# Atmospheric Dispersion Modelling Liaison Committee

## Annual Report 2002/2003

**INCLUDING**

## Sources of meteorological data for use in dispersion modelling

## Uncertainty in deriving dispersion parameters from meteorological data

## Dispersion from accidental releases in urban areas

**AND**

## Effect on atmospheric dispersion of changing land use around Heathrow


National Radiological Protection Board
Chilton
Didcot
Oxon OX11 0RQ

Publication date: April 2004
ISBN 0 85951 525 7

# PREFACE

In 1977 a meeting of representatives of government departments, utilities and research organisations was held to discuss methods of calculation of atmospheric dispersion for radioactive releases. Those present agreed on the need for a review of recent developments in atmospheric dispersion modelling, and a Working Group was formed. Those present at the meeting formed an informal Steering Committee, that subsequently became the UK Atmospheric Dispersion Modelling Liaison Committee. That Committee operated for a number of years. Members of the Working Group worked voluntarily and produced a series of reports. A workshop on dispersion at low wind speeds was also held, but its proceedings were never published.

The Committee has been reorganised and has adopted terms of reference. The organisations represented on the Committee, and the terms of reference adopted, are given in this report. The organisations represented on the Committee pay a small annual subscription. The money thus raised is used to fund reviews on topics agreed by the Committee, and to support in part its secretariat, provided by NRPB. The new arrangements came into place for the start of the 1995/96 financial year. This report describes the eighth year in which the Committee has operated under the new arrangements, and during which it placed four contracts. These covered a review of possible sources of meteorological data for use in dispersion modelling, uncertainty in deriving dispersion parameters from meteorological data, dispersion following accidental releases in urban areas and the effect on atmospheric dispersion of changing land use. The technical specifications for the contracts are given in this report, and the contract reports are attached as annexes to this report. The Committee funded twelve studies in previous years; they are described in its earlier annual reports.

The Committee intends to place further contracts in future years and would like to hear from those interested in tendering for such contracts. They should contact the Secretary:


Mr J G Smith
National Radiological Protection Board
Chilton
Didcot
Oxon OX11 0RQ

E-mail: ADMLC@nrpb.org.uk

# CONTENTS

# 1 ORGANISATIONS REPRESENTED ON THE COMMITTEE

The organisations on the committee during the year covered by this report were:

Amersham plc - now a GE Healthcare company

Atomic Weapons Establishment, Aldermaston

British Nuclear Fuels plc

BNFL Magnox Generation

Defence Science and Technology Laboratory

Department of the Environment Northern Ireland

Environment Agency

Health and Safety Executive

Methodology and Standards Development Unit, Hazardous Installations Directorate

Nuclear Installations Inspectorate

Ministry of Agriculture, Fisheries and Food

Meteorological Office

National Nuclear Corporation

National Radiological Protection Board

Nuclear Department, HMS Sultan

Rolls Royce Power Engineering plc

Scottish Environment Protection Agency

Westlakes Research Institute

The Chairman and Secretary are provided by NRPB.

# 2 TERMS OF REFERENCE

The terms of reference of the committee during the year covered by this report were:

1 To review current understanding of atmospheric dispersion and related phenomena and to identify suitable models for application primarily in authorisation or licensing, in the context of discharges to atmosphere resulting from nuclear industry activities.

2 The Committee shall consist of representatives of government departments, government agencies and primarily the nuclear industry. Each organisation represented on the Committee shall pay an annual membership fee of £1000.

3 The Committee will consider selected topics. These should be selected following discussion and provisional agreement at meetings of the Committee, followed by confirmation after the meeting. Where possible, it will produce reports describing suitable models for that topic. These will reflect either the views of an Expert Working Group appointed by the Committee or the outcome of a workshop organised on behalf of the Committee. The Working Group will determine who should be invited to speak at workshops, and will subsequently review their outcome and identify suitable models.

4 The money raised from membership fees and registration fees for the workshops will be used to support the Working Group, the drafting of reports, and any other matters which the Committee may decide.

# 3 WORK FUNDED DURING THE YEAR

## 3.1 Sources of meteorological data for use in dispersion modelling

ADMLC has previously funded studies by the Met Office into various topics relating to the most appropriate meteorological data to use in dispersion calculations. Following discussions between ADMLC and the Met Office, the following work programme was agreed.

