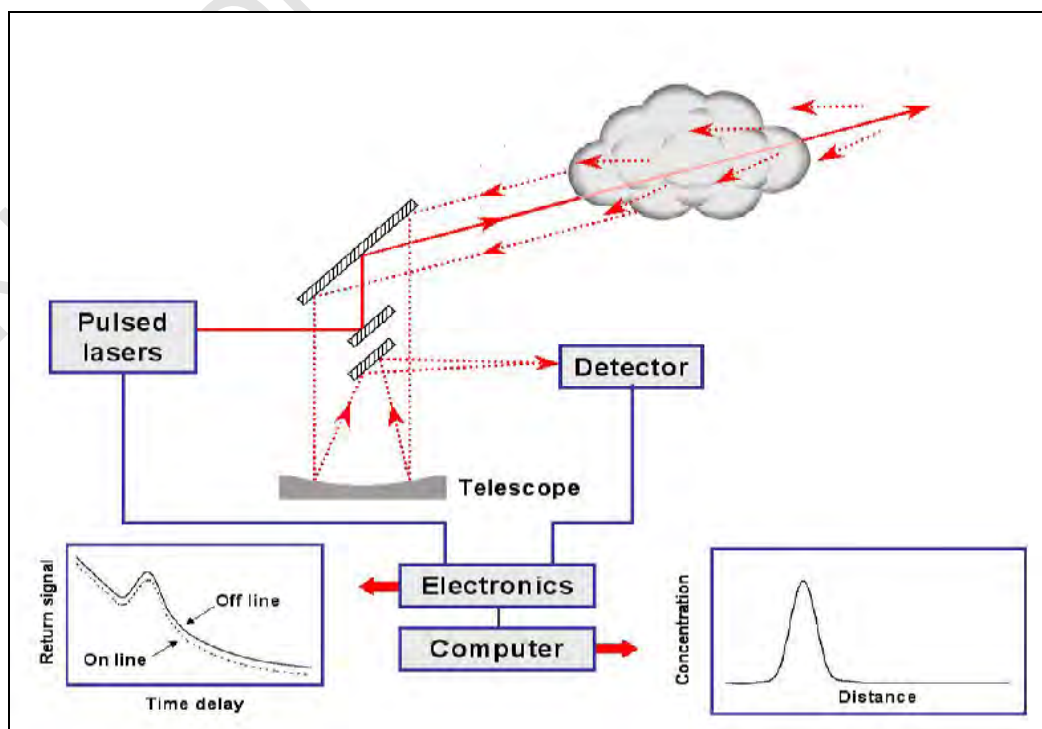

Figure 3.41: Scheme of the DIAL process

To check each potentially leaking component with hand-held analysers is time and cost intensive. Moreover, some leaking points might be difficult to access with the hand-held detectors to obtain a measurement. Sniffing surveys need careful preparation and are usually executed in campaigns that cover a specified portion of the refinery. Some companies have therefore developed a 'targeted monitoring' approach in which additional emphasis is put on components with a higher frequency of leaks. For more details see Section 3.26.1.3.

- **Optical gas imaging (OGI) method**

The optical gas imaging method involves the detection of leaks with advanced hand-held infrared cameras that are specially developed for this purpose. Both active and passive systems exist: active systems use an adequately tuned laser beam, while passive systems detect infrared radiation reflected by the equipment. Gas imaging based on passive cameras was introduced in the early 2000s, and enables direct visualisation of both leak and the leaking component and the recording of the images. On these recordings, gas clouds are visible as light or dark plumes.

Direct visualisation of leaks is of great value to improve the efficiency of maintenance on equipment as only the leaking equipment is repaired. Another advantage of the camera is the possibility to detect leaks under insulation and to screen from a distance, so that VOC emissions from components not accessible for sniffing can be located and repaired. However, as no reference protocol of use exists for these OGI instruments, detection limits and representativeness might differ from one user to the next (the type of gas and the minimum detected leak rate are generally provided on the supplier website). Furthermore, different commercially available instruments may lead to different sensitivities and detection efficiencies. Moreover, the intensity of the image projected by the camera depends on a number of factors and is not necessarily related to the concentration in the plume.

Infrared cameras therefore need to be employed with full knowledge of their limitations. These cameras can see only a small number of chemicals. For example, unless a BTEX leak is very large the camera will not detect it. In addition to this, they have relatively high detection limits (hundreds of ppm) and do not quantify or speciate the chemicals.

Some refineries are using infrared cameras before start-up to ensure the process is tight. Others are using cameras for safety purposes and for finding large leaks. For more details see Section 3.26.1.3.

Leak repair

A staged approach is often applied to the repair of leaks, involving

- An initial intervention such as tightening bolts to eliminate leaks from valve stems or flanges, installing tight caps on open ends. Such an intervention needs to be performed by skilled operators taking due recognition of necessary safety precautions.
- Repairing equipment with leaks that cannot be stopped by minor interventions. This may involve changing gaskets or packing, and may therefore require the equipment to be taken out of service.
- When no effective repair can be performed, considering the replacement of equipment.

The LDAR programmes based on sniffing typically do not include tanks and difficult to access plant areas. OGI and whole-plant measurements will identify problem areas that are not being monitored and allow them to be addressed. In many instances, they allow for more efficient allocation of maintenance efforts, by targeting the highest emitters first.

Achieved environmental benefits

Prevention and reduction of fugitive VOC emissions which are one of the largest sources of refinery hydrocarbon emissions.