BWROG Actions to Address Containment Accident Pressure Issues

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NRC-BWROG Meeting
January 19, 2011

BWROG Purpose

Define path forward for obtaining final SE for BWROG CAP LTR

Define path forward to reengage BWR EPU CAP reviews

Current Situation

BWROG LTR (NEDC-33347P)

- LTR developed at NRC request to provide consistent methodology for requesting CAP credit
- Draft SE issued on September 29, 2009 and revised draft SE on March 22, 2010
- Expect to address NRC guidance document elements in order to obtain final SE

Current Situation

EPU Submittals

- BWR EPU review has been delayed > 1 year by CAP resolution
  - Long-standing ACRS concerns on CAP overreliance
  - Finalization of NRC staff CAP guidelines
- EPU CAP reviews put on hold by NRC
  - Browns Ferry
  - Monticello
- Peach Bottom EPU submittal is pending

Topics

Brief background

NRC CAP guidance document and information request

BWROG response to provide information request

Path forward on NPSH evaluations

BWROG Action Items

Summary of BWROG recommendations

BWROG Response to NRC Information Request

Brief Background

NRC asked BWROG to develop a method for utilities to use in requesting CAP credit

- BWROG developed LTR NEDC-33347P
- Draft SE issued September 29, 2009

March 1, 2010, NRC published draft CAP guidelines

March 19, 2010, ACRS letter to staff outlining ACRS recommendations on CAP use

June 25, 2010, Commission issued Staff Requirements Memorandum for NRC staff to address similarities and differences between staff and ACRS positions

NRC CAP Guidance Document

NRC CAP Guidelines introduce

- Uncertainty terms for NPSHr
- Maximum erosion zone
- Testing requirements for NPSHa < NPSHr
- Defines events for which NPSHr uncertainties are applied

NRC CAP Guidance Document

For LOCA - use pump vendor 3% NPSHr plus an uncertainty adder

For special events - use pump vendor 3% NPSHr

- Appendix R
- ATWS
- SBO

NRC CAP Guidance Document Information Request

NRC requested industry and vendor input on CAP guidelines including LOCA uncertainty adders

- Pump field speed variation
- Suction piping configuration
- Dissolved gas

Other Issues

- Water temperature
- Instrument uncertainties
- Wear ring wear
- Effect of dissolved gas on pump seals

BWROG Response to NRC Information Request

Perform CFD analysis to address NPSHr uncertainty factors for 2 different size ECCS pumps

- Browns Ferry/Peach Bottom RHR pump
- Monticello RHR pump

Provide BWROG recommendations on other issues and alternative approaches to:

- Guideline 4.6 (operation with NPSHa < NPSHr)
- Guideline 4.9 (operation in maximum erosion zone)

Pump Field Speed Variation

Accounts for possibility that pump speed may be higher than factory test

Using pump scaling laws to define uncertainty;

$$NPSH_2 = NPSH_1 (n_2 / n_1)^2$$

Small effect – no more than 0.35 feet at maximum

Suction Piping Configuration

- Field configuration of pump suction piping may contribute to increase in NPSHr compared to factory testing
- Use CFD to determine to determine delta between 3% vendor NPSHr and field suction piping configuration at throttled and run out flow rate

Dissolved Gas

Centrifugal pump performance sensitive to gas voids when voids > 2%

BWR containments are inerted with nitrogen

- Nitrogen less soluble in water than oxygen

At 95 °F, if all gas came out of solution void fraction ~ 1.2%

At 140 °F, if all gas came out of solution void fraction ~ 0.7%

Dissolved Gas

Dissolved gas fraction will continue to decrease as pool temperature increases

Small amount of gas content reduces cavitation damage

Use CFD to determine to determine dissolved air delta in NPSHr at 95 °F and 155 °F at run out flow, and 155 °F and 210 °F at throttled flow

Other Issues: Water Fluid Temperature

Improvement in NPSHr with increasing water temperature is scientifically well-established

- Hydraulic Institute tables
- Stepanoff correlation

NRC CAP guidelines do not allow use of water temperature NPSHr improvement

BWROG position is that credit for water temperature NPSHr factor should be included in the LOCA uncertainty adder

