NOTES ON ATMOSPHERIC POLLUTION DISPERSION STUDIES AT THE AEC

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1. INTRODUCTION

Atmospheric dispersion studies at the Atomic Energy Corporation of SA Limited are encompassed within four categories viz:

(a) Long-term atmospheric dispersion studies
(b) Real-time plume dispersion prediction
(c) Meteorological and atmospheric stability studies
(d) Atmospheric tracer investigations

Atmospheric dispersion models are not developed *ab initio* within the AEC. Rather, proven alogirthms obtained elsewhere are modified where necessary for specific needs and applications. Each category of dispersion study dealt with at the AEC and as set out above, is discussed briefly.

2. LONG-TERM ATMOSPHERIC DISPERSION MODELLING

For long-term atmospheric dispersion estimates the AIRDOS-EPA computer code, developed by Oak Ridge National Laboratory (ORNL) is currently used. The AIRDOS model is used primarily to estimate radionuclide concentrations in air, rates of deposition on ground surfaces and radiation dosages to man from routine atmospheric releases.

AIRDOS-EPA was modified at the AEC to enable prediction of radon concentrations resulting from dispersion of emissions from wastes (tailings and slimes dams) on the Witwatersrand. A model evaluation study (Grundling, 1987) was conducted for a limited area on the Witwatersrand in which five tailings dams were considered to be the major radon sources for model evaluation purposes. The area was subdivided into a 1 km grid with the 5 radon sources more or less in the centre. Radon concentrations were measured and predicted (using the modified AIRDOS code) at 88 grid positions. Subsequently the measured and predicted values were analysed statistically using methods proposed by Wilmot (1981) and Stunder (1986) for the evaluation of dispersion model performance. Results are summarised in Table 1.

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TABLE 1: Quantitative measures of AIRDOS-EPA model performance

i) Summary measures	
Mean observed concentration ($\underline{O}$)	= 60,3 Bq/m^3
Mean predicted concentration ($\underline{P}$)	= 70,7 Bq/m^3
Standard deviation of $\underline{O}$ (S_o)	= 21,4 Bq/m^3
Standard deviation of $\underline{P}$ (S_p)	= 43,0 Bq/m^3
ii) Linear regression	
Intercept of the least-squares regression (a)	= 23,1
Slope of the least-squares regression (b)	= 0,79
iii) Difference measures	
Index of agreement (d)	= 0,54
Root mean square error (RMSE)	= 39,8 Bq/m^3
Unsystematic root mean square error (RMSE)	= 38,2 Bq/m^3
Systematic root mean square error ($RMSE_s$)	= 11,4 Bq/m^3
Mean absolute error (MAE)	= 26,6 Bq/m^3
iv) Prediction mode (M)	
% prediction within a factor of 2	= 84,1%
Over prediction (M> 30%)	= 25,0%
Correct prediction (-30% M + 30%)	= 59,1%
Under prediction (< - 30%)	= 15,9%

The results obtained are satisfactory in the sense that the AIRDOS-EPA dispersion model can be used to predict fairly accurately, areas of enhanced radon concentrations provided that emission sources are identified and quantified.

AIRDOS-EPA is one of the models recommended by US Nuclear Regulatory Commission (NRC) and can be used for licensing requirements of nuclear facilities as well as the assessment of radiological impacts.

3. REAL-TIME PLUME DISPERSION MODELLING

A Gaussian dispersion model, developed by Burger (1984) has been modified by the AEC for on-line plume prediction during non-routine atmospheric releases. The plume prediction model which is adaptable to any terrain and process, is a sophisticated, on-line system consisting of the following components:

* Olivetti M240 PC
* Campbell CR10 datalogger
* Meteorological mast and sensors including UVW anemometer
* Uninterruptable power supply (UPS)
* Lightning protection system
* Modem (data transfer)

The model is user-friendly and includes many menu options such as zoom, route legend, source information, wind data, maximum concentration value and position as well as pollution concentration contour values.

This real-time model, customised for site-specificity, is a powerful tool for planning and subsequently co-ordinating action in the event of non-routine emissions which might range from those resulting from plant start-up, through spillages to catastrophic failure of vessels containing toxic substances.

4. METEOROLOGICAL AND ATMOSPHERIC STABILITY STUDIES

To date the Turner method has been used to define atmospheric stability for long-term dispersion modelling purposes with dispersion coefficients subsequently being derived from the relevant Pasquill stability category. A more scientific way to determine the dispersion coefficients is to use orthogonal anemometers (UVW) and/or vertical temperature profiles of the atmosphere. Automatic weather stations at Pelindaba and Gouriqua (near Mossel Bay) are equipped to provide information for the means to define atmospheric turbulence and such studies are currently under way.

Arrangement of the weather stations at Gouriqua is such that study of the coastal boundary layer is enabled. The study of coastal boundary layer physics is of cardinal importance to air pollution planning in that significant dispersion parameters are variable on small time and distance scales in the lowest few hundred meters of the atmosphere.

5. ATMOSPHERIC TRACER STUDIES

Recently a new tracer dispersion technique has been evaluated by the AEC in an experiment to calibrate a pollution dispersion model. The radionuclide Technetium-99m, was used as a tracer in an experiment where concentrations up to 5 km from the release point were measurable. It is the intention of the AEC actively to pursue and refine tracer techniques for the purposes of apportionment of source contributions to measured environmental pollution concentrations as well as to further evaluate a range of dispersion models.

6. CONCLUSIONS

Atmospheric studies geared towards the refinement of predictive capabilities for planning as well as emergency response activities will continue to receive attention at the AEC. The technology and expertise engendered by years of devotion to development of the nuclear fuel cycle at the AEC places the organisation at the forefront of atmospheric studies and pollution dispersion modelling.