AP1000
As-Designed Pipe Rupture Hazards Analysis (PRHA)

Westinghouse Electric Co.

Meeting with NRC

May 20, 2009

Agenda

A. Objectives of as-designed pipe rupture hazards analysis
B. Outline and scope of as-designed PRHA report
C. Overview of criteria and methods
D. Schedule
E. Review of progress to date

A. Objectives of as-designed Pipe Rupture Hazards Analysis (PRHA)

- Objectives
  - Evaluate postulated break locations, and design the whip restraints and equipment shields to support plant design
  - Document the as-designed PRHA of critical lines to support Design Certification
    - No COL items for as-designed PRHA

A. Objectives of as-designed Pipe Rupture Hazards Analysis (PRHA)

- Approach to meet objective
  - Perform as-designed pipe rupture hazards analysis, using current design input, applicable to all AP1000 applicants.
    - The as-designed licensing report addresses critical lines and locations (energy, building design and constructability, proximity to safety related equipment)
  - Plant specific as-built reconciliation will be completed prior to fuel load
    - PRHA analyses for lines in scope of SRP 3.6.2 are documented in calc notes to support design and fabrication

B. Outline and scope of as-designed PRHA report

The report includes the following sections:

Part 1 - Methods and criteria

Part 2 - Hydraulic loads

Part 3 – Evaluation of unrestrained pipe whip

Part 4 – Design of whip restraints and jet shields

Part 5 - Hazards analysis (flooding, subcompartment pressure, environmental qualification, operability)

Part 6 – Results (summary tables)

B. Outline and scope of as-designed PRHA report

- Part 1 - Methods and Criteria
  - Reflects the methods and criteria for pipe rupture hazard analysis (PRHA) from the DCD
  - In accordance with DCD sections 3.6.1.3.2 and 3.6.2.5
    - Addresses High Energy and Moderate Energy lines

B. Outline and scope of as-designed PRHA report

- Part 1 - Methods and Criteria
  - Identifies critical lines (high and moderate energy)
  - Provides technical requirements for the various disciplines:
    - Location, shape and size of ruptures
    - Hydraulic loads
    - Whip and jet analysis and design of restraints and shields
    - Hazards evaluation: subcompartment pressurization, flooding, environmental qualification, operability

B. Outline and scope of as-designed PRHA report

- Part 2 – Hydraulic loads
  - Magnitude of hydraulic load
    - Simplified bounding thrust force $F = C_T P A$
    - Time-history thrust force F(t)
  - Direction
    - Circumferential breaks (guillotine)
    - Longitudinal breaks (anywhere around the pipe circumference)

B. Outline and scope of as-designed PRHA report

- Part 3 – Evaluation of unrestrained pipe whip
  - Perform an unrestrained analysis of post-break pipe motion
  - Develop zone of influence (ZOI) of unrestrained whip and jet
  - Overlay ZOI on plant 3D model
  - Refer to equipment list in operability evaluation

B. Outline and scope of as-designed PRHA report

- Part 4 – Design of whip restraints and jet shields
  - If consequences of unrestrained case are not acceptable, design a whip restraint and/or a jet shield
    - Bounding static design
    - Detailed FEA design

B. Outline and scope of as-designed PRHA report

- Part 5 - Hazards analysis
  - Subcompartment pressurization and analysis of pressures across walls and floors
  - Flooding analysis to determine the water levels in rooms and verify that post-rupture equipment is not affected
  - Environmental qualification to assess the effects of post-rupture environment: temperature, steam, released chemicals, radiation, spray, humidity
  - Operability: Identification of affected SSCs needed to achieve safe shutdown (Mode 4) after a postulated rupture, and feedback to evaluations and mitigation

B. Outline and scope of as-designed PRHA report

- Part 6 - Results (summary tables)
  - High Energy and Moderate Energy lines
  - Rupture types and locations
  - Hydraulic loads at ruptures
  - Design of whip restraints and jet shields
  - Hazards evaluation
    - Subcompartment pressures, flooding, environmental qualification, operability

C. Overview of criteria and methods

- The following section provides
  - Highlights of DCD sections for High Energy and Moderate Energy lines
  - Criteria for selecting critical lines
  - Summary table of locations for discussion
  - Overview of analyses applicable by break scenario