Other Issues: Instrument Uncertainties

BWROG recommends using vendor pump curves for 3% NPSHr without additional instrument uncertainties

- NPSHr is based on original pump test results from factory
- Methods and instrumentation based on industry standards of accuracy
- All pumps are tested so test uncertainties tend to cancel out
- Pumps are tested at low water temperature so NPSHr test results are conservative

Other Issues: Wear Ring Wear

Not discussed in NRC draft guidance document

BWROG position: Not expected to be a significant uncertainty factor:

- Core Spray pumps are operated only for surveillance tests
- RHR pumps are low use pumps
  - shutdown cooling during outages
  - multiple RHR pumps so operating duty is shared
  - infrequent suppression pool cooling
  - periodic TS or ASME surveillance testing
- Due to low operational use, wear ring wear is not a significant factor
- Unexpected wear would show as a decline in TS and ASME pump testing

Other Issues: Effects of Dissolved Gas on Pump Seals

- Concern is dissolved gas will migrate into pump seals which could cause excessive seal wear
- ECCS pumps have water seal injection
- BWROG will request pump vendor engineering evaluation to address

Summary of LOCA Uncertainty Terms

Uncertainty factor	BWROG Recommendation
Pump Field Speed	Use pump scaling laws to quantify
Suction Piping Configuration	Use CFD to quantify
Dissolved Gas	Use CFD to quantify
Water Temperature	Allow use in uncertainty factor determination
Instrument Uncertainties	Use vendor supplied 3% pump curves
Wear Ring Wear	Not an issue due to low pump duty

NRC Guideline 4.6

NRC Guideline: Operation with NPSHa less than NPSHeff (LOCA) or 3% NPSHr (non-design basis events) is acceptable if < 100 hours and like testing is performed

With CAP credit, NPSHa will be less than NPSHeff only during short-term LOCA response (< 10 minutes) for some plants

Maintenance of adequate core cooling is paramount concern for short-term LOCA response, therefore:

- Viable alternative to testing is demonstrated by analysis that core cooling is maintained for short-term LOCA response

NRC Guideline 4.9

NRC Guideline: The zone of maximum erosion rate should be considered to lie between NPSH margin ratios of 1.1 to 1.6. The permissible time in this range for very high suction energy pumps should be limited (< 100 hours).

BWROG recommends a pump impeller operational lifetime analysis as an alternative approach

Path Forward on EPU NPSH Evaluations

To address NRC draft guideline pending completion of CFD analyses:

- For LOCA: licensees should use 5 feet of uncertainty for NPSHeff
  - Consistent with NRC contractor recommendation to use larger of 1.15 x 3%NPSHr or 5 feet
  - 5 foot value represents a ~ 30% uncertainty imposed on a typical 3% NPSHr at BEP
- For special events: licensees should use pump vendor 3% NPSHr in accordance with NRC guideline
  - Appendix R
  - ATWS
  - SBO

BWROG Action Items

- BWROG will provide plan and schedule for response
- BWROG will perform CFD analyses to quantify LOCA uncertainty adders
- Engineering evaluation will address effects of gas on pump seals
- Report will be provided to NRC in a format to be determined

Summary of BWROG Recommendations

For LOCA; licensees should use 5 feet of uncertainty for NPSHeff or a lower value as justified by CFD analysis

For special events – licensees should use pump vendor 3% NPSHr in accordance with NRC guidelines

BWROG recommended alternatives for guidelines 4.6 and 4.9:

- 4.6 Perform analysis that core cooling is maintained for short-term LOCA response (<10 minutes)
- 4.9: Perform pump impeller operational lifetime analysis

