20A ODYNA/REDYA

This appendix is provided in response to Question 440.13 which requests a description of the ODYNA/REDYA changes from ODYNA/REDYA.

The ODYNA changes are presented in Section 20A.1. The REDYA changes are presented in Section 20A.2. Verification of the code modifications is addressed in Section 20A.3. Topic sections are arranged alphabetically by title.

All ODYNA changes are categorized as: (1) a required ABWR feature; or (2) a general code improvement.

All REDYA changes are categorized as: (1) an upgrade to make REDYA similar to ODYN; or (2) a general code improvement.

20A.1 ODYNA Changes

20A.1.1 ECCS

ABWR Required Changes

Two additional emergency core cooling systems (ECCS) are added to the existing systems:

(1) High pressure core flooder system 2 (HPCF-2)

(2) High pressure coolant flooder downcomer injection (HPFL-ves)

General Improvements

Each ECC system has separate characteristics such as automatic trip-on/off setpoints, flow rates and flow resistance functions. Any of the ECC systems may be modeled as a low pressure system as an option.

20A.1.2 Pressure Distribution

ABWR Required Changes

With two high pressure core flooder systems (HPCF-1 and HPCF-2), the core and upper plenum may become subcooled. Therefore the core/upper plenum (node 1) pressure rate has been generalized to accommodate a completely subcooled node 1 region.

General Improvements

A more detailed pressure distribution is implemented by breaking large flow paths into smaller pieces. For consistency with other computer codes, the following small changes were made:

(1) The definition of node 1 (core/upper plenum node) average pressure is moved from the center of the upper plenum to the core exit.

(2) Channel and bypass regions are included in the node 1 pressure rate equation.

(3) The bulkwater/downcomer region, L/A, is a continuous function of level.

20A.1.3 Recirculation System

ABWR Required Changes

The jet pump model was replaced with an internal pump model and controller. The new recirculation model has the following characteristics:

The internal pumps are modeled as induction motors with fixed impellers. The impeller speed may be limited to prevent reverse rotation. The internal pumps are separated into three groups, each group is called a “loop” and each loop operates as a unit.

There may be any number of pumps in a loop. Each loop may have different characteristics such as inertia, rated speed and controller settings. The pump flow model (one for each loop) allows forward or reverse flow. The pump head and hydraulic torque resistance characteristics are implemented as two-dimensional tables of pump speed and flow. Pump dynamic friction, static friction (stiction), seizure and windage resistance are accounted for separately in each loop.

Recirculation pump trip (RPT) actions are separate for each loop and include automatic RPT on low level, high pressure, turbine trip and load rejection. Automatic speed demand runback (recirculation runback) following low sensed level in conjunction with a feedwater pump trip is implemented separately for each loop.

Each loop may be initialized (i.e. its condition at the start of the transient simulation) as tripped, in manual speed control or in automatic speed control. As a consequence, the flow and speed in each loop may be different on initialization.

The internal pump control system is a proportional, integral, differential (PID) type and operates on pump speed feedback. Each of the three speed controllers receives a common demand from the master recirculation controller (the master recirculation controller signal may be modified by a PID Flux controller and/or a PID flow controller as a option).

The solid-state frequency inverters (one for each loop) are modified as general second-order transfer functions with non-linear function generators.

20A.2 REDYA Changes

20A.2.1 Automatic Trip Logic

Changes for ODYN Similarity

Automatic high level trip of feedwater pumps, turbine stop valves and scram have been included. (The same models are implemented in the NRC approved version of ODYN.)

20A.2.2 Bulkwater

Changes for ODYN Similarity

Variable steam quenching efficiency for exposed feedwater flow is included. The downcomer enthalpy delay corrects for variable liquid density and level. (The same quenching capabilities are implemented in the NRC approved version of ODYN, the enthalpy delay is implicit in the ODYN nodalized bulkwater region.)

