Enclosure 3

APP-GW-GLY-088 Revision 0
Condensate Return Closed Session ACRS Presentation
Non-Proprietary

(33 pages including cover page)

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AP1000® PXS Condensate Return Technical Evaluation Results

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E.G. Wagner, P.E. – Duke Energy
T.A. Kindred, P.E. - Westinghouse

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Previous ACRS Meetings Information Reviewed

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- Overview of the issue
- Analysis/calculation approach developed to quantify the return rate vs. time (spreadsheet calculation and condensate loss calculation).
- Integration of time variable return rate with LOFTRAN for determining RCS Tavg change with time
- Coupling of WGOTHIC model to provide containment pressure and temperature boundary conditions
- Empirical data used to determine losses
  - Westinghouse specific testing for losses on the shell due to beams, attachment plates, welds
  - Literature sources[1] used to determine losses from rainout phenomena based on inclination angle of shell.

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[1] Anderson, M.H.; Herranz, L.E.; Corradini, M.L.; *"Experimental analysis of heat transfer within the AP600 containment under postulated accident conditions."* Nuclear Engineering and Design Volume 185 pp. 153-172 October 1998.

Key Developments since Previous Meeting

- Calculation discrepancies identified in January 2015 that required analysis approach and supporting calculations to be modified
  - Investigate deviations in LOFTRAN as compared to spreadsheet calculation
- Root cause analysis (RCA) performed
  - RCA encompassed all CAPALs (corrective actions) associated with condensate return
- Updated analysis process eliminated the PRHR performance calculation and replaced return rate vs. time with WGOTHIC code calculation
  - Loss calculation for CV shell based on Westinghouse specific testing (constant 18%).
- PIRT performed to extend LOFTRAN to long term duration

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Issues to be Addressed

- Reevaluate Calculation Model
  - Error correction (Spreadsheet vs. LOFTRAN)
  - Simplification
  - Use of LOFTRAN with potential for two-phase flow
    - Heat loss vs. adiabatic analysis assumptions
- Extend Design Basis Accident (DBA) to 72 hours
- Confirm Safe Shutdown Analysis
  - System capability to cooldown to 420°F in 36 hours
- Determine Long Term PRHR Operation Capability (not indefinite)
- Assess operational impacts

Overview of Analysis Approach

- Calculation to determine condensate return losses
  - Pressurize Containment
  - Losses on Heat Sinks
  - Dome rainout
  - Losses on modified features
    - Downspouts on Polar Crane Girder
    - Downspouts on Stiffener
- Calculation to determine return rate vs. time
  - Simplified spreadsheet calculation
  - Calculates PRHR performance
  - Accounts for losses and determines the return rate to IRWST vs. time
- WGOTHIC Calculation to determine containment T&P boundary conditions
- LOFTRAN Calculation that utilizes:
  - Return rate vs. time
  - Containment T&P boundary conditions
  - Outputs RCS Tavg vs. time

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Reasons for Analysis Process Change

- Resolve discrepancies identified in January 2015
- Previous analytical approach was developed over time
  - PRHR Performance calculation (spreadsheet) already existed
  - Time to Safe Shutdown built from existing PRHR calc
  - When Condensate Return Issue surfaced, containment effects and condensate losses were added at the front end of the process
- Previous analytical approach was required to quickly analyze large variations in condensate return rates over time
- Design changes to extend gutter and add downspouts reduced variation in losses
  - Allows WGOTHIC to use a constant loss factor on the CV shell (18%)

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Benefits of Streamlined Analysis Approach

- Multi-disciplinary team reviewed and challenged standing assumptions in Condensate Return analysis approach
- Analysis approach was simplified to remove PRHR performance spreadsheet as intermediary calculation
  - Safe shutdown analysis passes inputs from WGOTHIC directly to LOFTRAN
- Benefits of streamlined approach
  - Reduce handoffs between calculations
    - Limits potential errors due to handoffs
    - Limits the addition of unnecessary conservatism to bound inputs and compensate for inconsistencies
  - Utilizes two analysis tools previously reviewed and approved by the US NRC
    - Code performance verified vs. integral system and separate effects testing
  - Simplifies licensing review

New approach improves quality and pedigree of analysis process by increasing reliance on approved licensing basis tools (WGOTHIC, LOFTRAN).

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Overview/Comparison of New Analysis Approach

Calculation	Previous Approach	Streamlined Approach
PRHR Performance Calculation	Determines condensate return rate vs. time for input to WGOTHIC and LOFTRAN	Eliminated
Condensate Return Calculation	Calculates flow dependent losses in condensate return rate	Calculates flow dependent losses in condensate return rate
WGOTHIC Calculation	Calculates containment T&P boundary conditions	Calculates containment T&P boundary conditions and condensate return rate vs. time based on calculated losses.
LOFTRAN Calculation	Utilizes return rate vs. time and containment T&P boundary conditions to determine RCS Tavg.	Utilizes return rate vs. time and containment T&P boundary conditions to determine RCS Tavg.

