

# **Fatigue in Operating Nuclear Power Plants Components after 60 years**

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Joint U.S. Nuclear Regulatory Commission (NRC) and U.S.  
Department of Energy (DOE)

Workshop on U.S. Nuclear Power Plant Life Extension Research  
and Development Issues

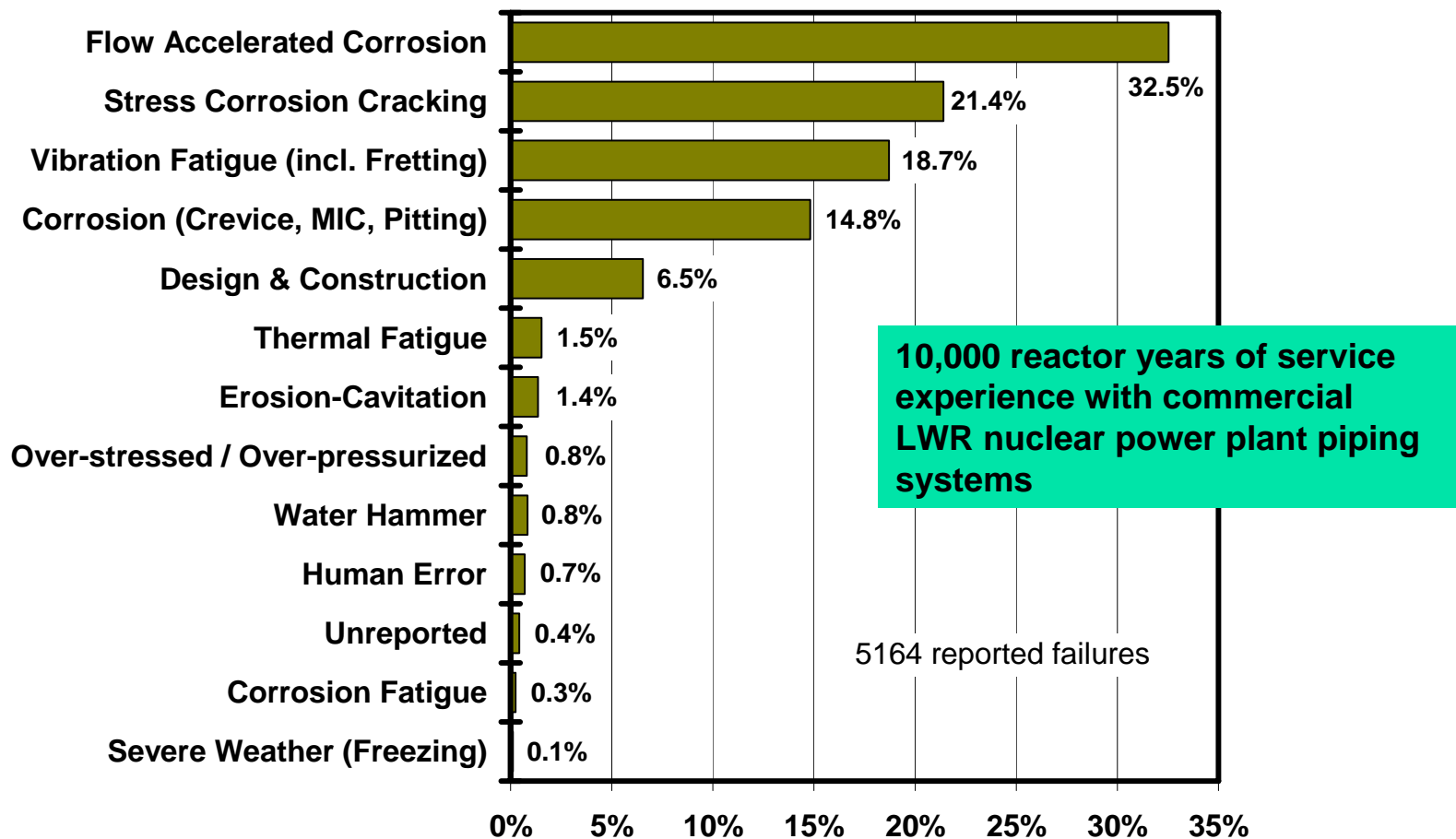
Bethesda, MD, February 19-21, 2008

# Summary

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- Service Experience
- Component Fatigue Qualification and Serviceability
- Challenges and Directions for the Future
- Questions and Discussion

