RASCAL 4.0
(RADIOLOGICAL ASSESSMENT SYSTEM FOR CONSEQUENCE ANALYSIS)

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Summary – RASCAL 4.0 is a significant program update. This presentation, in four parts, highlights various aspects of the new model. The 1st by Mr. Athey, addresses relevant changes occurring in this RASCAL update. The 2nd by Mr. Ramsdell, speaks to the technical basis, and verification and validation considerations. The 3rd by Mr. Brandon provides examples of how Version 4.0 results compare and contrast with Version 3.0.5. The 4th part of the presentation by Mr. Holland illustrates how Exelon and Entergy are using the RASCAL 4.0 atmospheric transport and dispersion model by applying customized interfaces for data entry and results display for streamlined use at licensee sites.

The RASCAL beta version of 4.0 was released March 1st. Comments are solicited until May 1, 2010. The updated core inventory in 4.0 is based on a SCALE/ORIGEN run which increases the number of nuclides considered from 33 to 58. The impact is a small change to the source term, but a large improvement in post plume perspectives. Similarly, the coolant inventory has been updated to include a larger radionuclide set with a small impact to the over all activity of the source term.

Included in version 4.0 are improvements to boiling water reactor (BWR) release pathways, pressurized water reactor (PWR) steam generator tube ruptures (SGTR), and drained spent fuel pool scenarios. For a BWR release, options include an unfiltered release at a chosen release height or a filtered release through the standby gas treatment system at the stack height. SGTR leaks can now be controlled with both a leak rate and a steaming rate and can have time varying release points. Spent fuel pool scenarios are now based primarily on the age of the newest batch of fuel and decays older batches at 18 month average refueling intervals.

RASCAL 4.0 permits the export of impact plots to shapefiles for easy import as a GIS layer. A multistep example is given in the presentation. An example is also provided that shows how to overlay a RASCAL plot onto Google Earth.

In Part 2 of the presentation, Mr. Ramsdell highlights changes to the radioactive decay scheme, corrections to the monitored mixture source term option, and details the new atmospheric transport and dispersion (ATD) module. Mr. Ramsdell has devoted considerable time to the decay schemes of specific radionuclides carefully determining which daughters can be treated implicitly with the parent radionuclide and which need to be treated separately. Of the 800 isotopes in FGR 12, Appendix A, only 15 short lived radionuclides are not included in the RASCAL database. Truncation errors are generally much less than 1%. Mr. Ramsdell's work replaces three decay schemes with one in the new version and captures the update with complete documentation. These changes will not significantly affect dose or derived response level (DRL) estimates.

The monitored release source term option has been carefully analyzed to correct poor assumptions and to portray monitored particulate releases primarily as a cesium iodide release. Analysis of the activities including all radio-iodines is illustrated to show that most particulate activity is in the iodines. Cesium activity released is characterized more realistically as a very low, less than 0.4% of the total.

The new ATD modules in RASCAL 4 brings the meteorological science in RASCAL from the 1950s to the 1980s. The models have changed from distance-based dispersion parameters to time-base parameters. This is an empirical model based on the Hanford Dose Reconstruction Study. It has been validated against real world release scenarios for years, including the Mayak reactor release studies in Russia. The new dispersion parameters are larger lending to more dispersed plumes with lower centerline values. Trends are illustrated in two graphs. Deposition velocities now change with atmospheric conditions. Iodines are treated in their various forms (3 species) which have different deposition characteristics. Methyl-iodide (45%) is assumed not to deposit, so thyroid dose projections are lower. The model projections compare favorably with several examples from real incidents.

In Part 3, Mr. Brandon uses a case study to illustrate new features of RASCAL 4.0 and compare results with RASCAL 3.0.5. Screen shots are detailed enough that users following the slides can reproduce the results. For the case of a Byron Unit 2 core being uncovered for an hour, with fission products leaking through containment, examples show the differences in results as wind speed changes from 2 to 8 mph and the stability class changes from B to E. Total activities released remain very similar between the old and new versions of RASCAL, but the impact plots are significantly different. In general, where a protective action recommendation (PAR) was warranted with RASCAL 3.0.5 (i.e. 5 miles downwind) it would typically be one zone less with RASCAL 4.0 (i.e. 2 miles downwind).

RASCAL 4.0 now calculates 1^{st} , 2^{nd}, and 50 year intermediate phase doses based on projected deposition. A new feature in the Detailed Results section of RASCAL is the option to display all the radionuclide activities deposited at a specified location. Deposited activities for individual radionuclides can also be displayed.

The Effluent Releases – by Mixtures source term option now permits entering an I-131 equivalent release rate. This should facilitate less confusing analysis when NRC licensees report release rates in terms of I-131 equivalent release rates. Radionuclides are decayed in 15 minute intervals while held up in containment before release. For long release times, the activity released is significantly lower due to short half life decay.

RASCAL also has a Field Measurement (FM) to Dose module that can be used to predict DRL values for the 1^{st}, 2^{nd}, and 50 year intervals by entering a soil sample radionuclide set.

The DRL results are consistent in both RASCAL modules when using the same soil sample data. TurboFRMAC results are also consistent when using the same sample data. The FM module allows an option to decay deposition for a specified time period for temporary relocation considerations.

On the horizon, in future updates, the RASCAL team hopes to automate the retrieval and entry of meteorology data, perform validation studies comparing with other major models, build in State of the Art Consequence Analysis (SOARCA) source terms for nuclear power plants, and eventually build in source term modules for new reactor types.

For part 4, Mr. Holland discussed the benefits of using the RASCAL ATD module as the basis of a customized and standardized licensee model. The customized model can take advantage of specific inputs from the plant systems and can be made simpler to run. The customized model will focus on the release rate source term. With this approach, they can update and develop the model as needed. It allows flexibility and control in a simple model with some admirable features. Mr. Holland demonstrated the prototype of this new model for about 15 minutes.