C. Overview of criteria and methods

Highlights of DCD sections

- Report to follow outline in DCD 3.6.2.5
- High energy lines identified
- Sift out Leak Before Break and Break Exclusion Zone piping (MSIV compartment)
- Pipe stress analysis results
- Identify terminal-end and intermediate break locations for high energy lines
- Room-by-room, break-by-break, identify essential targets (SSCs)

C. Overview of criteria and methods

Highlights of DCD sections

- Evaluate consequences of pipe whip and/or jet impingement interaction with targets
- Design and locate protective hardware, if required (DCD 3.6.1.3.2)
  - Barrier
  - Shield
  - Pipe-whip restraint

C. Overview of criteria and methods

Highlights of DCD sections

- Sub-compartment pressurization (DCD 6.2.1.2)
- Flooding effects (DCD 3.4)
  - Evaluate effect of flooding on essential equipment
- Spray effects environmental qualification (DCD 3.11)

C. Overview of criteria and methods

Criteria to identify critical lines

- The following criteria are used to identify critical lines (both high and moderate energy are ranked)
  - Proximity to safety related equipment needed for safe shutdown → in scope of report
    - Potential to cause damage → Energy content of the line
    - Potential to affect the structural integrity of a wall
    - Complexity of design

C. Overview of criteria and methods

List of lines considered (example: High Energy)

	System	Containment	Auxiliary Bldg	Turbine Bldg
Reactor Coolant System				
RCS	Reactor Coolant	Y	N	N
Nuclear Fluid Systems				
CNS	Containment	Y	Y	N
CVS	Chemical and Volume Control	Y	Y	N
PSS	Primary Sampling	Y	Y	N
PXS	Passive Core Cooling	Y	N	N
RNS	Normal Residual Heat Removal	Y	Y	N
SGS	Steam Generator	Y	Y	N
Auxiliary Fluid Systems				
PGS	Plant Gas			N
SSS	Secondary Samplin			Y
Steam and Power Conversio				
ASS	Auxiliary Steam Sup			Y
BDS	Steam generator Blo			N
CDS	Condensate			Y
CFS	Turbine Island Cher			Y
CPS	Condensate Polishi			Y
FWS	Main and Startup Fe			Y
GSS	Gland Seal			Y
HDS	Heater Drain			Y
MSS	Main Steam			Y
MTS	Main Turbine	N	N	Y
TOS	Main Turb. Control & Diagnostics	N	N	Y
HVAC Systems				
VES	MCR Emergency Habitability	N	Y	N
VYS	Hit Water Heating	Y	Y	N

The selection of critical lines / locations is being refined

Telecom suggested to discuss basis for selecting lines / locations to be included in reports for NRC review in support of Design Certification

C. Overview of criteria and methods

Methods: Analysis guides

- Analysis guides are the implementing procedures for the DCD commitments.
  - Guides → - Conform with the DCD
- Define methods for each evaluation
  - Results → - Will be documented in calculation notes
- Can be made available for NRC review

C. Overview of criteria and methods

Overview of analyses – by break scenario

	Type of Rupture		
	Break (HE)	Through-Wall Crack (HE, ME)	Leakage Crack (LBB)
Dynamic Effects	✓	×	×
Operability	✓	×	×
Subcompartment Pressure	✓	×	✓
Flooding	✓	✓	×[1]
Environmental Qualification	✓	✓	×

[1]Flooding for LBB leakage rate, generally bounded by through-wall cracks

✓ Included in PRHA
× Not included in PRHA

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D. Schedule

- 2 weeks after receipt from WEC of list of critical lines and locations
  - NRC concurrence with proposed sampling of line / location results to include in as-designed PRHA reports
- August 2009
  - As-designed PRHA report with application to pilot lines
- August 2009
  - NRC technical review at Monroeville of application to completed lines and locations
    - Analysis guides
    - Calculation notes
- 2010: Closeout of SER open item / confirmatory item
  - As-designed PRHA for critical HE and ME lines

E. Review of progress to date

Available for NRC review in Monroeville

- Phase I Work (completed)
  - Identified HE and ME lines (22 systems are HE)
  - Identified terminal end break locations (80 breaks)
  - Jet and whip assessment
  - Initial operability assessment
  - Identified breaks that will likely require whip restraints (29 of 80)
  - Loads on wall lines L and 11

Questions