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PIRT Overview

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PIRT Overview

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Technical Oversight

- Focused reviews accomplished via five multi day visits to WEC
  - DBA Extension Analysis (Case 1)
    - Extension of analysis to 72 hours with Chapter 15 acceptance criteria
  - Safe Shutdown Analysis (Case 2)
    - Confirms RCS cooldown to 420°F in 36 hours
  - Safe Shutdown Duration Analysis (Case 3)
    - Maintain Reactor Coolant System at 420°F for greater than 14 days
  - "Engineering Basis Document"
    - Validates use of LOFTRAN for Safe Shutdown long term duration analysis

Technical Oversight

- Results of Focused Reviews
  - Open Issues identified by the review team were resolved
    - Adiabatic assumption in LOFTRAN is conservative
    - Two phase flow in closed loop PRHR system does not degrade performance
    - Pressurizer overfill is prevented
    - ADS actuation criteria was defined
    - ADS actuation does not challenge containment integrity
  - Analyses are rigorous and accurately predict plant response to events crediting the Passive Cooling System
  - Adequate margin exists such that safety functions are ensured

Summary of Cases Analyzed

- Case 1: DBA Extension Analysis
  - Safety design basis assumptions
  - Analysis assumptions commensurate with Chapter 15
  - Chapter 15 accident analysis acceptance criteria met:
    a. Minimum DNBR limit = 1.5
    b. No water relief through pressurizer safety valves/No Escalation Criteria
    c. Maximum RCS pressure < 2748.5 psia
    d. Maximum SG pressure < 1381.5 psia
  - Analysis was created as part of issue resolution
  - Results support FSAR Ch. 6.3.1.1.1 conclusion that "*PRHR is designed to maintain acceptable RCS conditions for at least 72 hours following a non-LOCA event*"
  - 72 hour analysis duration consistent with DBA mission times in current licensing basis.

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Summary of Cases Analyzed

- Case 2: Time to Safe Shutdown
  - Licensing basis performance requirement
  - Demonstration of 420°F in 36 hours or less
  - Analysis is based on realistic (conservative, non-bounding) assumptions
  - Analysis summarized in FSAR Ch. 19E
- Case 3: Safe Shutdown Duration
  - Licensing basis performance requirement
  - Demonstrate PRHR can maintain safe shutdown for greater than 14 days
  - Analysis is an extension of Case 2
  - Analysis supports FSAR 6.3.1.2.1 and 7.4 conclusions

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Case1: Design Basis Extension Analysis Containment Pressure vs. Time

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Analyses consider containment pressure effects on IRWST steaming

Case 1: Design Basis Extension Analysis Margin To Acceptance Criteria

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Analysis demonstrates all pertinent Chapter 15 acceptance criteria are met (applicable to higher wet bulb temperature)

Case 1: Design Basis Extension Analysis Temperature vs. Time

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Core average temperature is stable at 72 hours

Design Basis Extension Analysis Pressurizer Volume

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Overfill criterion is not challenged for first 72 hours

Case 2:Safe Shutdown Analysis Temperature vs. Time

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Time to reach 420°F ~33.6 hours

Case 2: Safe Shutdown Analysis
Temperature vs. Time and Impact of CV Shell losses on Analysis Results

Safe Shutdown Analysis Results Summary

Description	Case	Decay Heat	Time to reach 420°F
90% Return Rate	DCD Revision 19	ANS +0 sigma	34.3 hr
Updated Return Rate	Updated Licensing Submittal	ANS +0 sigma	33.6 hr

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Significant margin exists based on conservatisms in decay heat.

