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An Industry Perspective of LOCA Acceptance Criteria

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Industry Cooperation with NRC on High Burnup Fuel LOCA Tests

- The industry continues to support NRC's overall objective of revising 10 CFR 50.46(b) and introducing **performance-based** acceptance criteria
  - Potential benefit in simplified qualification testing and introduction of new cladding materials without need for rule exemptions
- Provided high-burnup fuel test specimens, test design support and independent review of results
- Valuable data is being produced on high burnup fuel performance under LOCA conditions

No Urgent Need to Revise LOCA Fuel Acceptance Criteria

- Data obtained thus far does not indicate an imminent safety issue:
  - Current criteria are adequate for low-to-intermediate burnup fuel
  - Large operational margins exist for higher burnup fuel:
    - High-burnup fuel can not approach high temperature limits without low-burnup fuel exceeding them first
- Relevant Experimental Data Available in the next 2-3 years
  - Will address high burnup fuel behavior-related concerns
- On-going Discussion on Transition Break Size (TBS) not completed
  - Impacts initial conditions to consider for LOCA analysis

LOCA-related Issues that need to be Evaluated

- Inner cladding surface oxygen uptake effects
- Behavior of ballooned (brittle) region
- Pellet fragmentation, high burnup rim response, and relocation into the ballooned section
- Potential for dispersal of fuel through burst opening

A risk-informed perspective should be used to evaluate whether such effects need to be accounted for, and if so, to what extent

Primary Objective of Criteria

- Ensure fuel rod damage is limited during LOCA event
- Maintain a coolable fuel rod geometry following the LOCA event

