NEW DEVELOPMENTS IN THE RAPID ANALYSIS OF OFF-SITE CONSEQUENCES OF AIRBORNE RADIOACTIVE RELEASES

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INTRODUCTION

A number of techniques exist for the assessment of the offsite consequences of accidental airborne releases of radioactive material. These range from hand calculation methods using graphs and tables (reference 1) to very complex wind field computer models (reference 2). The larger computer models require specialist personnel to operate them and, being centrally based, may not be available to operators due to communications breakdowns. Smaller computer models of varying complexity exist which can be used by the site personnel to determine the need for countermeasures in the early stages of an accidental release.

The UKAEA UMPIRE system (reference 3) was developed to provide predictions of doses to individuals from airborne releases. Advances in computer technology made it necessary to update the hardware and carry out modifications to the programs. A method of incorporating monitoring data to modify the dose predictions has been under development and the increase in computing power has enabled this to be included in the new system.

PHILOSOPHY

The immediate needs of the health physicist in advising on the need for countermeasures ranging from sheltering and stable iodine tablet issue to evacuation are to predict the current and future doses to individuals (within a few km of the site). A simple method for doing this based on monitoring results is used in the Harwell Survey Report Scheme (reference 4). However, in the case of fluctuating releases, changing weather conditions and a number of different sampling locations it is difficult to interpret the results or to predict the effects at other locations.

The UMPIRE 2 system uses measured and forecast weather conditions to predict the spread of the plume. It can use a previously calculated source term to give individual dose predictions. Once monitoring data has been obtained the interactive mode allows the source term, wind direction and effective release height to be modified. The modified data is then used to predict the consequences at locations where monitoring has not yet been carried out.

DATA REQUIREMENTS

Meteorology: To determine the consequences of an airborne release data on meteorological conditions is needed. In the simplest form this consists of time, wind direction, wind speed, cloud cover and rainfall rate. The atmospheric stability category which governs the dispersion is obtained from these values and an estimate of the mixing depth is also made. For consistency the simple method in reference 5 has been used.

Alternatively, a scheme exists to obtain meteorological data from the Meteorological Office in terms needed for this sort of calculation. The PACRAM scheme gives stability category, mixing height, wind speed and wind direction predictions at various times and distances from the site.

Release: To run the system in the predictive mode requires data on the source term consisting of the nuclides releases, the rate of release and duration and the effective height of the release. The interactive mode assumes a release of unit activity of limiting nuclides in terms of countermeasures ie I131, Pu239 and 1 MeV/Bq noble gas at a uniform rate for 4 hours at ground level unless a different source term is defined.

MODELLING

The dispersion model used is a simple two dimensional Gaussian model as described in reference 5. Plume depletion by dry and wet deposition and consequent ground deposited activity are calculated.

The airborne and ground deposited activity is divided into alpha and beta/gamma emitters. Doses from inhalation, groundshine and cloudshine are calculated for individuals. The data for inhalation dose to three age groups (infants, 10 year old children and adults) are taken from a computer data base developed by NRPB (reference 6). Groundshine doses are interpolated from data taken from reference 1 and from the WASH-1400 study (reference 7). Gamma cloudshine dose is calculated using the simple technique described in reference 3 switching from line source to a look up table to a semi infinite cloud model depending on the shape of the plume.

RESULTS

The dose isopleths can be displayed overlaid on a simplified map of the area surrounding the site selected. Doses to different organs and for the three age groups are available from inhalation only or inhalation plus external radiation. The development of the release can be followed by changing the interval between the start of the release and the display of results.

The modifying effects of introducing countermeasures can be shown.

A summary printout gives the input data and doses at selected locations in the plume at various times after the start of the release. This enables the health physics controller to concentrate resources on immediately affected areas while making preparations for countermeasures in other areas.

MONITORING RESULTS

For the purpose of comparison with monitoring data the following values are also calculated:

1. Gamma dose rate at 1m above ground.
2. Airborne beta/gamma activity kBq m^{-3}
3. Deposited beta/gamma activity kBq m^{-2}
4. Airborne alpha activity Bq m^{-3}
5. Deposited alpha activity Bq m^{-2}

By comparing the predicted and measured results modifications can be made to the source term with respect to quantity, proportion of nuclides and release height. Airborne activities can be tracked back to the current release rate and nuclide proportions; ground deposited activity gives an integrated history of the plume (although the situation is complicated if local rain showers occur) and gamma dose rate, when corrected for ground deposited activity and airborne particulate, indicates the noble gas activity (in terms of Bq-MeV).

A method has been developed (reference 8) to allow corrections to be made for differences between the measured wind direction and the effective plume direction and to scale the magnitude of the release (either overall or in sections) to fit the monitoring results. Dividing the release into alpha and beta/gamma emitters allows the source term to be calculated in terms of I131 and Pu239 which give a pessimistic estimate of the doses incurred.

If more detailed nuclide information is available from a stack monitor a detailed inventory or gamma or alpha spectrometry results this can be substituted for the basic source data. The program then calculates the offsite consequences of the release modified by the survey results.

USER INTERFACE

A major aim of the UMPIRE project has been to ensure that the system can be operated easily in a high stress situation. Experience with the early system has shown that it must be possible to alter any part of the input data rapidly. UMPIRE2 is controlled from a single page divided into topic areas. Most items can be altered individually although some such as site and location within the site are interdependent, in these cases the user is prompted to enter the appropriate data.

FURTHER DEVELOPMENT

Despite the recent accident at Chernobyl it is in fact very unlikely that the system will ever be used in an actual accident. It is therefore proposed that a simulator is developed which produces aritifical data, possibly with random spurious results, which can be fed to emergency assessment personnel in emergency exercises. A second computer will probably be needed for this.

CONCLUSIONS

The UKAEA UMPIRE system has been used in emergency exercises to provide information to the health physics personnel assessing offsite consequences of an airborne radioactive release. UMPIRE2 has been developed to enable monitoring data to be used to reconstruct the release and extrapolate the resulting doses to other locations.

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