A Posteriori Verification and Validation of a Tritium Dispersion & Consequence Model[1]

Kevin R. O'Kula
Westinghouse Safety Management Solutions LLC
P. O. Box 5388, Aiken, SC 29804-5388
Phone: 803.502.9620
email: kevin.okula@wxsms.com

Jackie M. East and Danielle R. Marx*
Westinghouse Safety Management Solutions LLC
P. O. Box 5388, Aiken, SC 29804-5388
Phone: 803.502.9656/*803.502.9882
email: jackie.east@wxsms.com/*danielle.marx@wxsms.com

A critical aspect of the accident and consequence analyses documented in Safety Analysis Reports (SARs) and Basis for Interim Operation (BIO) reports for Department of Energy (DOE) tritium facilities are the radiological doses from atmospheric releases under postulated accident conditions. In principle, SAR-related doses are calculated applying a qualified spreadsheet or other software package using conservative inputs and user assumptions. In practice, many of the computer-based options available to DOE accident analysts are applied with incomplete software quality assurance (SQA) and little validation evidence that the model is fit for the specific applications. The analyses supporting SARs and BIOs for DOE tritium storage and processing facility operation face the same SQA issues such that results obtained with many computer models may be difficult to judge for conservatism and acceptance purposes. An American National Standards Institute (ANSI) a posteriori (backfit) process is available to provide assurance that software developed without following current qualification protocol is applied within the proper context, and has met minimum Verification and Validation (V & V) standards. The ANSI process has been applied to a special-purpose, versatile tritium dispersion model to the extent that the software is "fit" for consequence analysis of Savannah River Site and other DOE facilities, and is described in this paper.

The UFOTRI model was chosen to benchmark the limited V & V process because of its strengths in tritium-related consequence analysis. UFOTRI was developed at the Karlsruhe national laboratory in Germany to primarily support the international fusion program. Relative to most general-purpose dispersion software, UFOTRI is more applicable in the time-dependent modeling of tritium atmospheric dispersion, downwind deposition, reemission, conversion of tritium gas (HT) into tritiated vapor, and conversion of HTO into organically bound tritium (OBT). UFOTRI features an acute model of transfer processes from the postulated event (~ first one hundred hours), and a compartment module for the longer-term behavior of tritium species in the food chain. The Radiological Dispersion/Consequence Working Group of the Accident Progression and Consequence (APAC) Evaluation Project recommended UFOTRI over other software packages for deterministic safety analyses (SARs and BIOs), Environmental Impacts Statements, and probabilistic safety assessments of tritium nuclear facilities.

Six tasks defining the backfit SQA program were performed meeting the ANSI requirements. Included were:

1. An *Assessment Document* containing listing of, or reference to, technical data pertaining to existing software requirements and documentation, code source listing, test data, validation experiments and technical literature search.
2. A *Test Plan* defining tests performed and expected results, evaluation criteria, and technical bases for test data.
3. A *Configuration Procedure* defining code installation, a maintenance procedure for software/operating system modifications, test set contents and a routine testing procedure.
4. An *Error Notification Procedure* that defines user qualifications and approvals, maintenance of user and software error lists, and indicates the process for user notification.

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5. A *Comprehensive Technical Report* containing results of testing program, identifying areas of code applicability and potential limitations.
6. *SQA Qualification Report* containing completed SQA checklist, supplemental material and explanation, including software management and inventory programs interfaces.

Additionally, several comparisons are included in the full paper showing UFOTRI prediction against actual tritium release data.