COMPUTER CODE ABSTRACT

Name of Code: RETRAN-3D MOD004.7.1

Computers for Which Code is Designed

The RETRAN-3D code is designed to operate on any workstation or personal computer that supports a Fortran 95 compiler and a minimum of 32 MB of real memory. Large 3-D kinetics problems may require at least 256 MB (or more). RETRAN-3D is supported on Windows 7 and 8 personal computers and workstations running the Red Hat Linux operating system.

Nature of Problem Solved

RETRAN-3D is a transient thermal-hydraulic analysis code designed for use in best-estimate evaluation of light water reactor systems. It is an extension of the RETRAN-02 program and is designed to provide analysis capabilities for (1) BWR and PWR operational transients, (2) small break loss-of-coolant accidents, (3) extended loss of all power (ELAP) transients, (4) anticipated transient without scram, (5) long-term transients, (6) transients with thermodynamic nonequilibrium phenomena, (7) mid-loop operation with noncondensable gas present, (8) transients where three-dimensional power shapes and reactivity feedback effects are important, and (9) BWR stability events. RETRAN-3D also retains the analysis capabilities of RETRAN-02.

There are three basic formulations of the field equations for the user to choose from. They are;

- a five-equation thermodynamic nonequilibrium option which uses the mixture momentum, continuity, and energy equations along with a slip model and the vapor continuity equation;
- a four-equation equilibrium thermodynamics option which uses the mixture equations and a slip model; and
- a three-equation option which uses the mixture equations.

A gas continuity equation can be added to any of the three options described above to allow noncondensable gas to be included as a separate constituent.

The heat generation in a nuclear reactor core can be modeled using 3-D, 1-D, or point reactor kinetic models. Component and auxiliary models allow for complete modeling capability for the nuclear steam supply system including controls.

The code has been reviewed by the NRC and approved for use in licensing submittals. The NRC Safety Evaluative Report is included in Volume 1 of the documentation.

Solution Methods

Steady-state and transient solutions of the field equations are provided. Both schemes solve the coupled set of governing equations using fully implicit methods. Linear and nonlinear methods are available for the transient solution which also includes a number of algorithms to provide time-step size control.

The 3-D kinetics model uses the analytic nodal method and a numerical solution developed at Purdue University (Purdue Numerical Method - PNM). The quasi-static 1-D kinetics option and the point kinetics model are the same as those in RETRAN-02.

Restrictions on the Complexity of the Problem to be Analyzed

The limitation on the complexity of a problem is based on the amount of main memory storage available at execution time. This will vary from one platform to the next and will depend on the amount of random access and virtual memory available, as well as system configuration parameters. There is no fixed limit, although a practical limit is a system model with a 3-D kinetics core model with 24 axial nodes and three or four hundred core channels. The program memory space is dynamically allocated at execution time based on the size of the problem being run.

Typical Running Times

The running times required to analyze a particular transient with RETRAN are dependent on the detail of the model, the type of event to be analyzed, and the computer performing the calculation. Run times for a set of sample problems are provided with the code transmittal.

Features of the Code

RETRAN-3D has options to use the following features;

- unequal phasic velocities;
- thermal nonequilibrium;
- noncondensable gas;
- linear and nonlinear implicit solution of transient field equations;
- implicit solution of the steady-state field equations;
- low power implicit steam generator initialization;
- steady-state flow splits;
- off-rated condition steady-state initialization procedures;
- nondiffusive solution option;
- implicit two-surface heat conduction model;
- models for 3-D, 1-D, and point reactor kinetics;
- a channel model to simplify input for 3-D kinetics models;
- trip logic and control system models;
- forced and free convection heat transfer;
- condensation heat transfer;
- flow and pressure boundary conditions;

- component models for pressurizers, steam separators, centrifugal pumps, valves, and accumulators;
- special purpose models for modeling the movement of a temperature front or impurities;
- BWR leakage flow models;
- part-length fuel rods with water rods;
- automated data interface with VIPRE-01;
- plot data file.

The equation-of-state properties are generally valid between 0.1 psi and 6000 psi, allowing for the analysis over a wide range of operating conditions.

The user has control of the frequency and type of edit information generated. Restart capability is provided to archive solution information on a data file for later use in restarting a calculation or to plot or edit results from a previous calculation.

Code Documentation

The documentation for RETRAN-3D is provided in a four-volume code manual published as EPRI Report NP-7450(A). The content of these volumes is:

1. Theory and Numerics (Revision 10)	discusses the theoretical development of the general equations, the constitutive relationships, and numerical solution techniques. This volume also contains the NRC SER.
2. Programmer's Manual (Revision 10)	presents the general coding philosophy, code installation and maintenance instructions, descriptions of the code modules, subroutines and data files, and information on auxiliary programs that can be used with the code.
3. User's Manual (Revision 10)	provides the input data requirements and sample problem input and typical output data for each of the RETRAN modules.
4. Applications Manual (Revision 9)	describes the verification and validation analyses used to qualify the code for various applications.
5. Modeling Guidelines	provides modeling guidelines for specific plant types, physical phenomena, and transient type.

Code Modules and Support Programs

There are three modules in the RETRAN-3D code package, RETRAN, RESTRT and REEDIT. In addition to these modules, two other programs, COMPARE and BXFGEN are included in the code transmittal package. These modules and programs are described in the following.

RETRAN	-	The base code module that processes initial input data and provides the routines for the physical models in the code and the logic for the solution of these models.
RESTRT	-	The program module used to continue a RETRAN calculation.
REEDIT	-	The program module used to produce printed edits of data archived from a RETRAN or RESTRT calculation.
COMPARE	-	The program used to verify the installation of RETRAN-3D by comparing output from the installed code against a baseline data file.
BXFGEN	-	The program used to convert the cross-section files used with the 3-D kinetics option from the ASCII form included on the transmittal to the binary form used for execution.
get_R3D_plot_vars	-	A program used to strip plot variables from a RETRAN-3D plot file and write them to a new output file.

Computer System Requirements

Computing system requirements for using RETRAN involve memory storage and data input, output and archive functions. The base code requires approximately 7 MB of memory for the program and an additional 10-20 MB for data storage is sufficient for problems on the order of 200 volumes, 250 (without the multidimensional kinetics option). When the multidimensional kinetics option is used, 50-200 MB of data storage are used (additional space may be required for large problems).

The minimum memory requirement is 128 MB when the 3-D kinetics option is used; otherwise, 32 MB is required. The recommended values are 256MB and 64 MB, respectively.

RETRAN-3D uses disk storage for the input and output data files. Input data files typically require less than 300 Kbytes of disk space. The output data files can be very large if the user requests frequent output edits and has a large problem, e.g., one using 3-D kinetics. Archived data files are usually stored on disk devices. It is recommended that 1 to 5 GB of storage be available. Three-dimensional kinetics problem output files can be very large.

Programming Language Used

The RETRAN-3D source code is written in ANSI standard Fortran 95 and is portable to a number of different platforms. A Fortran 95 compiler is required to install the program from source. RETRAN-3D uses a single source code library that may be subdivided into subdirectories to facilitate locating various types of source code, e.g., subroutine, module, and interface source code.