The use of environmental monitoring to estimate diffuse emissions from storage tanks

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The aim of inverse dispersion modelling is to use a set of concentration measurements to estimate the location, strength and composition of the responsible emission or emissions. This information is combined with wind data and a dispersion model, and an iterative procedure adopted to seek the best fit between the observations and the concentration field calculated from the estimated source terms. The process can work very effectively for dispersion from a steady source over open terrain but in, say, many urban and industrial cases is compromised by the complexity of the dispersion processes and the consequent limited quality of available dispersion models. A further and very important constraint in practice is also the high levels of uncertainty that may be attached to the concentration data themselves. The particular application of interest here is that of diffuse emissions from oil and product storage tanks, for which there is no reliable, fast-running, short-range dispersion model. Nevertheless, monitoring is undertaken at short range (for a number of good reasons) and there is a clear need to understand the levels of uncertainty that this imposes on any estimation of source terms.

Flow and dispersion downwind of storage tanks is a complex function of the tank shape, group configuration, source position and, for floating roof tanks, the roof height. The subject has been studied to a considerably lesser degree than the equivalent building and urban dispersion problems. What previous research there is has concentrated more on fixed roof cases, though some work has been undertaken with floating roof tanks. However, the picture is far from complete and the aim of the wind tunnel experiments (with single tanks and groups of tanks) was to remedy this deficiency and, at the same time, quantify the variability in dispersion behaviour and inform protocols that would lead to successful source evaluation in the field.

The first phase of the study treated point concentration measurements and the overall objectives were fourfold:

> i) to clarify the role of tank geometry and arrangement, floating roof height and source location on flow and dispersion downwind,
> ii) to quantify the fetch required for near-field effects to decay,
> iii) to provide detailed data sets that could be used to evaluate the performance of CFD simulations of selected cases, and
> iv) to inform the development of protocols for making reliable measurements at full scale.

However, line integrated measurements are often used in the field and the second phase of the work focused on the statistics of line integrated concentrations in dispersing plumes. The methodology involved the measurement of two-point concentration fluctuation correlations, so that much additional information was obtained along the way. The overall objective of the second phase was to obtain the mean and standard deviation of line integrated concentrations in a number of situations that simulated potential field measurements, as might be used to determine pollutant fluxes. The cases were selected to study effects of:

i) distance downwind from the storage tank,
ii) the emission release height and tank geometry, and
iii) the scan orientation (lateral, vertical or radial with respect to the storage tank).

The experiments were carried out in the boundary layer wind tunnel of the Environmental Flow Research Centre (EnFlo), at the University of Surrey, UK. This is an open circuit wind tunnel with a 20 m long, 3.5 m wide and 1.5 m high working section. The wind speed can be in the range 0.3 to 3.5 ms^{-1}, and the facility is capable of simulating both stable and unstable atmospheric conditions, although this feature was not used in this study. Reference flow conditions were measured by two ultrasonic anemometers, one held at a fixed location and the other positioned as required, and two propeller anemometers mounted on either side of the traverse carriage. Velocity and concentration field data were obtained, respectively, with a Dantec two component laser-Doppler anemometer and a Cambustion fast flame ionisation detector (frequency response of order 200Hz). The wind tunnel and its associated instrumentation are fully automated and controlled using LabVIEW virtual instrument software created at EnFlo.

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