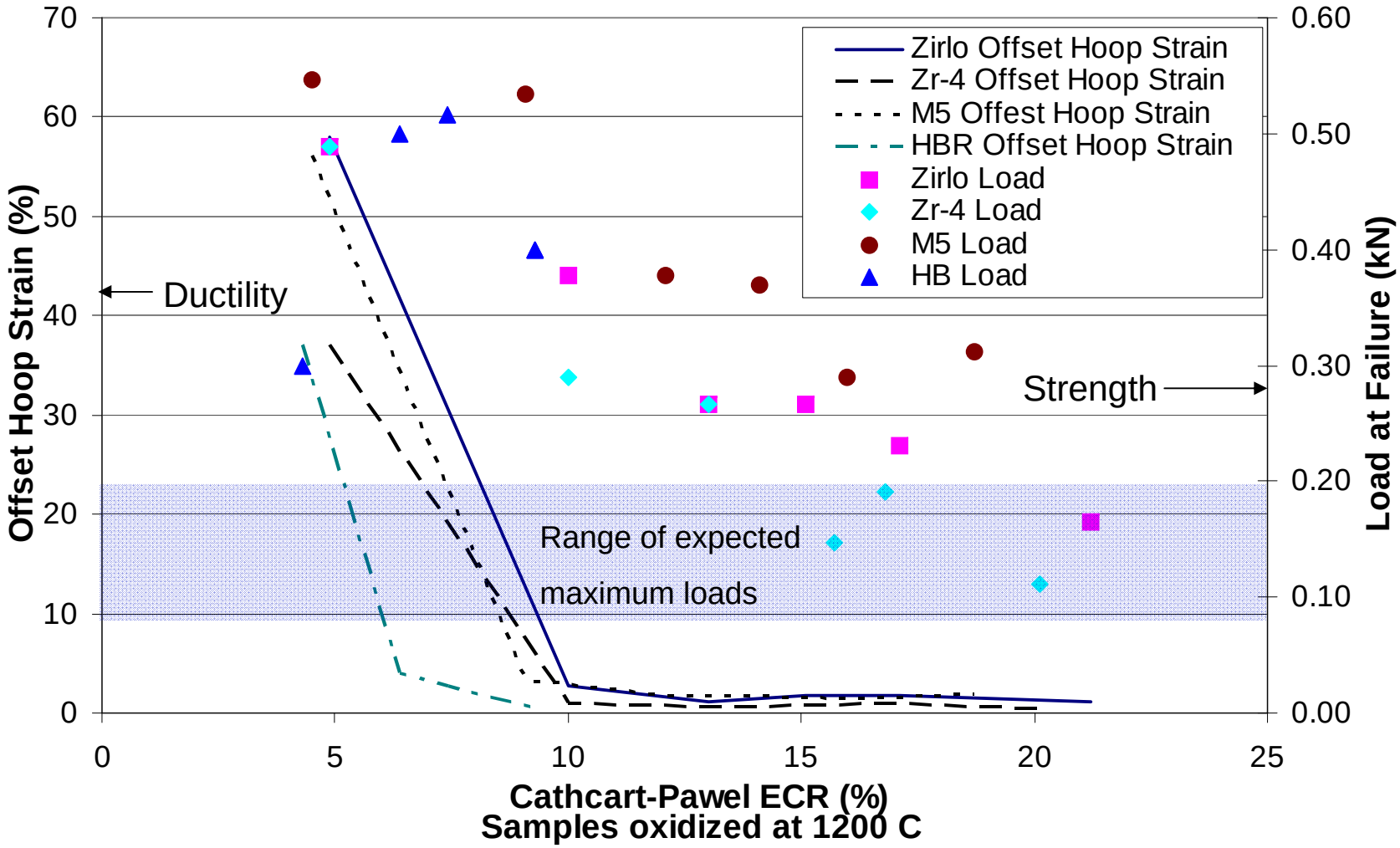
Basis for the Current LOCA limits

- NRC has chosen to use a zero-ductility limit as a sufficient measure for ensuring long-term core coolability and geometric stability
  - Used ring-compression tests (RCT) to measure residual ductility
  - Advantages:
    - Historical precedence to maintain residual ductility
    - RCT relatively easy to perform
    - Can account for hydrogen effects
  - Disadvantages of a Ductility-Based Approach
    - Ring compression tests measure local properties of de-fueled cladding, not structural response
    - The zero-ductility limit may be test-dependent (RCT vs. 3-pt. bend tests)
    - Does not address the balloon region

Potential Alternatives: Strength-Based Approaches

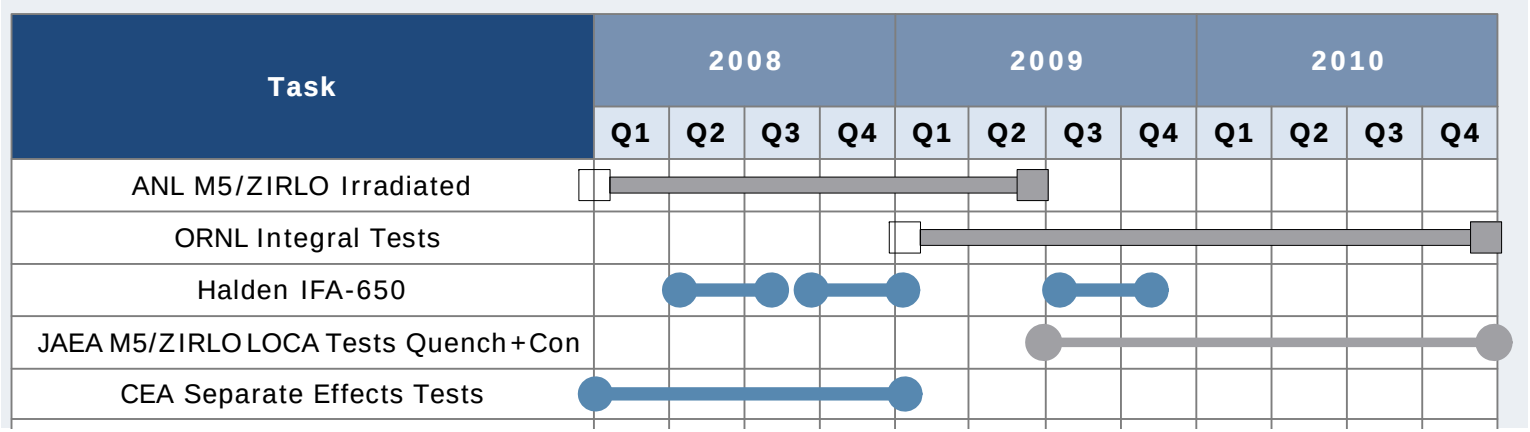
- Even though the material may have low residual ductility it still retains load carrying capability
  - Strength/Impact Resistance
  - Quench Survivability
- Strength is an appropriate metric for ensuring continuation of a coolable geometry
  - Advantage
    - Gain margin away from the balloon
    - Can address the balloon region
  - Disadvantage
    - Difficulty in estimating the expected fuel rod loading conditions
    - Development of methods to demonstrate compliance