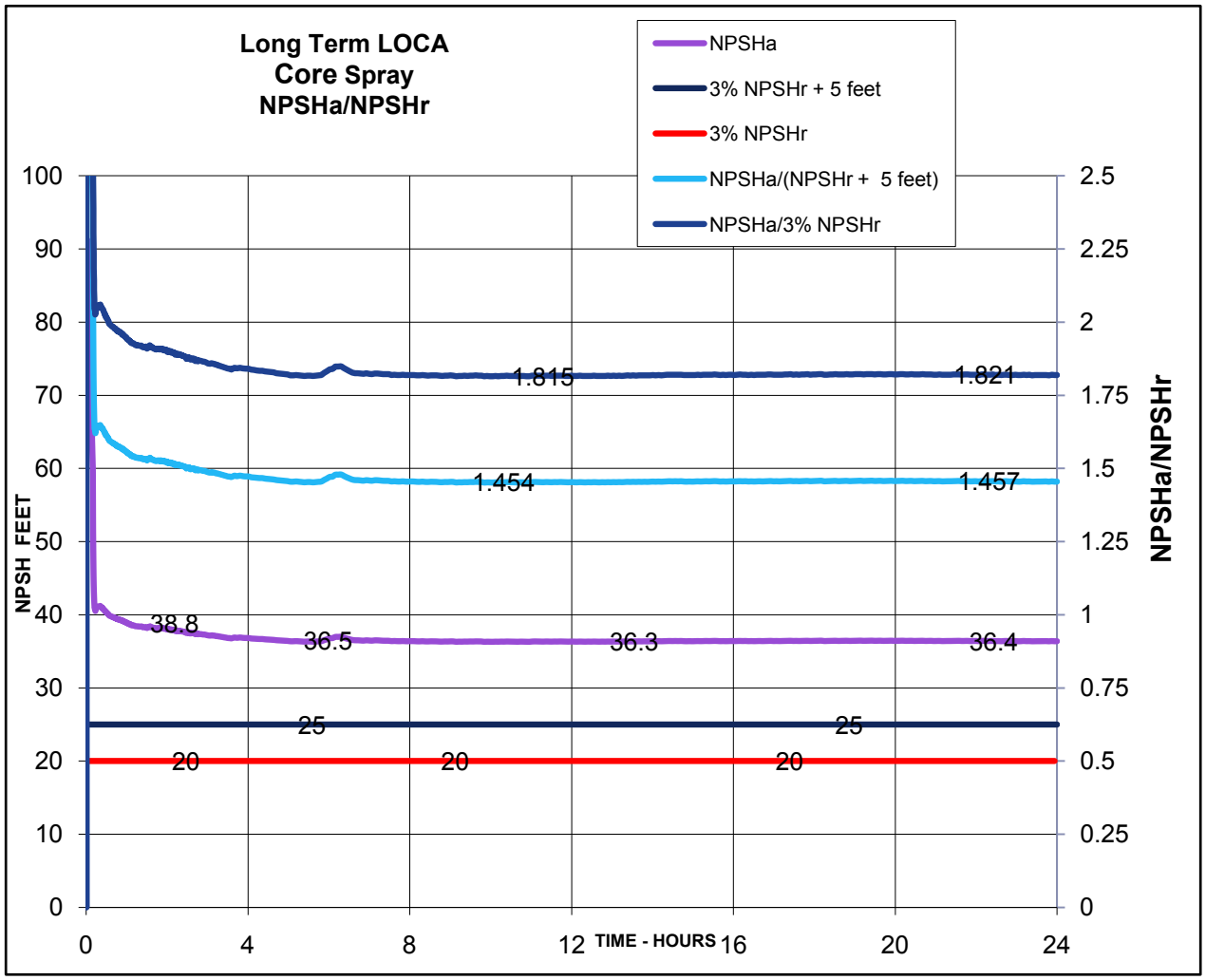
BWROG Response to NRC Information Request

The BWROG requests feedback from NRC on the general approach and specific elements of the proposed CFD analysis