# U.S. Failures by Degradation Mechanisms



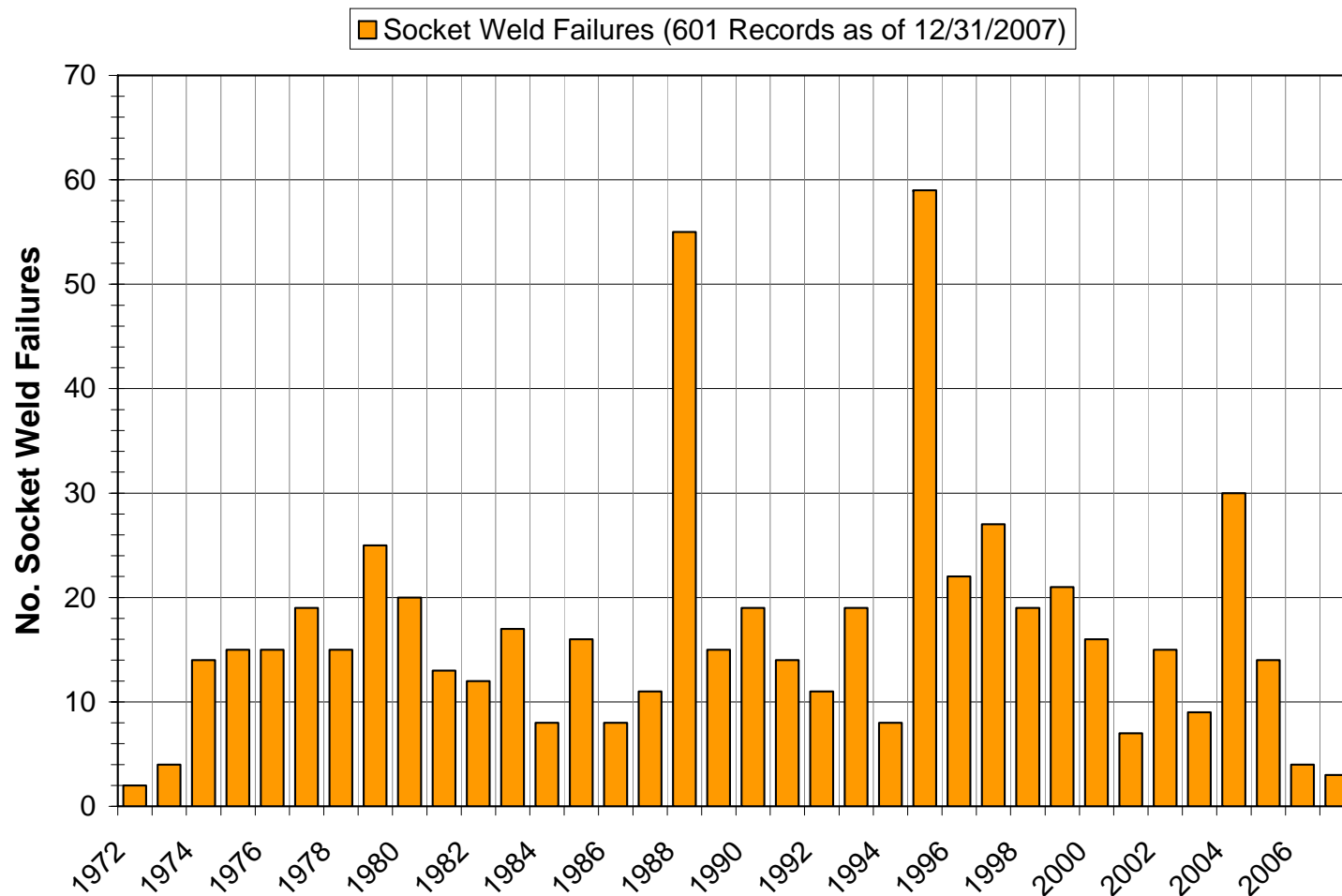
Source: PIPExp Database Data from 1970-2007