Case 3: Safe Shutdown Duration
Temperature vs. Time

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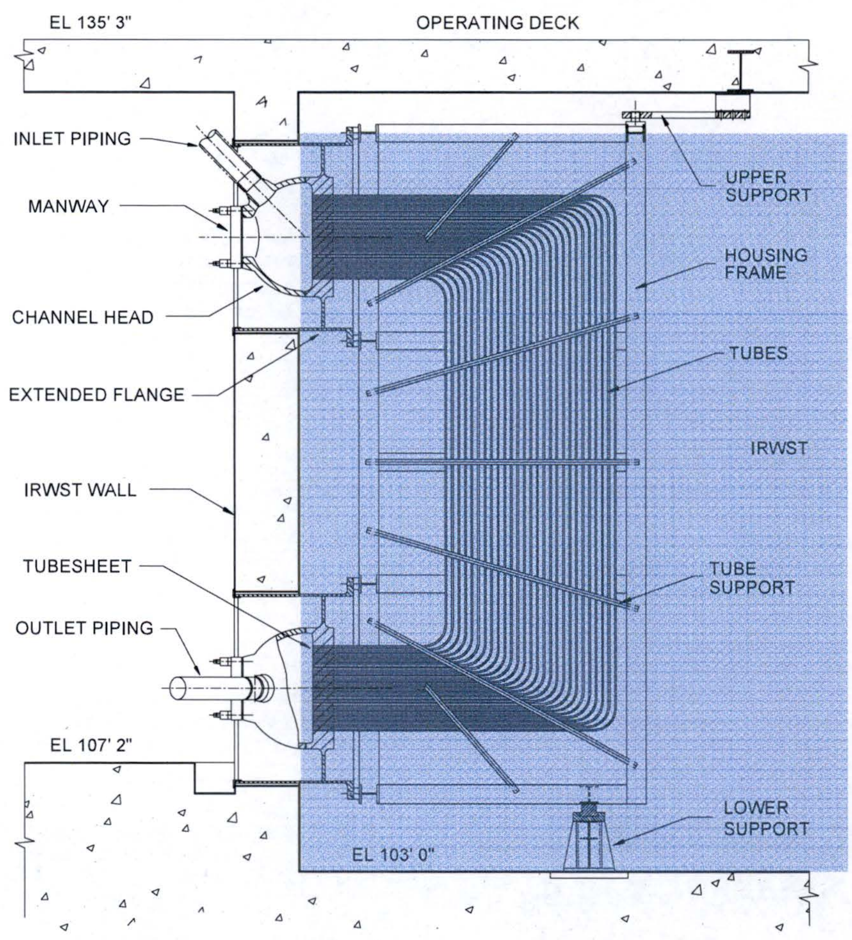
Coping time much greater than 14 days assuming ANS-79 DH with zero sigma uncertainty

Case 3: PIRT Sensitivities PRHR HX Tube Uncovery/Pool Boiling (LOFTRAN)

- LOFTRAN nodalization of PRHR HX assumes a single flow path with equivalent heat transfer area
- Driving head based on midplane of the upper horizontal tube bundle
- Heat removal capability is linearly reduced as each node uncovers
- No heat transfer credited above collapsed liquid level in IRWST
- Unchanged from DCD R.19



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Case 3: PIRT Sensitivities PRHR HX Tube Uncovery/Pool Boiling (RELAP)

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Case 3: PIRT Sensitivities
PRHR HX Tube Uncovery/Pool Boiling (RELAP)

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Case 1:Additional Sensitivities
Heat Loss Assumption (Non-Adiabatic RCS)

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Historic licensing basis assumption of no heat loss results in a more conservative analysis methodology as compared to acceptance criteria

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Analysis Conclusions

- Design basis analysis demonstrates:
  - PRHR closed loop cooling can maintain the plant in a safe stable condition for 72 hours
- Conservative, non-bounding analysis demonstrates:
  - PRHR closed loop cooling can cool the RCS to 420°F in less than 36 hours
  - PRHR closed loop cooling can maintain safe shutdown (<420°F) for greater than 14 days
  - Adiabatic analysis of the RCS is appropriate

Operational Considerations

Larry Taylor – Duke Energy

OPERATIONAL CONSIDERATIONS

- Operator Actions at the end of 72 hours if AC Power has <u>not</u> been restored on site:
  - Ancillary Diesel Generators power control room system indications and PCS Recirculation Pumps
  - Makeup to the PCCWST from the PCCAWST
  - Monitor parameters for acceptable RCS cooling capability, continue PRHR HX heat removal and continue efforts to restore power

  Note: Safety-related connections are provided to connect portable equipment to replace ancillary equipment if necessary.

- Operator Actions at the end of 72 hours if AC Power has not been restored on site (continued):
  - When RCS cooling capability parameters depart from acceptable values, initiate RCS depressurization via ADS, stages 1, 2, 3 and 4.
  - After ADS Stage 4 valves open, IRWST injection valves and recirculation valves from the containment sump will open.
  - During RCS depressurization, CMTs and Accumulators will discharge into the RCS. RCS pressure and temperature will decline and heat transfer from inside containment to outside containment will continue.

- Operator Actions if AC Power is restored (by Standby DGs or off-site power) with PRHR in service:
  - Re-establish feed flow to the Steam Generators and begin a slow RCS cooldown with steam exhaust to atmosphere or condenser
  - Restore makeup to the RCS using Makeup Pumps
  - When RCS Temperature is <350 degrees, place normal decay heat removal system (RNS) in service
  - Continue RCS cool-down