Monitoring and reporting of CO_2 emissions from oil refineries

Guidance for member companies

The 'Greenhouse gas emissions trading Directive' (2003/87/EC), due to take effect in 2005, will require oil refineries to obtain permits for emitting CO_2 and, more generally, greenhouse gases (GHG).

The scheme will be based on allocated or purchased emission permits that will need to match actual emissions. It will therefore rely on an accounting system for GHG emissions which must be based on a sound methodology for measuring actual emissions from industrial sites. Accordingly, in January 2004 the EU Commission issued a set of Guidelines for Member States and local authorities concerning monitoring and reporting of GHG emissions in installations covered by the emissions trading Directive[1]. The Guidelines contain a number of general provisions as well as a specific section for each of the trading sectors, oil refining being one of them.

Monitoring and measurement are potentially expensive activities; costs increase sharply as the required frequency, accuracy and number of measurement points increase. It is therefore essential that the objectives of the measurements be clearly defined to avoid unnecessary expense and, in this case, bureaucracy.

Although the oil industry was given the opportunity to comment on the draft Guidelines, not all its recommendations were taken on board. There remain serious concerns, particularly regarding the level of uncertainty that would be acceptable and the way this would be evaluated. The level of uncertainty proposed by the Guidelines is seen to be incompatible with general refinery practice and would either be unachievable or would lead to significant extra costs for little benefit. Not all implications of the specific circumstances of oil refineries were fully recognised in the Guidelines.

---

[1] *Commission decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council*

In addition, there are areas of the Guidelines which may lead to different interpretations by different authorities.

In order to assist CONCAWE member companies/refineries in their discussions with Member States and their competent authorities, CONCAWE has prepared a short report (CONCAWE report 10/04), discussing realistic uncertainty expectations and the methodologies that are most appropriate to their particular circumstances. The main points dealt with in the report are summarised in this article.

What to measure?

In oil refineries, CO_2 is by far the dominant greenhouse gas. Emissions of other GHGs are site-dependent and the most appropriate estimation methodologies for these need to be defined locally. One of the features specific to oil refineries is the multiplicity of their CO_2 emission sources: most process plants have one or several furnaces plus utility plants (e.g. steam boilers) and flares. Chemical CO_2 from hydrogen manufacture must also be accounted for. The contribution of the various sources to the total emissions varies greatly, some sources such as flares accounting only for a few percent of the total. Clearly, the greater the CO_2 contribution of a particular source, the more effort should be devoted to measuring it. Another issue is that refinery streams in general are of variable composition, particularly fuel gas.

Direct measurement of CO_2 emissions (i.e. from the flue gases of combustion installations) is not practical and would be highly inaccurate. Establishing a complete carbon balance over the refinery, although possible in theory, would require accurate knowledge of the carbon content of all feed and product streams. Indirect measurement based on fuel consumption and carbon content is the most straightforward method, and also the one that will result in the least uncertainty. Evaluation of both the quantities (activity data) and the carbon content

Monitoring and reporting of CO$_2$ emissions from oil refineries

Guidance for member companies

(emission factor) of all fuel sources still relies on a number of measurement devices and laboratory analyses.

How to measure?

Refinery fuel systems are generally complex, with many producers (especially of fuel gas) and many consumers. The material to be used as internal fuel is in some cases gathered at a central point, appropriately mixed and homogenised, and distributed to the consumers. For those cases a central point of measurement should be preferred, as a high quality instrument can be installed maintained and calibrated to a higher standard than multiple meters on each consumer. On fuel gas it can also be coupled with an on-line quality measuring instrument (usually a densimeter, occasionally a chromatograph). This grouping of sources by fuel type, with a single or a small number of central measurement points, is allowed for in the Commission Guidelines.

In order to estimate CO$_2$ emissions one needs to have access to the mass flow of the fuel as well as to its carbon content (the so-called 'oxidation factor' is of little relevance to refineries because, essentially, the whole of the fuel's carbon is turned into CO$_2$).

The uncertainty of a flow meter measurement depends on the medium being measured, the measurement method and also the maintenance and operating practices (e.g. calibration frequency). The actual 'in-the-field' precision of a metering device is, as a rule, lower than the figure indicated by the manufacturer. Measurements tend to be more accurate for liquid than for gas flows. Practical values vary from around 0.5% in the best circumstances, to several percent.

The determination of the carbon content of fuels is in many ways a new subject, inasmuch as it was hitherto of no great interest. For light gases it can generally be calculated from compositional data obtained by, e.g., a chromatograph. For liquids correlations based on other common properties, such as density and distillation, data are generally preferred to direct measurement, which lacks accuracy. Whatever the method, it has to be kept in mind that refinery streams are constantly

changing in composition and this often has more impact on the overall accuracy than does the quality of the measurement method.

In refineries with a catalytic cracker (the vast majority in Europe) the coke, which is burned off the catalyst in the regenerator, acts as fuel for the process and is a significant contributor to the total emissions. The best method by far to estimate these emissions is to carry out a stoichiometric balance over the regenerator. Calculating the overall heat and material balance over the whole cracker, as suggested by the Guidelines, is impractical and would be very inaccurate.

Local versus global uncertainty

The Guidelines establish so-called 'tiers' or classes of measurement precision that should be applied to all sources within a site. The objective of the measurements, however, remains to estimate, with an acceptable level of accuracy and precision, the total emissions from a site.

In a typical refinery with 10 to 15 emission sources, only a small number of these account for the bulk of the emissions. A simple statistical analysis shows that, due to the combination of variances, the overall level of uncertainty is driven by that of the main sources and is usually significantly less than the uncertainty of each of the individual measurements, particularly with regard to the minor sources. In other words, while the Guideline's tier requirements may not be achieved for all sources, the uncertainty on the total emissions is within the allowable limits. Bringing the minor sources within the tier requirement would have an insignificant impact on the overall accuracy. In such a case, the installation of complex and expensive measuring devices on minor sources would be grossly cost-ineffective.

The Commission Guidelines require an analysis of the overall uncertainty for estimating CO$_2$ emissions from a refining site. The above approach can be used to identify the most important sources and to arrive, together with the permitting Authorities, at the most cost-effective solution to achieve the overall uncertainty objective.