CONF-9504131--1

HASCAL - A SYSTEM FOR ESTIMATING CONTAMINATION AND DOSES FROM INCIDENTS AT WORLDWIDE NUCLEAR FACILITIES

A. L. Sjoreen
Computing Applications Division
Oak Ridge National Laboratory*
P. O. Box 2008
Oak Ridge, Tennessee 37831-6236

R. Ian Sykes
Titan/ARAP
P.O. Box 2229
Princeton, New Jersey 08543

To be presented at the ANS Fifth Topical Meeting on Emergency Preparedness and Response
Aiken, South Carolina, April 1995

*Managed by Martin Marietta Energy Systems, Inc.,under contract DE-AC05-84OR21400 with the U.S. Department of Energy.

HASCAL - A SYSTEM FOR ESTIMATING CONTAMINATION AND DOSES FROM INCIDENTS AT WORLDWIDE NUCLEAR FACILITIES

Andrea L. Sjoreen
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6326
(615) 574-5333

R. Ian Sykes
Titan/ARAP
P.O. Box 2229
Princeton, NJ 08543
(609) 452-2950

SUMMARY

The Hazard Assessment System for Consequence Analysis (HASCAL) is being developed to support the analysis of radiological incidents anywhere in the world for the Defense Nuclear Agency (DNA). HASCAL is a component of the Hazard Prediction and Assessment Capability (HPAC), which is a comprehensive nuclear, biological, and chemical hazard effects planning and forecasting modeling system that is being developed by DNA. HASCAL computes best-guess estimates of the consequences of radiological incidents. HASCAL estimates the amount of radioactivity released, its atmospheric transport and deposition, and the resulting radiological doses.

I. INTRODUCTION

HASCAL, version 0.4, is based on the Radiological Assessment System Consequence Analysis[1] (RASCAL) version 2.1, which was developed for the U.S. Nuclear Regulatory Commission for the analysis of accidents at U.S. power reactors. Versions of HASCAL that run under DOS and Windows are available. At present, the major enhancements of HASCAL over RASCAL are (1) the addition of site-specific data for all power reactors in the world, (2) the addition of new source-term computation options for the new types of reactors included,and (3) the addition of the atmospheric transport model, SCIPUFF, as an alternative to the TADMOD model.

Different versions of HASCAL will be developed for different computing platforms, with calculational models appropriate for that scale of machine. For example, a portable personal computer version will be available for responding to incidents in the field; a work station version will be available for more detailed analysis and emergency planning; a super computer version will be used for research applications. So far the focus has been on the personal computer version. The DOS version of HASCAL is very similar in appearance to RASCAL 2.1. The Windows version of HASCAL has been completely rewritten so that the user interface conforms with the Windows style.

II. SITE-SPECIFIC DATA

HASCAL contains a database of all nuclear power reactors in the world. This database contains the reactor name, location, type, rated power, and keys to the inventory file and files of meteorological data, if available. More detailed data are present for U.S. reactors and are being added for non-U.S. reactors.

Files of meteorological data for the meteorological station nearest each reactor site are being added to HASCAL. These files contain 15-day mean hourly meteorology and standard variations for wind speeds. They can be read by HASCAL to provide default meteorologic conditions over the assessment period for the day and time of the incident for either the SCIPUFF or TADMOD models. This meteorological data file is required to run SCIPUFF in its probabilistic mode.

The reactor inventory files that are being added to HASCAL contain more detailed reactor inventories than are used in RASCAL. Currently, files are available for PWRs and RBMKs. These inventories were computed using ORIGEN2[2] and can be used to perform source-term calculations for reactors for which no accident scenarios have been defined, using the percentage of total inventory source-term option.

III. SOURCE-TERM CALCULATIONS

The five source-term options from RASCAL are available in HASCAL: isotopic, gross mix, plant conditions, monitor reading, and spent fuel pool. However, since several of these are specific to U.S. power reactors, two new source-term calculation options

have been added to HASCAL: (1) a percentage of total inventory by MELCOR[3] element category and (2) a prompt critical release (based on the Chernobyl accident) for RBMKs. In addition, the gross mix source-term option has been modified to use the MELCOR element categories instead of the old WASH 1400 categories, and the computed source-term table is now subdivided by MELCOR element category.

The new source-term calculation for a prompt critical accident involved one-third, two-thirds, or all of the core at operating power. The release fractions used are based on assessments of the Chernobyl accident.[3,4]

Comparisons of the doses computed using RASCAL PWR inventory vs the new inventory result in small differences, at most a factor of 2 to 3. The inclusion of short-lived radionuclides in these inventories will allow estimation of doses for very short exposures for those radionuclides for which dose factors are available.

