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Project Report

Editorial Note

Currently there are many national and international collaborative research programmes being undertaken or planned that are concerned with hazardous materials. In an attempt to improve the general awareness of these programmes, their structure and status I would like to encourage submission of brief Project Reports. These would be assured of publication in the earliest possible issue of the Journal.

REX BRITTER

RESEARCH ON CONTINUOUS AND INSTANTANEOUS GAS CLOUDS

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Summary

This project, which is one of six currently supported under the Major Technological Hazards Programme of the Commission of the European Communities, is briefly described in terms of participants, subtasks, etc. However, the main purpose of this note is to inform about the planned field phases of the project.

Introduction

The dispersion of heavy gases over flat terrain in terms of time-averaged concentration is quite well understood. The project is concentrating on the following more complex situations.

1. In practical situations, obstacles will be present in the form of buildings and other installations. These obstacles may significantly influence the dispersion process, but little quantitative guidance can presently be given on the magnitude of the effect on the spatial and temporal distributions of the concentration field.
2. Until now, models used for predicting atmospheric concentrations of contaminants have been those which produce time or ensemble-averaged val-

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ues. These models are appropriate in cases where the effects of the contaminants depend on their accumulation over a time period which is long compared to the time scales of the fluctuations in concentration which occur as a result of atmospheric turbulence. However, some contaminants are so toxic that harmful effects may be produced at exposure times much shorter than these larger time scales. For these contaminants models that provide only expected values of averaged concentrations are inadequate.

The aim of the project is to provide enhanced numerical and/or physical methods to predict heavy gas behaviour relevant to the above. In order to fulfil this aim a number of research groups with complementary expertise were drawn together to form this joint project (see Appendix).

Contents of the project

Some of the main activities in the project are listed below together with the institutions responsible (regarding abbreviations, see Appendix)

- Review of available data, identification of gaps in knowledge, and recommendations for experiments to be carried out (SRD).
- Full-scale tests with continuous heavy-gas jets of the obstacle influence on the downwind concentration field (Risø, TÜV).
- Wind-tunnel simulations of the full-scale tests, and simulations in more systematically varied parameter combinations than obtainable in the atmosphere (TNO, UH, WSL).
- Multiple repetition of wind-tunnel simulations of Thorney Island Trials. (see ibid, 11) and wind-tunnel studies of generic obstacles such as streets, canyons, slopes, ridges, etc. (WSL, UH).
- Analysis of full-scale and model-scale concentration measurements (HSE, TNO, Risø, BU, UH).
- Numerical model study of the effect of obstacles and comparison with the experimental results (Solvay, SRD, Risø, TNO).

As a last point, it was originally proposed to perform a dispersion study at a real industrial site supplemented with a wind-tunnel study. Since for other reasons we have now decided to use propane as the heavy gas, this last point may not be realizable. Options are of course to find an abandoned factory or change to a safe gas such as CO_2.

The field phase

Three experimental phases will take place: the first one already started in October 1988. This is a "dry run" where different sorts of instrumentation will be tested together with procedures for erecting the obstacle, etc. In the second phase during April 1989 we will test the set-up in different wind speeds and spill rates; in this way the plume height will be varied relative to the obstacle.

During this phase we will gain a good understanding of how the obstacle interacts with the gas plume in various situations. Also the obstacle porosity may be varied.

During the third phase in the autumn of 1989 we will restrict ourselves to a more rigid plan, varying only a few important parameters, emphasizing quantitative results. We might use the experience from the second phase to improve the experimental set-up. Also we foresee some interplay with the results from wind-tunnel experiments.

As to obstacles we are of course trying to model the effect of building-like structures. However, it has been decided that since the wake behind a bluff body is not dependent on the streamwise dimension (provided it is not very long compared to the height of the building), it is sufficient to use sheet material to mimic the building silhouette. In the first phase we will use a "fence" of such silhouettes with about equal areas of open and obstructed space arranged in a perpendicular line to the wind.

As concerns instrumentation, TÜV will deploy 11 infrared and about 40 catalytic instruments for concentration measurements. The infrared sensors are relatively fast (some seconds' time response), the catalytic instruments somewhat slower.

In addition to four sets of temperature and wind profile instrumentation (time resolution about 1 s) Risø will deploy 6 ultrasonic anemometer-thermometers. In addition to turbulence statistics these may be able to supply high-frequency concentration fluctuation measurements.

In addition to the above, auxiliary equipment will be used for intercalibration measurements of concentration, temperature, etc.

The instrument lay-out will consist of three groups of vertically and horizontally (laterally) spaced sensors: a group in front, and a group behind the line of obstacles. We suggest that the distances from these groups to the line of obstacles are made large enough to avoid local differences between the wakes of the obstacles and the increased gas flow in the gaps. The necessary distances are estimated to be three heights of obstacle upstream and seven heights of obstacle downstream. The measurements from the two groups are expected to provide information of the bulk effect of the obstacle.

We are also interested in information about the detailed flow and concentration field around the obstacles. This will improve our knowledge of the mechanisms involved. It is therefore suggested that a third group of sensors be dedicated to a detailed study of the flow and concentration field around an obstacle near the centre line.

The detailed array is designed so as to answer some of the following questions.

1. What is the speed-up velocity in the gap and over the fense?
2. What is the turbulence in the various areas?
3. Will a so-called horseshoe vortex occur?
4. To what extent does the presence of the gas alter the above quantities?

5. Will any mixing effect of the obstacle occur upstream, or does all additional mixing occur in the wake?
6. Are reduced concentrations found on the obstacle surface?

The general spill rate will be 0.5 tons per minute with a typical duration of 10 minutes, but the rate can be varied by almost a factor of two to either side. The spill facility operated by TÜV is located in Lathen, North Germany.

Suitable distances are estimated to 50 and 100 m, respectively, from the spill point to the obstacle and width of the obstacle array. These dimensions may not be the best choice and may be altered. A simple heavy gas plume model at Risø was not in good agreement with the report and pictures from earlier TÜV experiments without obstacles, perhaps due to the initial momentum in the jet. The criteria should be at least a 4% propane content in the cloud near the obstacle, but no excess momentum in the plume, and that the concentration sensors should cover the whole plume with reasonable allowance of variability in the wind direction.

Future communications

After the first field phase we shall report in this journal on the preliminary findings. We shall also give a description of the instruments selected for the main trials as well as the calibration procedures adopted. We hope to be able to submit a report on the results of the second field phase in June 1989 together with final plans for the autumn experiment in 1989.

Acknowledgements

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Appendix

The following organizations participate in the project. TNO also act as project coordinator.

MT-TNO, Apeldoorn, the Netherlands (TNO)
Risø National Laboratory, Roskilde, Denmark (Risø)
Solvay SA Laboratory, Brussels, Belgium (Solvay)
University of Hamburg, Met. Inst., Hamburg, F.R.G. (UH)
SRD, Warrington, Cheshire, U.K. (SRD)
Health and Safety Executive, Safety Eng. Lab., Sheffield, U.K. (HSE)
Warren Spring Lab., Dept. of Trade and Industry, Stevenage, U.K. (WSL)
Brunel, The University of West London, Uxbridge, U.K. (BU)
Techn. Überwachungs-Verein Norddeutschland, Hamburg, F.R.G. (TÜV).