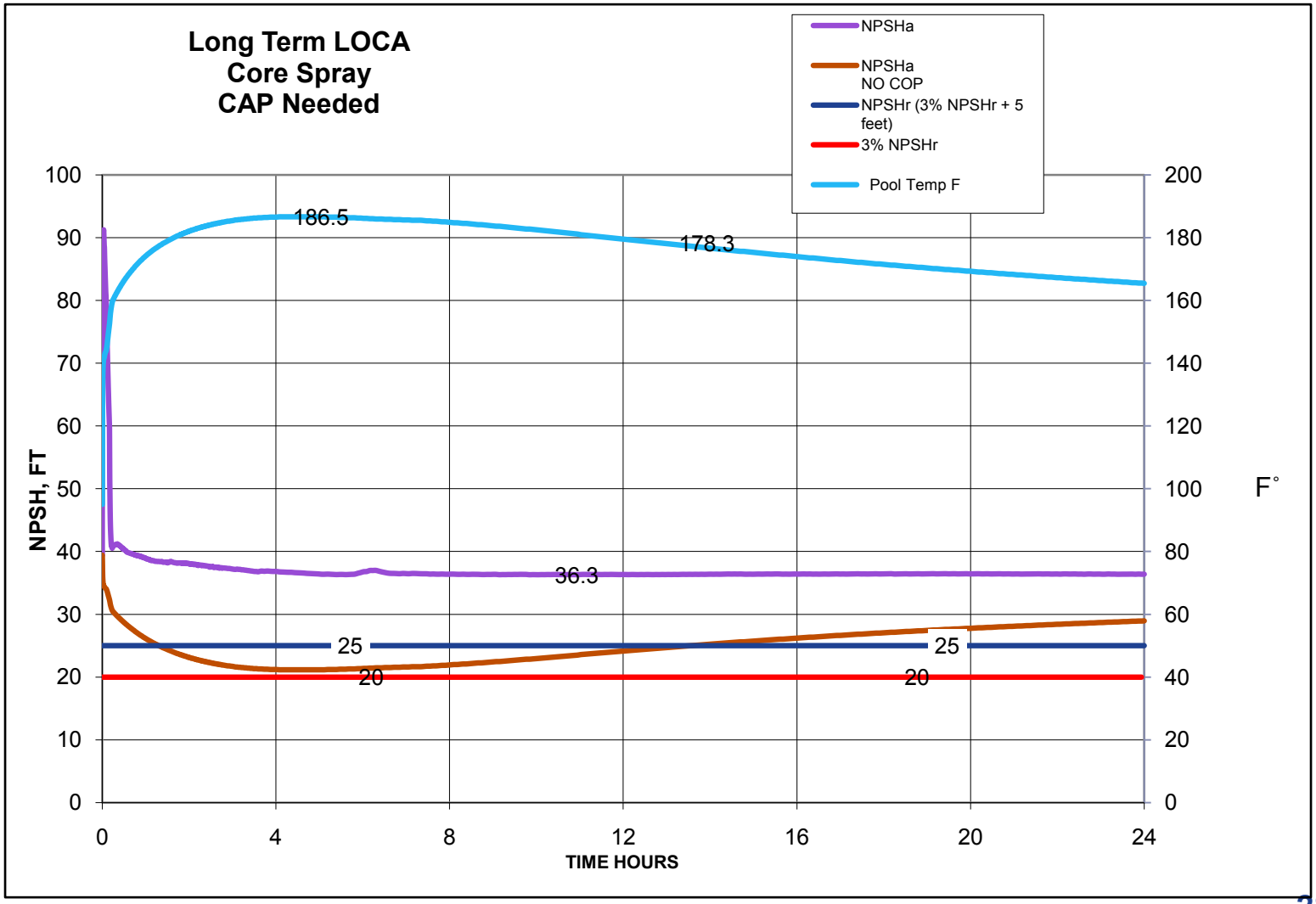
The BWROG will propose for NRC concurrence a plan and schedule for completing its response