Traditionally the dispersion modelling community has used meteorological data recorded at observing sites as input to their prediction models. However, the increased automation of weather observing (and the consequent absence of some variables formerly observed by eye) has prompted consideration of alternative approaches which might provide suitably representative data for dispersion studies. These alternatives include data derived from the analysis fields of the Met Office's Numerical Weather Prediction (NWP) model, the use of Laser Cloud Base Recorder (LCBR) cloud amount and the application of a site-specific model to NWP data to provide truly local data. Following discussions with ADMLC, the Met Office undertook work to describe the following:

a Met Observations, how they are made and the quality control applied to them.

b The representivity, both temporally and spatially, of observed met data.

c Available data in Met Office archives suitable for ADMS or R91 type dispersion models and how data are processed for input to ADMS.
d The NWP Process.
e The Site Specific model.
f The NWP Archive.
g Deriving ADMS datasets from NWP data and Site Specific Model.
h Pre-processing met. data to reduce the calculation burden.
i The provision of met. data and/or dispersion calculations in real time.

The report on this work is published as ADMLC/2002/1.

## 3.2 Uncertainty in deriving dispersion parameters from meteorological data

The calculation of concentrations of material released to atmosphere is achieved using models of the dispersion process. Such models use estimates of the relationship between plume growth and indicators of atmospheric turbulence, with the indicators of turbulence being derived from measurements of the state of the atmosphere. Older models define the state of the atmosphere in terms of a small number of stability categories, while more recent models use continuously varying quantities, such as the Monin-Obukhov length and the depth of the boundary layer.

There are several sources of uncertainty in deriving estimates of plume growth from measurements of the atmospheric conditions. The Atmospheric Dispersion Modelling Liaison Committee is interested in a review of the uncertainty in predicted plume growth arising from uncertainty in

a Describing the atmospheric conditions
b Deriving a description of the atmospheric boundary layer (quantities such as Monin-Obukhov length and the depth of the boundary layer) in the measured conditions.

The review should address questions such as what parameters should be used, how accurately can they be known (including the difference between spot measurements and averages over longer periods), how well do they represent conditions through the boundary layer, and the importance of quantities that are not routinely measured but for which a value is required when characterising the boundary layer.

The review should also address the time variation of quantities, such as the Monin-Obukhov length and the depth of the boundary layer, and the effect changes in such parameters might have on predicted concentration. Situations when these, and other parameters, might change rapidly should be identified. Comments should be made on the growth of the boundary layer depth during a typical day, and the likely difference in predicted concentrations for the same surface conditions in the morning and the evening, reflecting the differences in the boundary layer depth.

The contractor should consider in particular the methods used in ADMS and AERMOD, identifying the general weaknesses and strengths of the models and commenting on the meteorological situations when the two models might produce substantial differences in predicted concentration derived from the same meteorological conditions.

ADMLC requires comments on the reasons for the different predictions, guidance on the most appropriate method and comments on whether the use of particular stability indicators would lead to lower uncertainty in the final predicted concentration, rather than simply a comparison between the two programs. This could include comments on whether the same process for deriving stability indicators for meteorological data is appropriate for different users, with different needs. The contractor should address the problems of selecting parameters suitable for a range of different releases for example releases at a constant rate over periods of months and short duration releases.

The contractor should recognise who the report will be used by (industry, regulators, model users), and identify their needs and in what way the results will be used.

The report on this work is published as ADMLC/2002/2.

## 3.3 Dispersion from accidental releases in urban areas

Prof. J C R Hunt (University College London and Cambridge Environmental Consultants) suggested to ADMLC that a review of dispersion following accidental in urban areas was required, and that ADMLC may be the most appropriate body to oversee the work. ADMLC accepted this suggestion and the following work programme was agreed.

### Scientific Overview

Key Problems

The range of possible scenarios is very large so therefore not all problems or possible scenarios can be covered in detail. The main considerations in this review are as follows:

Airflow and thermal conditions in various types, and scale, of urban area, (including open spaces and also closed spaces such as tunnels) and different meteorological conditions inside and outside the urban areas. The effects of mesoscale influences such as nearby mountains and coasts will be considered. The main emphasis will be on the UK, but with some reference to complex conditions abroad. Spatial scales will include local effects and city wide impacts.

Different types of accidental release including buoyant, neutral and dense gases over different periods/areas/elevations, and also liquid spills.

