REGULATORY CONTROL OF DIOXIN RELEASES IN THE UK

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1. INTRODUCTION

1.1 Releases of dioxins to the environment whether by means of stack emissions to air, discharges to watercourses or disposals to land pose challenges for regulatory authorities. In November 1990 the United Kingdom Government passed the Environmental Protection Act 1990 (EPA'90) which introduced a new system of Integrated Pollution Control (IPC) for the most potentially polluting and technically complex processes.1) This paper describes the application of IPC to industries with the potential to release dioxins and reviews the requirements for monitoring of dioxin releases.

2. BACKGROUND

2.1 The development of pollution control in the UK has been built up stage by stage over many years in response to particular problems. Releases from major polluters to the three environmental media of air, water and land have historically been subject to three distinct control regimes. Emissions to air have been controlled under the Alkali etc Works Regulation Act 1906 and the Health and Safety at Work etc Act 1974 by a system of prior registration and a duty on the operator to use "best practicable means" (BPM) to minimise air pollution. Regulation involved a preventative approach using testing to ensure that the design, construction and operation of the process constituted BPM. Discharges to water were controlled by state owned Water Authorities until 1989 when responsibility passed to the National Rivers Authority. Regulation involved the setting of discharge limits and sampling for compliance at the point of discharge with enforcement action following the discovery of non-compliance. In the case of solid waste disposals these have not been controlled at source but receiving landfill sites have been licensed by local Waste Disposal Authorities acting under Part 1 of the Control of Pollution Act 1974.

2.2 The new system of IPC has given the regulators, Her Majesty's Inspectorate of Pollution (HMIP) in England and Wales, the challenge and opportunity to combine the best of these previous approaches across all environmental media.

3. INTEGRATED POLLUTION CONTROL

3.1 The main objectives of IPC are:

(a) to prevent or minimise the release of prescribed substances and to render harmless such substances which are released; and

(b) to develop an approach to pollution control that considers releases from industrial processes to all media in the context of the effect on the environment as a whole.

3.2 IPC applies to all processes in England and Wales falling within any descriptions of processes prescribed for the purpose by the Secretary of State for the Environment. The Act provides that no prescribed process may be operated without an authorisation from HMIP after the date specified in the regulations for that description of process.[2] These regulations are also the means by which certain substances are prescribed for particular control under IPC. These are substances such as dioxins and furans which are considered to be the most potentially harmful or polluting when released into the environment.

3.3 Combustion processes are regarded as the main source of dioxins and furans to the UK environment. In particular, between 2.5 and 3 million tonnes of municipal waste, 61,000 tonnes of chemical waste, 170,000 tonnes of clinical waste and 40,000 tonnes (dry wt) of sewage sludge are incinerated in the UK per annum[3]. Reliable data on dioxin releases are sparse with best estimates of annual emissions being available for municipal waste incinerators (10.9kg), chemical waste incinerators (minimal - 'a few grammes of TCDDs') and clinical waste incinerators (1.7kg)[4]. Other sources attracting regulatory interest are coal burning for power generating purposes, metallurgical processes and the chemical processing of organo-chlorine compounds.

4. AUTHORISATIONS

4.1 In setting the conditions within an authorisation, HMIP is under a duty to ensure:-

(a) that the best available techniques not entailing excessive cost (BATNEEC) are used to prevent or, if that is not practicable, to minimise the release of prescribed substances into the medium for which they are prescribed; and to render harmless both any prescribed substances which are released and any other substances which might cause harm if released into any environmental medium;

(b) that releases do not cause or contribute to, the breach of any direction given by the Secretary of State to implement European Union or international obligations relating to environmental protection, or any statutory environmental quality standards or objectives, or other statutory limits or requirements; and

(c) that when a process is likely to involve releases into more than one medium (which is the case in many processes prescribed for IPC), the best practicable environmental option (BPEO) is achieved (ie the releases from the process are controlled through the use of BATNEEC so as to have the least effect on the environment as a whole).