Comparison of Residual Ductility and Load at Failure



LOCA-Related Work Continues to Be Conducted Worldwide

- Key data is expected in 2008 to 2010 from ongoing programs around the world
  - HALDEN IFA-650
    - Questions about fuel relocation and dispersal
  - Continuation of the ANL (and ORNL) Programs (Integral tests, strength and ductility)
  - Other international programs in Europe and Japan
  - Industry strength-based approach evaluation



Expected Consequences to Industry from a Rule Change

- Vendors
  - Re-license EMs, potential need for additional hot cell testing
- Licensees
  - Updated analyses, Tech Specs, FSARs
  - Potential for increased fuel cycle costs, with increased spent fuel
  - Potential interference with the use old Zircaloy clad fuel assemblies from spent fuel pool for core redesign
  - Potential for reduced operational flexibility
- NRC
  - Resources to review vendor and licensee submittals

Requires Significant Resources
Should be Performed Only When a Sound Technical Basis is Established

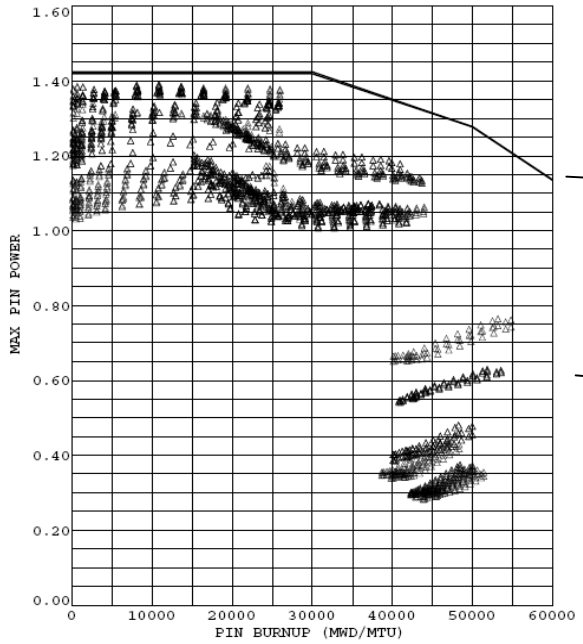
Conclusion

- More data and work is needed to support a possible future revision of 10 CFR 50.46(b) acceptance criteria
  - Evaluation of information from ongoing LOCA experiments
  - Consistency with transition break size regulation
- A proposal for a Rule Change based on residual ductility is simple and easy to implement, but may be overly restrictive
- Alternative approaches based on strength, may be needed to meet overall objective of the criteria and address possible outstanding issues
- Any revision will require careful consideration of how to forward fit the regulation
  - Industry-coordinated rollout strategy over an appropriate length of time

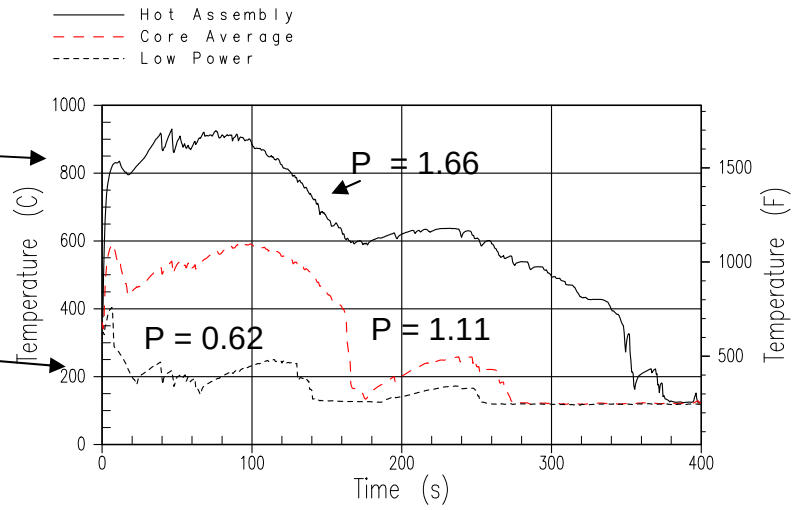
Backup Slides

Large Safety Margins Indicate There is No Issue at High Burnup

Typical 3-Loop PWR
Achievable Pin Power vs. Burnup



Typical 4-Loop PWR
LBLOCA PCT Response for Baseload Operation



High burnup UO_2 fuel cannot approach 1200°C without fresher fuel violating limits