Westinghouse

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Westinghouse 3D Accident Analysis Program

RAVE Methodology Development Program

NRC/Westinghouse Meeting
Rockville, MD
March 2004

Westinghouse 3D Accident Analysis Program

- Agenda
  - Overview and Purpose
  - Computational Methods
  - Sample Applications
  - Applicability to Various Plant Types
  - Objectives/Schedule
  - Summary

Overview

- RAVE – An integrated non-LOCA analysis methodology based on NRC approved codes
  - RETRAN-02 (Westinghouse version)
  - ANCK (SPNOVA)
  - VIPRE-01 (Westinghouse version)

- Primary objective is to develop methods for a more realistic, yet conservative, analysis (i.e., by reducing inconsistent assumptions) to better understand safety margins

- Representative limiting transients modelled to demonstrate methodology and applicability

Overview

- Changes compared to current non-LOCA methodology:
  - Integrated data transfer among codes
  - Consistent assumptions of some transient parameters
  - 3D core kinetics

- Not changed compared to current methodology:
  - Acceptance criteria and design basis
  - Bounding analysis approach
  - DNB subchannel and statistical design methodology
  - WCAP-9272 reload safety evaluation methodology

- [ ]a, c

Overview

- The objective of the program is to link existing computer codes to reduce inconsistent assumptions and perform more realistic transient calculations
- The first phase of the program was the 3D Rod Ejection methodology, which was approved by the NRC in 2003
- This phase will link the NSSS systems code to the neutronic and thermal hydraulic codes
- Submittal of the topical to the NRC is planned for [ ] a, c

Enhancements of 3D Methods (Compared to Point Kinetics)

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Computational Method - Codes

- SPNOVA (ANCK) 3D Core Neutronics Code

[ ] a, c

- SPNOVA code report (WCAP-12394-P-A) received NRC approval in 1991 (approved for application to core reactivity transients)

Computational Method - Codes

- VIPRE-01 3D Core Thermal-Hydraulics Code

[ ] a, c

- Westinghouse methodology for use of VIPRE model presented in report WCAP-14565-P-A, received NRC approval in 1999

Computational Method - Codes

- RETRAN-02 RCS Thermal-Hydraulics Code

[ ] a, c

- Westinghouse methodology for use of RETRAN-02 presented in report WCAP-14882-P-A

- NRC approval received in 1999 for applicability to all Westinghouse 2-, 3- and 4-loop plants

Computational Method - Data Transfer

- Data is transferred between codes by an external communication interface
- Modifications were made to codes only to effect data transfer; [ ]a,c
- Codes can be run either stand-alone or in the linked mode (Westinghouse does not maintain two versions of the codes)
- Data transfer method was reviewed during the NRC review of the Westinghouse 3D Control Rod Ejection methodology topical, WCAP-15806-P-A
- WCAP-15806-P-A approval was received in 2003 for applicability to all Westinghouse plants

Code Interfaces – Core Model

a, c

Code Interfaces – Core-RCS Loop Model

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Application Topical Outline

- Introduction/Purpose

- Generic Models
  - Reactor Core Model (SPNOVA/VIPRE-01)
  - Reactor Plant Model (RETRAN-02)
  - Hot Rod Model (VIPRE-01)
  - Initial Conditions/Assumptions
  - Application of Conservative Allowances
  - Applicability to Various Plant Types
  - Reload Safety Evaluation Method

- Sample Applications
  - Complete Loss of Flow Event
  - Locked Rotor Accident (DNB)
  - Locked Rotor Accident (Overpressure)
  - Steamline Break Accidents (HFP/HZP)

Application Topical Outline

- For Each Event
  - Description of the Event
  - Reactor Protection and Limits
  - Current Analysis Method
  - Revised 3D Core Neutronics Analysis Method
  - Comparison of Results to Current Analysis Method
  - Reload Safety Evaluation Method
  - Sensitivity study performed to verify selection of conservatisms

Application Benchmark

- Currently Performing OECD/NRC/PSU PWR Main Steam Line Break Benchmark Problem
  - Phase 1 – Point Kinetics Simulation
  - Phase 2 – Coupled 3D Neutronics/T&H Evaluation of Core Response
  - Phase 3 – Best Estimate Coupled Core-Plant Transient Model

Applicability to Other Accident Events

- Events chosen to demonstrate applicability to severe accidents
- Applicability to severe reactivity insertion event (RCCA Ejection) already approved by NRC
- Ability of individual codes to model all non-LOCA FSAR events has not been affected
- Methodology is applicable to other less-severe events

NRC R.G. 1.70 Accident Events

- Increase in Heat Removal by Secondary System
  - Feedwater Malfunctions Causing a Decrease in Feedwater Temperature (II)
  - Feedwater Malfunction Causing an Increase in Feedwater Flow (II)
  - Excessive Increase in Secondary Steam Flow (II)
  - Inadvertent Opening of a SG Safety or Relief Valve (II)
  - Steam System Piping Failure (III & IV) *(Analyzed as Condition II)*

- Decrease in Heat Removal by Secondary System
  - Loss of Electrical Load and/or Turbine Trip (II)
  - Loss of Non-Emergency AC Power (II)
  - Loss of Normal Feedwater (II)
  - Feedwater System Pipe Break (IV)

- Decrease in Reactor Coolant Flow Rate
  - Partial Loss of Forced Reactor Coolant Flow (II)
  - Complete Loss of Forced Reactor Coolant Flow (III) *(Analyzed as Condition II)*
  - RCP Shaft Seizure (with & w/o Loss of AC Power) (IV)
  - RCP Shaft Break (IV)

NRC R.G. 1.70 Accident Events

- Reactivity and Power Distribution Anomalies
  - Uncontrolled RCCA Bank Withdrawal from a Subcritical Condition (II)
  - Uncontrolled RCCA Bank Withdrawal at Power (II)
  - RCCA Misoperation (RCCA Misalignment, Rod Drop (II), Single Rod With. (III))
  - Startup of an Inactive Reactor Coolant Loop (II)
  - Uncontrolled Boron Dilution (II)
  - Inadvertent Loading of a Fuel Assembly in an Improper Location (III)
  - Spectrum of RCCA Ejection Accidents (IV)

- Increase in Reactor Coolant Inventory
  - Inadvertent ECCS Actuation at Power (II)
  - CVCS Malfunction Causing an Increase in Reactor Coolant Inventory (II)

- Decrease in Reactor Coolant Inventory
  - Inadvertent Opening of a Pressurizer Safety or Relief Valve (II)
  - Steam Generator Tube Failure (IV)
  - Loss of Coolant Accident (IV)

Applicability to Various Plant Types

- This methodology will be applicable to various plant types (Westinghouse fleet and possibly others) and is consistent with the WCAP-9272 reload safety analysis methodology

- This methodology has the same modelling capabilities and limitations as the individual "backbone" codes

- If the backbone code is appropriate for modelling a given characteristic or feature; then use of that same code in the linked format is also appropriate

- ANC/VIPRE/RETRAN-02 code models have already been developed and used for the CE-designed [ ] [a,c] plant

Licensing Schedule

- Topical report submittal to the NRC is anticipated in [ ] a,c
- Westinghouse would like approval by [ ] a,c to support anticipated fuel upgrade and uprating submittals in [ ] a,c
- Westinghouse would support interactive dialogue during the review process to facilitate review of the methodology

Summary

- The RAVE methodology links NRC-approved computer codes to improve the consistency of the assumptions
- The methodology is an extension of that already approved for 3D Rod Ejection
- Topical submittal is anticipated in [ ] a,c

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