Update of the PWR Industry Plan to Address GSI-191

Tim Andreychek
Westinghouse Electric Company
Phone: (412)-374-6246
E-mail: andtreyts@westinghouse.com

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Presentation Overview

Presentation Outline

- Pipe Breach Size
- Fluid Velocity Calculation
- Debris Transport Assessment

ATTACHMENT 5

Pipe Breach Size

Objective:

- Identify and justify the use of a size of a breach piping to be used to evaluate consequential debris generation

Pipe Breach Size

Approach:

- A Fracture Mechanics (FM) approach will be used as a basis to define a stable through-wall flaw that, in turn, will provide the basis for evaluating consequential debris generation for loop (hot leg, cold leg, and crossover leg) and surge line piping
- For all other piping break, a complete severing of the pipe will be assumed

Pipe Breach Size

Basis:

- Mechanistic evaluations of pipe flaws in primary system piping have been performed:
  - Assess if a postulated instantaneous through-wall flaw would become unstable and lead to an instantaneous complete pipe rupture
  - Evaluations used:
    - Realistic but conservative assumptions, and,
    - Worst case combination of plant loadings

Pipe Breach Size

Documentation of Basis:

- For Westinghouse Plants
  - WCAP-9558 Revision 2, "Mechanistic Fracture Evaluation of Reactor Coolant Pipe Containing a Postulated Circumferential Through-Wall Crack," documents
- Same approach for
  - B&W Plants
  - CE Plants.

Pipe Breach Size

WCAP-9558 Conditions Considered:

- Conservatively large flaw size based on the detection of a given size flaw, inspection history, flaw growth during operation, and leak detection limits
- Identification of actual minimum material properties
- Establishment of local and global, static and dynamic material properties by testing
- Verification of fracture resistance of weld material by testing

Pipe Breach Size

WCAP-9558 Conditions Considered: (con't)

- Testing of cracked and uncracked pipe scaled using thickness to diameter ratios identical to primary piping
- Elastic-plastic, static and dynamic finite element analyses of primary coolant piping containing postulated through-wall flaws subjected to worst case plant loadings
- Postulated through-wall flaw lengths considered in the study ranged from 3.75 to 7.50 inches
- These are conservative conditions for flaw sizes and loadings

Pipe Breach Size

Conclusions From WCAP-9558 Work:

- Dimensions of the through-wall flaws considered in the mechanistic calculations documented in WCAP-9558:
  - Selected using conservative assumptions
  - No known mechanism to cause the flaw size postulated
  - Shown to be stable under static and dynamic loading: did not grow

Pipe Breach Size

Application:

- Fracture Mechanics methods will be used to identify conservative, stable through-wall flaws for the reactor coolant system and surge line piping
- This flaw dimension will define the pipe breach size used to evaluate debris generation

Will not effect sump flow requirements:

- Design basis ECCS flow rates will be used to assess:
  - Debris transport to the sump
  - Head loss across sump screens

Pipe Breach Size

Selection of Piping Breach Size:

- For the primary loop piping (hot leg, crossover leg, and cold leg):
  - The breach size to be used by a plant to evaluate debris generation shall be:
    - A stable 8-inch through-wall flaw or crack, or,
    - The size of the stable through-wall flaw or crack calculated for the primary loop piping in the plant's licensing basis

Pipe Breach Size

Selection of Piping Breach Size:

- Similarly, for the surge line piping:
  - The breach size to be used by a plant to evaluate debris generation shall be:
    - A stable 8-inch through-wall flaw or crack, or,
    - The size of the stable through-wall flaw or crack calculated for the surge line piping in the plant's licensing basis, or,
    - The area corresponding to a complete severing of the surge line pipe.
- For all other piping inside containment, a complete severing of the pipe will be assumed for the purpose of evaluating debris generation

Debris Generation

Summary

- Fracture Mechanics methods will be applied to determine flaw size for debris generation
  - Method and supporting date have been previously reviewed and approved by NRC
  - There is no known mechanism to cause the size flaws postulated for the evaluations documented in WCAP-9558
- For RCS and Surge Line Piping, will use:
  - Postulated 8-inch through-wall flaw and a corresponding opening area to determine debris generation, or,
  - The size of the stable through-wall flaw or crack calculated for the primary loop and surge line piping in the plant's licensing basis
- **Design basis ECCS flow rate will be used to assess debris transport to the sump and head loss across sump screens**

Fluid Velocity Calculation

Guidance:

- To determine the transportability of debris, the velocity of the liquid on the containment floor must be calculated
- Two methods of performing this calculation are presented
  - Hydraulic Network Modeling
  - CFD Modeling

Fluid Velocity Calculation

Hydraulic Network Approach:

- Calculate bulk velocity of liquid moving across the containment floor
- This is done using standard hydraulic network modeling techniques:
  - Segregate the containment into discrete flowpaths
  - The flowpaths are connected by nodes
  - The sump represents a terminal or "sink" node
  - The break represents a supply or "source" node in the network
  - The source node may be moved to represent different break locations
  - Other supply or "source" nodes may be located in the network.

Fluid Velocity Calculation

- Evaluate hydraulic characteristics of each flow path using reference manuals (such as I'delchek) and standard hydraulic practices
- Several options exist for solving the hydraulic network to calculate bulk fluid velocities.
  - Application of a nodal network code
  - Application of an engineering calculation software package, such as TkSolver®
  - Enter the equations into a spreadsheet and solve them iteratively
- Once the velocities in the network are solved for, an assessment of debris transport is made

Fluid Velocity Calculation

CFD Approach:

- A detailed calculation of the flow patterns in the liquid pool on the containment floor may be calculated using a computational fluid dynamics (CFD) code
- The model is constructed using detailed containment geometry information
- This approach provides for detailed local fluid velocities throughout the model region

Debris Transport Assessment

- Being developed for the Hydraulic Network Approach to calculate fluid velocities
- Methodology will involve:
  - Comparison of calculated velocities to debris transport data and elimination of debris that cannot transport
  - Consideration of debris settling and elimination of debris that settles and cannot slide
  - Consideration of curbs and screens in path to the sump
- For CFD Approach, use approach similar to BWR's

Summary

- Debris Generation:
  - Use Fracture Mechanics to evaluate break size for debris generation
  - Use design basis ECCS flow rates to assess debris transport to sump and pressure drop across sump screen
- Velocity Calculation
  - Hydraulic Network Approach
  - CFD Modeling Approach
- Debris Transport
  - Being developed for Hydraulic Network Approach
  - Similar to that for BWR's for Detail Approach