4.2 The term BATNEEC and similar formulations is gaining increasing currency in international legislation and agreements relating to environmental protection. In practice what constitutes BATNEEC for an individual process takes into account variable factors such as configuration, size and other site specific matters. Nevertheless, broad consistency in these decisions, especially between processes of the same kind, is important. This is achieved by application of guidance to inspectors on specific classes of process published by HMIP in the form of Chief Inspectors Guidance Notes. These take into account international obligations of which European Union directives on environmental protection are the most common.

4.3 For processes with the greatest potential to release dioxins, such as incinerators, guidance is provided on process design, abatement techniques and achievable release levels. As an example of the latter the draft EU Hazardous Waste Directive proposes a dioxin emission limit value of 0.1 ng I-TEQ/m^3. In the UK this is reflected in Chief Inspectors Guidance Notes as an achievable release of 1 ng I-TEQ/m^3 and a target design standard of 0.1 ng I-TEQ/m^3.

4.4 The BPEO is the option for a particular process which provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term. In order to determine the BPEO a systematic study of the environmental impact of different release options has to be considered. HMIP is developing a procedure for evaluating optional impact scenarios. This will require an understanding of the environmental behaviour of prescribed substances, background levels and their potential harmful effects. However, although much work remains to be done dioxins are not regarded as being different in principle to other substances.

5. REGULATION

5.1 Measurement of dioxin releases has limitations associated with sampling methods, the frequency at which expensive sampling can be undertaken and limits of analytical detection. For substances such as dioxins which cannot be measured in situ monitoring involves two distinct steps; sampling and laboratory analysis. The sampling of liquid and solid wastes or environmental materials pose no unique problems and provided precautions are taken to avoid cross-contamination and loss of volatiles can be carried out using conventional techniques. Similarly laboratory analysis involving extract clean up using column absorption chromatography followed by identification and quantification using Mass Spectroscopy is well established.[5]

5.2 However, the reliable measurement of dioxins in stack emissions presents difficulties not least because of the continuing downward pressure on emission limits. The European Standards Organisation - Comité Européen de Normalisation (CEN) - have been tasked with producing a standard method suitable for making stack measurements of dioxins in response to the requirements of the draft EU Hazardous Waste Directive. Although the original impetus for a CEN Standard on dioxins came mainly from the draft Hazardous Waste Directive, it is now intended that the field of application for the Standards should extend beyond measuring emissions from waste incinerators to power and other combustion/carbonisation plant. It is planned to advocate minimum requirements in each case, rather than specifying rigid protocols which must be followed to the last detail. This contrasts with the US EPA approach whereby detailed methods are set which do not allow an operator any flexibility to make modifications, even if they improve on the specified approach.

5.3 A Working Group quickly identified different national preferences, particularly regarding sampling techniques, and potential difficulty in selecting an absolute Standard approach. It was decided that three separate Standards were needed, under the general title "Determination of the Mass Concentration of Polychlorinated Dibenzo-p-Dioxins (PCDDs) and Dibenzofurans (PCDFs), Stationary Source Emissions" covering:-

1. Sampling
2. Extraction and Clean-Up
3. Identification and Quantification.

5.4 The Working Group has found it relatively easy to agree the content of the second and third Standards. In fundamental terms, ^{13}C-labelled PCDD/PCDF clean-up spikes will be added to the different components of the sampling train, after sampling, before they are extracted with suitable solvents. Extract clean-up will be carried out by column absorption chromatography. It is planned that the identification and quantification Standard will specify minimum requirements for both low resolution GC-MS and high resolution GC-MS approaches to dioxin characterisation.

