August 5, 2011

MEMORANDUM TO: Brian W. Sheron, Director
Office of Nuclear Regulatory Research

FROM: Eric Leeds, Director ***/RA/***
Office of Nuclear Reactor Regulation

SUBJECT: USER NEED FOR THE INCLUSION AND APPLICATION OF A REACTOR CYCLE STEADY-STATE DEPLETION CAPABILITY IN THE SCALE CODE

This memorandum describes the Office of Nuclear Reactor Regulation (NRR) user need request to include a reactor operating cycle steady-state depletion capability in the Standardized Computer Analyses for Licensing Evaluation (SCALE) code.

Technical Background:

Currently, U.S. Nuclear Regulatory Commission (NRC) relies on the node-by-node burnup and void history distribution provided by the licensee for confirmatory analyses of nominal operating conditions. Any attempt to reproduce the vendor results requires a lumping of these nodal values, which introduces error. In addition, the initial state for a transient simulation presently uses the vendor-defined initial conditions. However, this can vary significantly from the lumped steady-state conditions to which the transient simulator would converge.

There are several recent examples where the use of the transient system analysis code suite has not met the NRC needs for steady-state core analysis. In 2006, the NRC funded Oak Ridge National Laboratory (ORNL) and Purdue University to perform an analysis of Cycles 1 and 2 of the Peach Bottom Boiling Water Reactors (BWR) using TRITON-PARCS/TRACE. The project was seriously challenging because of the burden of applying a time-dependent code to a steady-state problem and the lack of flexibility in the code to meet the analysis needs. A recent NRC effort for confirmatory analysis of the GE-Hitachi ESBWR analysis was attempted with RAMONA and later completed with RELAP5-3D, but also proved a substantial challenge because of a limited ability to provide assembly-by-assembly reactor core analysis solutions for BWRs.

Recently, NRR staff identified as a priority the quantification of the reactivity impact of various BWR inadvertent control rod withdrawal scenarios, based on the Dresden 3 event of November 3rd, 2008. During staff discussions on the formulation of this User Need, RES staff agreed that a scoping study using several different control rod combinations and core models was the best means of providing the information needed by NRR. This scoping study will be a timely and appropriate first application of the added SCALE steady state depletion capability. The results from this scoping study will help update the NRR Significance Determination Process (SDP) for shutdown operations.

Enclosure:
As Stated

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(301)415-8539

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Regulatory Application:

The new SCALE module sequence will be able to perform steady-state cycle depletions and allow for an independent generation of nodal burnup values and void fractions in the evaluations and reviews of applicant submittals. It will also ensure more accurate cross section data files for the PARCS-TRACE transient evaluation.

Following the Dresden 3 inadvertent control rod withdrawal during shutdown, NRR plans to capture the evaluation results in the NRC Instruction Manual IMC 0609, Significance Determination Process, Appendix G, Shutdown Operations.

Deliverables:

The main deliverable will consist of a new sequence within the SCALE control module TRITON that will perform cycle steady-state depletion calculations for current and new design Light Water Reactor (LWR), in full core, quarter-core, and eighth-core configurations.
This sequence will be able to also support advanced and next generation reactor designs, if needed, with little modification. The steady-state function will be added as a “plug-in” feature to allow the user to choose between the default reactor physics code (NESTLE) or an equivalent code such as PARCS. The new SCALE sequence will have the SCALE code features and graphics user interface (GUI) that are common to the current sequences which support faster and easier problem definition, input file generation, and automated serial execution of the various codes required to perform the calculations.

The BWR inadvertent control rod withdrawal study will be the topic of a technical report that will document the application of the new SCALE function. This study will include calculations at several cycle exposures using a representative high reactivity core. These calculations shall include enough combinations of control blades to allow for conclusions to be drawn regarding possibility of inadvertent criticality and/or prompt criticality following unplanned control blade withdrawal. The results should be presented in a format (ideally a graphical format) which will allow risk analysts to quickly derive the reactivity impact of a combination of control cell exposure and the number of control blades withdrawn.

The associated documentation will consist of a user’s manual and a theory manual the content of which will be consistent with the SCALE code documentation standards.

An initial hands-on training will be provided to NRR staff, preferably at the NRC Professional Development Center to avoid travel expenses, and will use actual BWR and PWR fuel designs and core loading patterns. Subsequent training sessions will be arranged per additional acquisition requests.

Schedule:

RES support is expected to be provided for approximately 18 months on an as needed basis depending on identified issues during the review of an application.

Priority:

This request is of high priority to ensure a timely safety significance determination of the reactivity impact of inadvertent control blade withdrawal and to support near term licensing actions.

Points of Contact:

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