IV. ATMOSPHERIC TRANSPORT CALCULATIONS

The inclusion of SCIPUFF in HASCAL provides the capability of probabilistic prediction of atmospheric transport. The multidimensional wind field capability allows SCIPUFF to treat longer range assessments than can TADMOD. However, wind field data are not yet available in HASCAL. SCIPUFF does not currently include building wake, while TADMOD does. The dispersion algorithm in SCIPUFF is based on second-order closure theory and is therefore very different from that in TADMOD. Also, the DOS version of SCIPUFF does not include the effects of rainfall. Differences in resulting concentration predictions from the two models can be more than an order of magnitude under extreme conditions when the atmosphere is very stable or for very light wind conditions.

SCIPUFF provides a probabilistic prediction of the atmospheric dispersion and surface deposition processes, with the capability to model multidimensional, time-dependent wind fields. Uncertainty in the wind field, including both boundary-layer scale turbulent eddies and larger scale unknown variations, leads to a random component in the concentration field which requires at least the mean value and the standard deviation for a quantitative description. SCIPUFF uses turbulence closure theory to predict the concentration fluctuation variance as a function of the wind field uncertainty,[5,6] and provides a probabilistic description of the resulting impact using a parameterized probability distribution function.[7] HASCAL can then use the SCIPUFF prediction to compute probabilistic radiological doses, and provide an assessment of likelihood for various levels of health effects. A new interactive graphics interface is used to display the SCIPUFF results from HASCAL.

V. DOSE CALCULATIONS

The dose calculations in HASCAL are designed for comparison to U.S. EPA protective action guides.[8] They are unchanged from RASCAL, except that SCIPUFF does not compute cloud shine dose. The data used for those calculations have been expanded to take into account as many radionuclides as possible from the newly calculated reactor inventories. However, only about 300 of the approximately 800 nuclides in the inventory files match with the approximately 800 nuclides in the Federal Guidance 11 and 12 reports (refs. 9 and 10, respectively). Even fewer 30-day dose factors are available.

VI. PLANNED ENHANCEMENTS

Planned enhancements to HASCAL include adding other types of radiological facilities, including research and production reactors, enrichment and storage facilities, waste processing and storage facilities, and mining and milling operations. Incident scenarios for the various types of power reactors are being developed. Additional scenarios appropriate for each type of facility will be developed, along with models of damage response and the resulting doses from various kinds of weapons attacks on worldwide nuclear facilities.

ACKNOWLEDGEMENTS

Research sponsored by U.S. Defense Nuclear Agency under an Interagency Agreement under Martin Marietta Energy Systems, Inc., contract DE-AC05-84OR21400 with the U.S. Department of Energy.

REFERENCES

1. A. L. Sjoreen, G. F. Athey, J. V. Ramsdell, and T. J. McKenna, *RASCAL Version 2.1 User's Guide*, NUREG/CR-5247 Vol. 1, Rev. 2 (ORNL-6820), U.S. Nuclear Regulatory Commission (1994).

2. A. G. Croff, *A User's Manual for the ORIGEN2 Computer Code*, ORNL/TM-7175, Oak Ridge National Laboratory (1980).

3. R. M. Summers et al., *MELCOR 1.8.0: A Computer code for Nuclear Reactor Severe Accident Source Term and Risk Assessment Analysis*, NUREG/CR-5531 (SAND 90-0364), U.S. Nuclear Regulatory Commission (1991).

3. B. Sorensen, "Chernobyl Accident: Assessing the Data," *Nucl. Safety*, Vol. 28, No.4 (1987).

4. USSR State Committee on the Utilization of Atomic Energy, "The Accident a the Chernobyl Nuclear Power Plant and its Consequences," *Working Document for the Post-Accident Review Meeting, Information compiled for the IAEA Experts' Meeting, 25-29 August 1986, Vienna, Part I. General Material*, draft (August 1986).

5. R. I. Sykes, W. S. Lewellen, and S. F. Parker, " A Gaussian Plume Model of Atmospheric Dispersion Based on Second-Order Closure," *J. Clim. Appl. Met.*, **25**, 322-331 (1986).

6. R. I. Sykes, S. F. Parker, D. S. Henn, and W. S. Lewellen, "Numerical Simulation of ANATEX Tracer Data Using a Turbulence Closure Model for Long-Range Dispersion," *J. Appl. Met.*, **32**, 929-947 (1993).

7. W. S. Lewellen and R. I. Sykes, "Analysis of Concentration Fluctuations from Lidar Observations of Atmospheric Plumes," *J. Clim. Appl. Met.*, **25**, 1145-1154 (1986).

8. U.S. Environmental Protection Agency, *Manual of Protective Action Guides and Protective Action for Nuclear Incidents*, EPA-520/1-75-001A, U.S. Environmental Protection Agency (1992).

9. U.S. Environmental Protection Agency, *Limiting Values of Radionuclide Intake and Air Concentrations and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report No. 11, EPA-520/1-88-020, U.S. Environmental Protection Agency (1988).

10. U.S. Environmental Protection Agency, *External Exposure to Radionuclides in Air, Water, and Soil*, Federal Guidance Report No. 12, EPA-402-R-93-081, U.S. Environmental Protection Agency (1993).

DISCLAIMER