20A.2.3 Boron

Changes for ODYN Similarity

Anticipated transients without scram (ATWS) modeling capability is added which includes models for boron concentration in the vessel and core, and the corresponding reactivity worth of boron in the core. The boron injects into the lower plenum and is transported into the core. The boron concentration model allows for variable mixing efficiency based on vessel flow. Boron stratification or settling and flow rate dependent remixing of settled boron is included. (The same capabilities are implemented in the NRC approved version of ODYN but in much greater detail.)

20A.2.4 Core Bypass

Changes for ODYN Similarity

The reactor core bypass region is now treated as a lumped node. Two pressure drop driven leakage flow paths are included, (1) lower plenum to bypass and, (2) lower tie plate to bypass. Energy deposition is from gamma heating and conduction across the channel wall. The bypass liquid expansion due to density change is accounted for (optional). Bypass flow may be forward or reverse. (The NRC approved version of ODYN also has a separate bypass model with pressure drop driven bypass flow.)

20A.2.5 Decay Heat

Changes for ODYN Similarity

Two (optional) additional decay heat groups are added to the 1 existing group. This allows more accurate modeling of decay fractions with short, medium and long half-lives. (The NRC approved version of ODYN has a maximum of 5 decay heat groups.)

20A.2.6 Edits

General Improvements

The steady-state initial condition edits have been expanded. The final peak value edits have been expanded.

20A.2.7 ECCS

Changes for ODYN Similarity

The REDYA ECCS model is the same as described in Section 1.1 for ODYNA except that one additional system is modeled:

(1) High pressure coolant flooder, core-by-pass injection (HPFL-byp).

20A.2.8 Lower Plenum

General Improvements

Liquid expansion due to density changes is included (optional). An arbitrary liquid injection/expulsion flow is included (optional). (Not included in ODYN.)

20A.2.9 Pressure Distribution

Changes for ODYN Similarity

A more detailed pressure distribution is implemented by breaking large flow paths into smaller pieces. The following changes have been made:

(1) The definition of node 1 (core/upper plenum node) average pressure is moved from the center of the upper plenum to the core exit.

(2) Subcooled channel and bypass regions are included in the node 1 pressure rate equation.

(3) The bulkwater/downcomer region L/A is a continuous function of level.

(4) The pressure drop due to density changes in the acceleration term is calculated.

(5) Subcooled downcomer region is included in the dome/bulkwater node (node 2) pressure rate equation.

(Items 4 and 5 are included in the NRC approved version of ODYN, items 1, 2 and 3 are included in ODYNA.)

20A.2.10 Recirculation System

Changes for ODYN Similarity

The REDYA recirculation system model is the same as described in Section 1.3 for ODYNA except that the optional flux and flow controllers are not implemented.

20A.2.11 Relief Valves

Changes for ODYN Similarity

The relief valve model has been changed to allow independent setpoints for each of up to 25 valves. The Moody homogeneous two-phase critical flow correlation is used to calculate relief valve flow. (The same model is implemented in the NRC approved version of ODYN.)

20A.2.12 Steamline

Changes for ODYN Similarity

An eight-node momentum coupled steamline model is included as an option. (The same model is implemented in the NRC approved version of ODYN.)

20A.2.13 Turbine/Pressure Controls

Changes for ODYN Similarity

A notch filter is added to the normal and feedback pressure controllers for steamline (acoustic resonance) compensation. (The same model is implemented in the NRC approved version of ODYN.)

20A.3 Verification of Code Modifications

In accordance with GE Nuclear Energy Engineering Operation Procedure (EOP) 40-3.00, Engineering Computer Programs (ECP's) must undergo independent design verification prior to approval for design application (Level 2 status). Validations consist of comparisons to data or alternate methods and user testing. These comparisons are then reviewed by a design review team for independent design verification, consistent with EOP 42-6.00.

The independent design verification thus consists of a verification of the calculated response to assure correctness, rather than a review of the ECP coding changes. A review of the ODYNA and REDYA models has confirmed that these requirements were properly followed for these ECPs.