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Computer Code Qualification Program for the Advanced CANDU Reactor

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INTRODUCTION

Atomic Energy of Canada Ltd (AECL) has developed and implemented a Software Quality Assurance program (SQA) to ensure that its analytical, scientific and design computer codes meet the required standards for software used in safety analyses. This paper provides an overview of the computer programs used in Advanced CANDU Reactor (ACR^{TM}) safety analysis, and assessment of their applicability in the safety analyses of the ACR design. An outline of the incremental validation program, and an overview of the experimental program in support of the code validation are also presented. An outline of the SQA program used to qualify these computer codes is also briefly presented. To provide context to the differences in the SQA with respect to current CANDUs, the paper also provides an overview of the ACR design features that have an impact on the computer code qualification.

ADVANCED CANDU REACTOR DESIGN

The Advanced CANDU Reactor is an evolutionary advancement of the current CANDU 6 reactor [1], aimed at producing electrical power for a capital cost and at a unit-energy cost significantly less than that of the current reactor designs. The ACR reactor retains the modular concept of horizontal fuel channels surrounded by a heavy water moderator, as with all CANDU reactors. However, ACR uses slightly enriched uranium (SEU) fuel, compared to the Natural uranium (NU) used in CANDU 6. This achieves the twin goals of improved economics (via large reductions in the heavy water moderator volume and replacement of the heavy water coolant by light water), as well as improved safety.

This paper provides an overview of the ACR design innovations that have an impact on the computer code applicability and validation.

SAFETY ANALYSIS REQUIREMENTS

The ACR Software Quality Assurance program is based on the CSA N286.7-99 standard [2], which specifies the requirements for quality management systems applicable to the design, development, maintenance, modification and use of computer programs in nuclear power plant applications. It is summarized in Fig. 1.

A high level identification and ranking of governing phenomena for major plant accidents establishes the basis for the computer code validation process for ACR safety analysis [3]. The identification and ranking of phenomena is based on a set of major accident categories and event sequences, the safety concerns associated with the phases of the accidents, and the impact of the associated governing processes and phenomena on the identified safety concerns.

This paper reviews the classification and ranking of fundamental physical phenomena that are relevant for code validation for ACR safety analysis applications. A summary of the process of identification and ranking of the phenomena for the ACR and its application to large LOCA events is presented in this paper, including an outline of the technical basis for computer code validation for ACR safety applications [4].

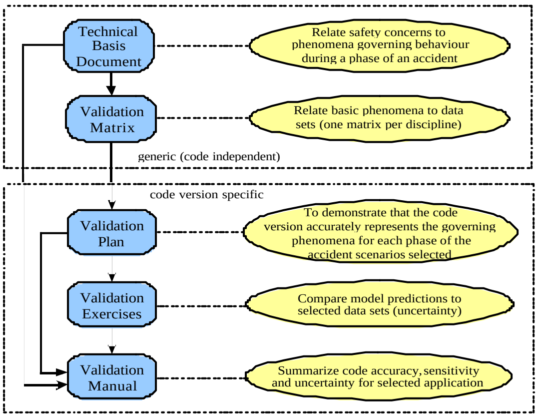

Fig. 1. Computer Code Validation Process

SAFETY ANALYSIS CODE ASSESSMENT

The computer codes that are validated and used for safety analyses of the CANDU 6 plants are also generally applicable to the ACR safety analysis.

A systematic assessment of computer code applicability to ACR applications was performed covering important aspects of the computer code structure, models, constitutive correlations, validation database, etc [3]. Some computer codes are applicable to ACR with no changes, and some codes require minor adjustments and upgrades to match ACR design-specific features and conditions. A few of the computer codes require modifications and experimental database extensions. This paper provides an outline of the computer codes, and an assessment of their applicability to the ACR safety analysis.

CODE VALIDATION

Most of key phenomena associated with the safety analyses of ACR are common with those in the current CANDU 6 design. A Technical Bases Document for validation of computer programs for ACR application was prepared [4]. It identifies and ranks the key phenomena that are important for validation of ACR computer programs.

The objective of the Validation Matrix documents is to cross-reference the key phenomena for each accident scenario against the applicable data sets for validation.

A set of Validation Matrix documents for validation of the computer codes used in the safety analysis of the CANDU 6 reactor has already been developed, and the computer codes used for safety analysis of CANDU 6 have been validated.

Review of CANDU 6 Validation Matrix documents against the ACR design, and preparation of the ACR-specific Validation Matrix documents [5] that address the new ACR design features are covered in this paper. This paper outlines the plan for incremental validation of the ACR computer codes, and summarizes some key experiments planned and in progress in support of this validation.

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