5.5 For the first Standard covering sampling minimum requirements are being considered for three generic approaches to sampling. This wide tolerance provides scope to use most national and other reasonably well founded methods, and gives the user the option to choose the approach most suited to a particular measurement task. Isokinetic sampling is required in all cases and instructions are being incorporated to add ^{13}C-labelled spikes to the sampling apparatus, before sampling, to check subsequent recoveries. The three sampling variants are:

1. A filter/condenser/adsorber method.
2. A dilution/adsorber method.
3. A cooled probe/adsorber method.

5.6 Variant 1 provides cover for the US EPA methods (Modified Method 5, and Method 23). This approach typically involves drawing sample gas through a sharp edged nozzle and heated probe to a heated filter. Temperatures are not allowed to exceed a maximum temperature of 120°C. The gas stream is then cooled and the remaining vapour phase dioxins captured by a solid resin or liquid absorbents, or both. The dilution/adsorber method involves sampling via heated probe before rapid cooling of the gases to temperatures below 40°C in a mixing chamber using dried, filtered air. Particulates are removed on a plan filter, and remaining vapour phase dioxin removed by solid adsorbent downstream. The third variant includes the Water Cooled Probe approach which has been developed by UMEA University (Sweden). Sample gas is cooled below 20°C and the condensate retained in a condensate flask. Downstream impingers/solid adsorbers, or both, are used to capture remaining vapour phase dioxins. A filter is incorporated before the last absorption trap to retain remaining airborne small particles and to break up aerosols.

5.7 Comparison trials have been organised by CEN between the various methods using testing at incineration plant with a dioxin loading of less than 0.1 ng I-TEQ/m^3. It is hoped to demonstrate reasonable reproducibility between the methods and also between the use of different sampling teams. Although some trials have been completed, the work and its findings are yet to be published.

5.8 In the UK, HMIP engaged the Warren Spring Laboratory, WSL (now part of the UK National Environmental Centre, NETCEN,) in 1992 to examine the uncertainties associated with sampling dioxins in flue gases at levels below 1 ng I-TEQ/m^3. WSL had previously investigated method and laboratory inter-comparisons at dioxin loadings down to about 5 ng I-TEQ/m^3 under the auspices of the UK National Measurement System, with considerable success[6,7]. Good agreement was observed between results obtained using an EPA Modified Method 5 sampling train and those acquired using a water cooled probe. The Water Cooled Probe results consistently demonstrated slightly higher determinations (by on average 10%2). This was in part attributed to the more efficient retention likely to be possible when sampling the gases without a heated filter.

5.9 The programme of work at 0.1 ng I-TEQ/m^3 again compared the relative performance of the EPA Modified Method 5 and Water Cooled Probe systems over five paired test periods. On this occasion the Water Cooled Probe measured lower than the EPA method throughout, considerably so over the first three tests. This disparity has never been explained satisfactorily. However, it should be noted that the final two runs did demonstrate good agreement between the two methods, and that the Water Cooled Probe did show a reasonably consistent measurement over all five runs. On the basis of the above limited test work, WSL concluded that dioxin concentrations around 0.1 ng I-TEQ/m^3 cannot yet be measured with sufficient confidence to test compliance of this particular incinerator with a limit at this level.

5.10 IPC provides HMIP with a combination of powers over the process and its operation as well as over releases to the environment. This means that HMIP is not dependent for regulatory purposes solely on information derived from measurement of releases. These powers enable HMIP to exercise preventative control over releases and deduction of data on releases. In the case of incinerators limitations may be placed on their design (eg adequate residence times) and operation (eg minimum burn temperatures) to ensure that the target design standard for dioxin releases of 0.1 ng I-TEQ/m^3 is achieved. Deduction of releases can be a valuable method for substances such as dioxins which are present at very low concentrations and may be better estimated by reference to measurements of process inputs or some other process surrogate with a known fixed relationship to the substance in question.

6. CONCLUSIONS

6.1 Integrated Pollution Control provides HMIP with powerful regulatory powers over industrial processes. For industries with the potential to release dioxins HMIP's powers over the design of processes and their operation provides means for regulating effectively even when reliable measurements of releases can be difficult to achieve.

References

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