Dispersion and deposition in urban areas (including sources just outside and just inside - eg airports), over short to long time scales (i.e. seconds to hours) considerations of spatial averaging (street scale to city wide), limited discussion of chemical transformations. The study will consider outdoor rather than indoor impacts.

Research progress

Theoretical concepts including parameterisations beyond roughness length, flow zones (canopies), release and dispersion processes etc. Review of recent field and lab experiments and concepts/contradictions that have emerged (eg US experiments). New approaches to numerical simulation in urban areas including random flight and approximate simulation of boundary conditions/physics etc.

Practical Modelling Approaches

c Discussion of principles and operating features of models (data requirements, run times, computer capacity), user sophistication/verification.

d Reviews of US and European mesoscale approaches; local scale eddy viscosity modelling (e.g. CFD codes); computed flows plus diffusion (eg modified FLOWSTAR, plus diffusion formulae (as in ADMS) or plus random flight simulation); plume/box modelling formulae (Gaussian and non-Gaussian) with special urban parameters (e.g. ADMS adaptation; Met Office approach of D Middleton); explicit consideration of the model developed at Porton.

e Tests done so far against data (eg on local and urban wide scales) in laboratory and field studies.

f Discussion of sensitivity of models to input parameters including release location. Estimates will be given of where current research indicates significant errors from using current practical methods.

g Codes currently available (or under development)

Recommendations for Action

h Validation exercises (how they should be done for various purposes) with prioritisation based on results of d above.

i Need for new data/experiments (requirement that they can be compared with models).

j Suggestions for collaborations and ‘harmonisation’ exercises for comparison experiments and codes, use of current/developing programmes (eg UWERN, Cost Action ... etc).

The report on this work is published as ADMLC/2002/3.

## 3.4 Effect on atmospheric dispersion of changing land use around Heathrow

Dr D Harvey (ADM Ltd) approached ADMLC with comments on an earlier ADMLC study ('Options for the Most Appropriate Meteorological Data for Use in Short Range Dispersion Modelling' published in the Annual report for 2000/2001). Dr Harvey felt that the grid size used in that study may not have been adequate, and suggested that further work should be carried out to check the original results. Following discussions, ADMLC accepted the following proposal.

The proposed study is intended to complement the work carried out by the Meteorological Office for the ADMLC Annual Report 2000/2001 publication W3 title 'Options for the Most Appropriate Meteorological Data for Use in Short Range Dispersion Modelling'. This study investigated how representative the use of historic meteorological data is by using meteorological data sets from the 1950's onwards. The study concluded that the urbanization around Heathrow has affected both the measured met data and resulting predictions of ground level concentrations. Concern has however been raised that the stack height and grid size used have reduced the confidence in the findings of the study as the grid resolution was not sufficient to capture the maximum ground level concentrations.

This study will repeat some of the previous work using two sources and a grid size that ensures the maximum concentrations are captured. In addition, predictions will be made to see if the urbanization of the region surrounding Heathrow can be replicated in the modelling.

ADMS 3.1 dispersion modelling will be undertaken using two point sources;

a 40 m stack; no buoyancy

b 150 m stack; with buoyancy

The use of two stacks heights will enable assessment of whether there is any difference in the trend in predicted ground level concentrations with time for two source heights. The sources selected will also be more representative of typical sources than that selected in the previous study which was a 10 m stack with no building downwash. The two sources selected will be identical to those modelled in the Environment Agency's October 2000 Intercomparison study and subsequent papers. This will facilitate cross referencing of the predicted concentrations with other work.

Predictions will be made for each of the 12 separate years of met data (from the years 1950 to 2000) giving a total of approximately 24 separate ADMS runs.

Predictions will be made for a range of statistics including annual average, 100th, 99.9th, 99.8th, 99.7th 99th and 98th percentile of hourly means.

The concentrations predicted by this set of predictions will be analysed and the results of this analysis compared to the previous study.

If this studies findings are similar to those of the previous work and show a trend in predicted concentrations with the age of the meteorological data a further series of predictions will be undertaken using ADMS 3.1 to see if the trend in predicted concentrations can be replicated and hence explained by changing the surface characteristics used in the modelling (eg roughness length, minimum Monin-Obukhov length, albedo and Priestly-Taylor parameter).

The report on this work is published as ADMLC/2002/4.