Computer Code Abstract

CRTA — A Computer Program for Fast Reactivity Transient Analysis in Light Water Research Reactors

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1. Program Identification: The CRTA code[1] is developed for safety analysis and dynamic studies of light water research reactor cores.

2. Description of the Problem Solved: The CRTA code is specially tailored to predict detailed behavior of reactor transients initiated by rapid local changes in reactivity, such as rod-ejection accidents. The code kinetics model is based on a numerical solution of a set of two-group, space- and time-dependent diffusion and precursor equations coupled with transient thermal-hydraulic calculations.

   The core is schematically represented, in cylindrical geometry, by a fuel zone representing one or more homogeneous regions of different fuel compositions and a reflector zone representing the axial and radial reflectors surrounding the reactor core. The control elements are represented by one or several rings that can be moved upward or downward along the axial direction.

3. Method of Solution: The CRTA code uses a two-step method to solve a set of two-group, two-dimensional, and time-dependent diffusion equations and of a maximum of six delayed neutron precursor group equations. The first step is a finite difference numerical solution of a system of two-dimensional elliptic partial differential equations.[2] The second step is an integration with respect to time of the obtained equations using a two-step diagonally semi-implicit Runge Kutta algorithm (Makinson formula).[3]

   A simple model is used in the CRTA code to evaluate coolant thermal-hydraulic parameters. This model ignores coolant boiling and assumes the coolant to go only once through the reactor core in the axial direction. The CRTA code was used to analyze one protected reactivity transient in the International Atomic Energy Agency 10-MW benchmark core.[4,5] Further assessment studies that use experimental data are in progress.

4. Related Material: No additional programs are required.

5. Restrictions: The code uses a thermal-hydraulic model based on a unique single-phase heat transfer correlation. In general, this may considerably affect the calculations; however, for most projected applications of the CRTA code, boiling could reasonably be ignored because of its taking place very late in the transient time scale.[5]

6. Special Features of the Program: The diagonally semi-implicit Runge Kutta algorithm used for time integration of the neutron kinetics equations is a direct (noninteractive), rapidly converging and A-stable numerical scheme. This latter has shown a net superiority over the standard accelerated inner-outer numerical method used in some codes, such as RETRANS (Ref. 6).

7. Computers: The code was developed on a VAX-4000 workstation.

8. Running Time: The running time depends essentially on the core-grid dimension and on the time step selected by code users.

9. Machine Requirements: Minimum space required is ~750 kilobytes.

10. Program Language: FORTRAN 77.

11. Operating System: VMS.

12. Additional Programming Information: The code requires at least two logical units for input and output files. An optional thermal-hydraulic table can be given in a third logical unit or inserted into the input file.

13. Material Available: A referenced report and a floppy disk containing a source file, a sample problem, and its related output file. The material is available from the Centre de Radioprotection et de Sûreté, 02 Bd Frantz Fanon, BP 1017 Alger-gare, Algeria or from the authors.

14. References:

[1]B. BAGGOURA and K. IBRAHIM, "C.R.T.A. — A Program for Fast Reactivity Transient Analysis in Light Water Research Reactors," Centre de Radioprotection et de Sûreté Internal Technical Report (1993).

[2]S. NAKAMURA, *Computational Methods in Engineering and Science*, Wiley-Interscience, New York (1977).

[3]J. DEVOOGHT and E. MUND, "Numerical Solution of Neutron Kinetics Equations Using A-Stable Algorithms," *Prog. Nucl. Energy*, **16**, *2*, 97 (1985).

[4]"Research Reactor Core Conversion from the Use of High Enriched Uranium to the Use of Low Enriched Uranium Fuel Guide Book," I.A.E.A-TECDOC-233, International Atomic Energy Agency (1980).

[5]*I.A.E.A Safety and Licensing Guide Book of Research Reactor Core Conversion from the Use of High Enriched Uranium to the Use of Low Enriched Uranium*, Vol. 3, Appendices G–H, International Atomic Energy Agency, Vienna (1990).

[6]G. KAMELANDER et al., "RETRANS – A Program for Calculating Reactivity Transients," OFZS-Ber N° 4287, RS-242/84, Osteerreich Forschungs Zentrum Seibersdorf (1984).