Pilot Studies of CEN Protocols for Evaluating the Emission of Airborne Hazardous Substances from Machines – A Review of Progress

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Background

The European Union is currently involved in developing and approving a major directive on the Safety of Machinery for use by member states. The evaluation of the emission of airborne hazardous substances from machines is an important part of the approvals procedure as it should lead to a reduction in the pollutant emissions, and thereby minimise the risk of exposure of the workforce to these substances. In recognition of this CEN/TC114/WG15 is producing a suite of standards under the heading EN 1093 (1), two parts of which involve measurement of the pollutant emission rate. However, it is only in Germany, France and Finland where limited practical experience has been gained on measuring the emissions of hazardous substances from machines.

In Germany, for example, the asbestos and wood industries have developed standards for the measurement of dust emissions from various different types of machinery (2). These measurements involve the use of purpose-built test cabins in which the machines are placed, and estimates of the dust emission rate are determined from measurements of the dust concentration made in a measurement duct through which air is exhausted from the cabin. Despite the considerable number of tests that have already been made, there are serious doubts (backed up by predictions from CFD modelling) about the suitability of the existing test methods for measuring the emission rate of the coarse particles that can comprise the inhalable fraction (EN 481 (3)). It is this aerosol fraction that is measured to assess risk to health from many industrial processes (including the wood and metals industries, for example). Tracer techniques developed in France (4), Finland and Sweden, have been successfully applied to gaseous pollutants, and on a limited basis, to particles. They show great potential to become European Standards, especially for emission rate measurements from machines located in the actual workplace itself. However, in order to be able to draft a reliable protocol for a standard method, further work on the various aspects of the method is required (e.g. choice of the most appropriate tracer gas and associated analytical techniques).

Therefore, before this aspect of the EU Safety of Machinery Directive can be reliably applied, it is necessary to produce reliable standard methods for the measurement of the emission rate of hazardous substances from machines. This paper describes the progress made in a collaborative project funded under the 4th Framework Standard Measurements and Testing Programme to produce those methods.

Objectives of Project

There are two main objectives of this project.

1) To resolve the technical difficulties of the standard method for the measurement of the emission rate as specified in Part 3 of EN 1093 (Test Bench Method), and to evolve the necessary methodology for Part 2 (Tracer Method).
2) To evaluate the reproducibility of the improved methods by means of preliminary tests using firstly, a reference pollutant source, and secondly a simple machine (for example, a cutting machine for aerosols, and/or a solvent cleaning machine for gases and vapours).

Progress

Test Bench Method

In Part 3 of EN 1093 the machine is placed in a ventilated test rig. This comprises three sections: 1) a test cabin which is generally square or rectangular in cross section with of sides of the order of 3 m, and length > 5 m; 2) a measuring section which is a square or rectangular duct of side between 0.6-0.8 m, and length > 5 m, and 3) a rectangular conical connection to connect the two sections. The rig is connected to a fan, which provides airflow of uniform velocity profile in both the test cabin and the measuring section. The machine is placed in the centre of the test cabin, and any dust emitted is transported by the airflow through the transfer cone to samplers in the measuring section. Generally, the cabins are constructed from wood or metal sheet, with no plastic used to minimise particle losses due to electrostatic forces, and the air velocity profile entering the cabin is made uniform by making the entry wall from a fabric filter material or perforated plate.

A reference dust source (the PALAS RBG1000 dust feeder) was used in the place of the machine to investigate the operating parameters that could affect the emission rate measurement. With this source the emission rate can be measured directly and accurately by weighing the dust reservoir before and after the emission run. In preliminary set-up runs using tracer gas, it was found that with the standard operating velocity in the test cabin of 0.25 ms-1, there was very little mixing of the gas, such that the concentration profile in the measuring station reflected the density of the tracer gas. This was improved by the installation of an axial flow mixing fan located in the transfer cone, and proved to be suitable for dusts also, with very little evidence of dust deposits on the fan blades.

Work is currently underway to investigate the effect on emission rate measurements of parameters such as; injection velocity, height and orientation of source, transport velocity and distance, position of sampling points, and particle deposit on cabin walls.

Preliminary results (Figure 1) show that the performance of the test bench is very dependent upon particle aerodynamic diameter, with efficiency ranging from over 90% for 6 µm particles to 30% for 75 µm particles.

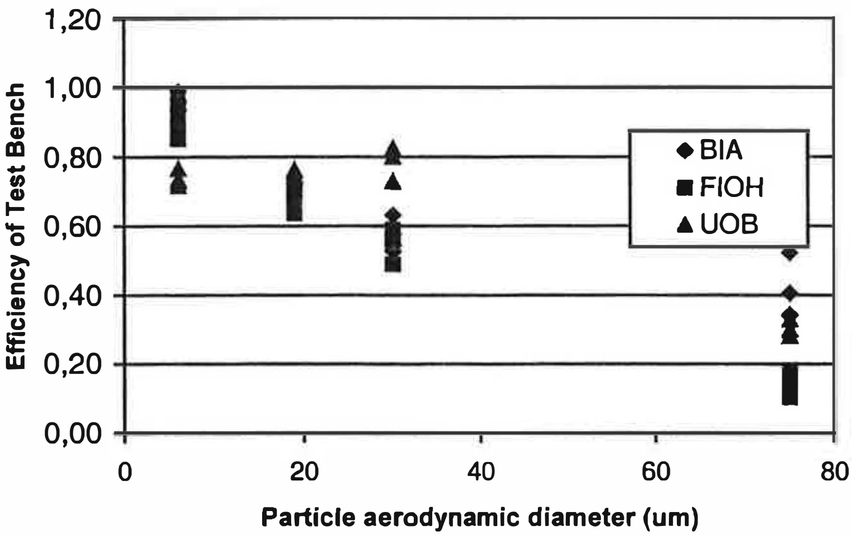

Figure 1. Preliminary results of emission rate measurements in Test Bench - U=0.25m/s, source on axis, emitting with wind

Tracer Gas Method

The tracer technique involves the dispersion into the air of a small quantity of tracer gas alongside the real pollutant. The concentrations of tracer gas and pollutant reaching a series of measurement points are determined and, if the emission rate of the tracer is known, the emission rate of the pollutants can be calculated. The potential major advantage with the technique is that it can be carried out in the actual workplace, provided there are no confounding sources.

Reference point and plane gas sources have been produced, involving the controlled evaporation and emission of acetone as the pollutant. Tracer gases, N_2O, SF6 and He have been used in three of the laboratories, with appropriate fast response gas analysers. In the first set of experiments, the emission rates of acetone from the reference sources were determined in controlled conditions in rooms where the ventilation could be varied. The effects of room ventilation pattern, number and position of sampling points, and the closeness of the tracer gas source to the acetone source, were investigated to enable an experimental protocol for a draft standard method to be produced. The results showed that the accuracy of the method is dependent upon the relative densities of the tracer gas and the pollutant, with large errors occurring when low-density pure helium was used. Poor results were also obtained when the tracer gas was emitted separately from the pollutant, pointing to the need for the tracer gas to be emitted as close to the pollutant source as possible. As expected, the use of auxiliary mixing fans greatly improved the results. From these results a draft protocol for the tracer gas method for measuring the emission rates of gaseous pollutants has been produced.

References

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