Backup slides

NPSHa/NPSHr Ratio v. With/Without Adder



CAP need with/without LOCA adder



Short-Term LOCA Design

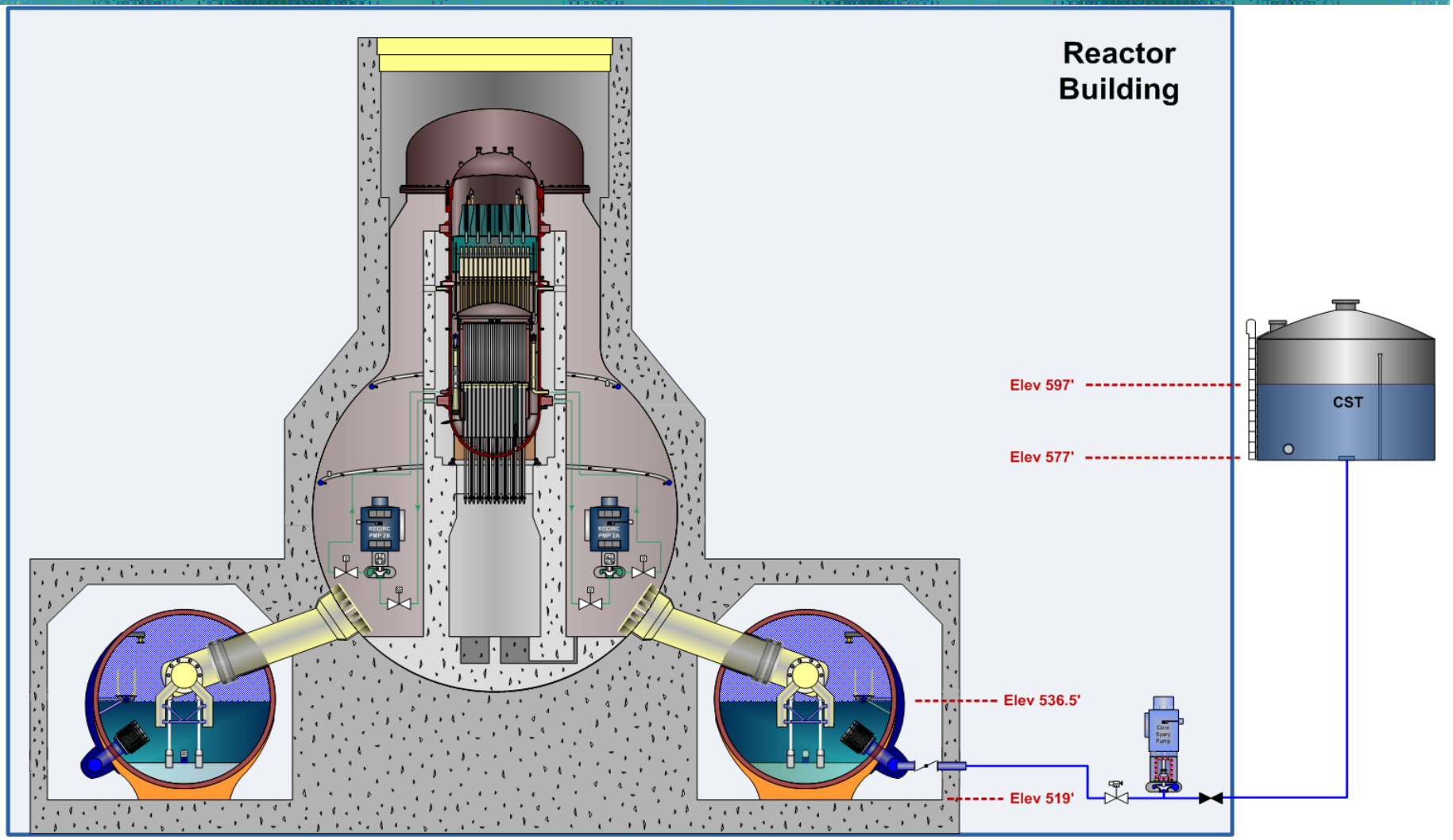
In the event of a LOCA, ECCS logic will auto-start all 4 RHR and 4 Core Spray pumps and inject to the reactor

Design ensures adequate core cooling (fuel peak clad temperature) when reactor decay heat is highest (assuming worst case single failure)

High system flow in this short-term mode results in temporary pump operation in regions of high NPSHr and low NPSHa

At 10 minutes operator throttle Core Spray and RHR pumps

Suppression Pool Flooding (cont.)



Typical NPSHr Curves (Browns Ferry RHR)