ELECTRIC POWER RESEARCH INSTITUTE

Recirculation Line Break and Annulus Pressurization Loads for BWRs

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Background
SC 09-01

- On 6/8/09, GE-Hitachi (GEH) issued Safety Communication (SC) 09-01, “Annulus Pressurization Loads”
  - A postulated circumferential pipe break, at the piping/RPV nozzle safe-end interface weld, in any NSSS piping that penetrates the biological shield wall will discharge mass and energy into both the annular cavity between the RPV and the biological shield wall (BSW) and into the drywell
    - Asymmetric ΔP within annular region
    - Jet Impingement (fluid striking the RPV and BSW)
    - Jet Reaction (reactor blow down load)
    - Pipe Whip Restraint loads (load caused by the severed pipe whipping into the pipe whip restraint)
  - AP load applies to the RPV and internals, and attached piping and containment structure/steel with attachments to RPV and BSW

Background
SC 09-01 (cont.)

- The AP dynamic load was included as part of the NSSS "New Loads Evaluation" that applied to plants licensed in the late 70's and 1980's. This program included new containment hydrodynamic loads such as chugging condensation oscillation and SRV discharge loads and AP loads
  - Evaluated the existing NSSS equipment for the original design loads plus the "New Loads"
  - Applied to two Mark I plants (reduced scope at 3 plants), and all Mark II and later containment designs
  - The regulatory accepted AP loads methodology assumed that the maximum mass/energy release would maximize the structural response and stresses on the RPV, internals, and containment structures

Background
SC 09-01 (cont.)

- Design based solely on maximum mass and energy release rate may not determine peak structural response
  - Assumptions used for defining input thermal/hydraulic loads did not consider effect on dynamic structural response
  - Other postulated break locations or power/flow map operating conditions originally dispositioned as not limiting could result in higher loads on reactor internals and attached piping and containment structure/steel
- GEH/BWROG taking lead to resolve
  - BWRVIP working closely with BWROG to understand any impacts of this issue on structural evaluations of internals

GEH Assessment

- SC 09-01
  - GEH completed a 10CFR21 evaluation
  - Sufficient conservatism in the current structural analysis methodology and in the individual component stress margins to accommodate the estimated impact of the increase in the AP load cases for the two sample plants analyzed
  - Does not create a substantial safety hazard or lead to the violation of any Technical Specification Safety Limits
  - GEH has performed sensitivity studies and also taken advantage of leveraged information from current projects with plants. GEH has not identified deficiencies in any hardware to date
  - Additional efforts continuing to resolve technical issues

Background
SC 09-03

- On 8/3/09, GEH issued Safety Communication (SC) 09-03, “Shroud Screening Criteria Reports”
  - Core shroud screening criteria reports provide allowable flaw lengths for the shroud circumferential welds
    - Reports may have been used by utilities to accept existing shroud weld flaws and determine inspection frequencies
  - Some screening criteria reports may contain some non-conservative recirculation line break (RLB) loads; (Acoustic (AC), Annulus Pressurization (AP) and/or Flow-Induced (FI))
    - AC Load: Very short duration (~ 20 ms) load that acts over the finite length of time it takes for the shock wave from the break to travel from the broken recirculation line to the other side of the annulus
    - AP Load: Short duration (~ 500 ms) starts to build during AC load period

Background
SC 09-03 (cont.)

- FI Load: Quasi-Steady state load is a pressure gradient load caused by fluid acceleration escaping through the break
  - Follows AC load but overlaps the AP load; shroud sees impact starting at ~ 500 ms and is fully developed at ~ 1.0 sec
- The allowable flaw lengths for the shroud welds provided in the shroud screening criteria reports or plant-specific core shroud flaw evaluations might be affected
- BWRVIP taking lead to resolve

GEH Assessment

- SC 09-03
  - GEH completed a 10CFR21 evaluation
  - Does not create a substantial safety hazard even if RLBs loads were not included in the core shroud flaw evaluations
  - Plants with GEH installed tie rod repairs are not affected since the RLB load combinations include AC + SSE
  - Although not a plant safety or functional concern; AC, AP and FI loads may affect core shroud flaw evaluations for plants that have not installed GEH shroud repairs

Core Shroud Evaluations

- In the 1994-1995 period, a safety assessment of the core shroud was funded by the BWRVIP
  - The BWRVIP contracted GE to perform calculations to assess shroud integrity and included AC and FI loads calculated using GE's TRACG (original WHAM for acoustic & potential flow model for flow-induced load concluded to be non-conservative by NRC and GE)
  - Demonstrated that the shroud integrity is not compromised for significant cracks, up to 90% of wall thickness, such that shroud separation is very unlikely
- NUREG-1544 states "In consideration of the consequences of a 360 degree thru-wall failure of the shroud coincident with a LOCA, the NRC has conservatively estimated the risk contribution from shroud cracking and determined that it does not pose a high degree of risk at this time."
- BWRVIP concluded there was no immediate safety or operability concern

Core Shroud Evaluations (cont.)

- AC, AP and FI loads were typically combined separately with seismic loads using SRSS method, i.e., AC + SSE and AP + SSE (typically AC bounds FI load)
  - AC load is applied directly to the shroud. It affects all of the shroud welds, but the affects are greater on the H5 thru H7 welds due to tipping (bending) moment generated during event.
  - AP load is applied to the biological shield wall and the RPV and is of different duration and magnitude compared to the AC load.

Core Shroud Evaluations (cont.)

- There is a potential that some inspection frequencies might be impacted by inclusion of AC and/or AP loads but the number of affected plants is thought to be few. Reasons are:
  - Plants with minimal cracking (<10%) are not expected to be impacted due to large flaw tolerance
  - “Corrective/Preventative Actions” section of SC09-03 states that plants having GEH shroud repairs installed are not impacted
  - At least one utility is actively reviewing flaw evaluations for their plants. To date, their re-evaluation has shown that inspection frequencies are not impacted
  - GEH found in three sample (not considered bounding or typical) cases that the allowable flaw length changed by less than 4%. The sample cases were evaluated using the original NSSS AP loads and may change depending on the outcome of the BWROG SC 09-01 work.

Current GEH/BWROG Actions on SC09-01

- GEH/BWROG Project Plan
  - Develop generic basis for plant operability
    - Realistic analyses to identify margin inherent in original design basis analyses
    - Leverage recent EPU, MELLLA, MELLLA+ analysis results
      - Scope expanded to address SC 09-01 issues
    - Summarize conservatisms in current structure/component evaluations
  - Determine process for future analyses (EPU, MELLLA)
    - Address SC 09-01 issues
    - Maintain sufficient conservatism overall

Current Actions on SC09-03

- BWRVIP-76, Core Shroud I&E Guideline has been clarified to state that all postulated design loads, including RLB loads should be considered if part of the design basis of the plant
- BWRVIP has issued a survey to BWR owners to determine the number of plants that are indeterminate regarding impact of AC and AP loads for flaw evaluations
  - NRC has reviewed and provided comments on survey
  - Will be used to assess the extent of the problem and determine if any generic actions by the BWRVIP are warranted or whether the issue is better left to be resolved by the individual plants
- GEH plans to issue a revision to SC 09-03 for clarification and addition of historical and quantitative information
  - Including load definitions
  - Including recommended load combinations
  - Discussion on change in methodology (WHAM, TRACG, Method of Characteristics)
  - Including sample case data