Safety Analysis Approach for ACR

Part 1: Bases

By Massimo Bonechi

Manager, Safety Engineering, ACR Development

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Overall Outline

- **PART 1, Bases (this presentation):**
  - Event categorization into design basis accidents, severe accidents and severe core damage accidents
  - Classes of events within each category
  - Major events in categories/classes
- **PART 2, Application (next presentation):**
  - Acceptance criteria and targets for categories/classes of events
  - Walk through examples of application of event classification and acceptance criteria and targets for a few major events

General Approach

- Key to the safety analysis approach is the definition and classification of events in and beyond the design basis of the plant
- ACR analysis approach is founded on the risk-based objective:
  - The most probable occurrences should yield the least radiological consequences, and situations having the potential for the greatest consequences should be least likely to occur

General Approach

- **ACR approach:**
  - adopts five classes of events with associated radiological dose limits
  - adopts acceptance criteria and targets that are based on safety margins increasing with the likelihood of the events in a class
  - uses assumptions and methods that provide a good balance between the need for conservatism at the higher event likelihood end of the classification and the reasonableness of a design centered assessment at the lower likelihood end.

General Approach

- The radiological limits for the five classes of events are those of CNSC Consultative Document C-6 Rev. 1.
- Initiating events are identified through a systematic review of the plant design
- The approach is consistent with international standards

Event Classification

- Three categories of events for ACR
  - Design basis events
  - Severe accidents
  - Severe core damage accidents

Design Basis Events

- **Design basis events are events which must be accommodated by the plant design within specified limits of the radiological dose to the public and of the key barriers to the release of radioactivity to the environment:**
  - **Fuel**
  - **Reactor Coolant Pressure Boundary**
  - **Containment**
- **Analyze the plant response to design basis events using conservative assumptions and detailed models**
- **Safety analysis for Design Basis Events assumes single failure in the aggregate of mitigating systems**

Design Basis Events

- Three event classes in the design basis event category:
  - Class 1: events of moderate frequency
  - Class 2: infrequent events
  - Class 3: limiting events
- Classification is consistent with that in NRC RG 1.70 Rev. 3

Examples of Design Basis Events

Class 1: Events of Moderate Frequency

- Loss of Pressure and Inventory Control
- Loss of Secondary Circuit Pressure Control
- Loss of Reactivity Control
- Total Loss of Class IV Power*
- Single Reactor Coolant Pump Trip
- Moderator Events (except pipe ruptures)
- Loss of normal SG feedwater flow

* Class IV Power is the station's normal AC power supply

Examples of Design Basis Events

- Class 2: Infrequent Events
  - Pressure Tube Failure (calandria tube intact)
  - Small LOCA
  - End Fitting Failure
  - Off-Stagnation Feeder Break
  - Feedwater Pipe Break
  - Moderator Events (pipe ruptures)
  - Partial Single Channel Flow Blockage
  - Steam Generator Tube Rupture

Examples of Design Basis Events

- Class 3: Limiting Events
  - Large LOCA
  - Main Steam Line Break (inside containment)
  - Reactor Coolant Pump Seizure
  - Pressure Tube / Calandria Tube Failure

Severe Accidents

- Severe accidents are more improbable events beyond the design basis which must be accommodated within specified radiological dose limits to the public
- Class 4 and 5 generally include combinations of events, in particular combinations of initiating events and total failure of a safety system. The two classes have different radiological dose limits associated with them.
- Targets on the performance of the barriers against the release of radioactivity may be set to facilitate meeting the dose limits
- Analyze severe accidents using design centered assumptions and detailed models

Examples of Severe Accidents

Class 4/5:

- Small LOCA + LOECC
- End Fitting Failure + LOECC
- Large LOCA + LOECC
- Pressure Tube / Calandria Tube Failure + LOECC
- Single Steam Generator Tube Rupture + LOECC
- Stagnation Feeder Break
- Severe Channel Flow Blockage

Radiological Dose Limits

(from CNSC C-6 Rev.1)

Requirements	Event Class				
	1	2	3	4	5
Effective dose (mSv)	0.5	5	30	100	250
Lens of the eyes (mSv)	5	50	300	1,000	1,500
Skin (mSv, averaged over 1 cm^2)	20	200	1,200	4,000	5,000

Severe Core Damage Accidents

- Severe core damage accidents are extremely improbable events beyond the design basis, which lead to loss of core geometry.
- Target is to have very low cumulative frequencies of severe core damage and large release.
- Analyze severe core damage accidents using design centered assumptions and integral models
- Analyses will be done as part of the Level 2 PRA
- Example of major severe core damage accident is
  - LOCA + LOECC + unavailability of moderator heat sink

Global Approach to Event Analysis

Event Category	Analysis Assumptions	Analysis Models	Acceptance Criteria	Targets
Design Basis Events (Classes 1,2 and 3)	*Conservative*	*Detailed*	*Performance Criteria – Radiological Doses*	*Performance targets*
Severe Accidents (Classes 4 and 5)	*Design Centered*	*Detailed*	*Radiological Doses*	*Performance Targets*
Severe Core Damage Accidents	*Design Centered*	*Integral*		*Frequencies of Severe Core Damage and Large Release*

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