# Fatigue Failure Experiance

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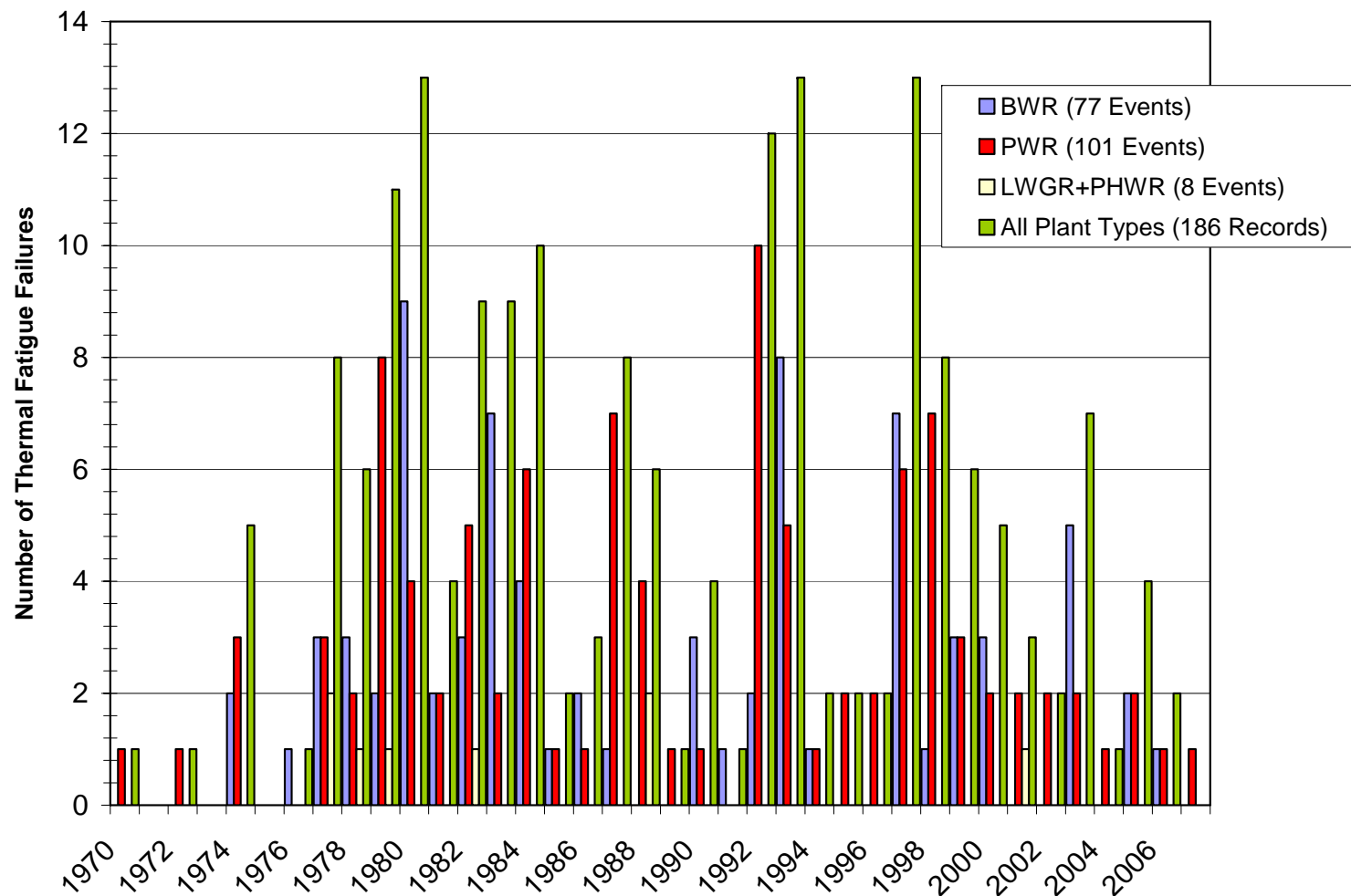
- Fatigue accounts for 21% of all reported failures in domestic operating NPPs
- Vibration Fatigue
  - ▶ 90% of the reported fatigue failures
  - ▶ Most all in small bore socket weld connections
- Thermal Fatigue
  - ▶ 2% of all reported failures
    - Thermal Stratification
    - Turbulent Penetration Effects
    - Hot/Cold Mixing
- Generally the occurrence of these failures has not significantly changes in the last 35 years

# Vibration Fatigue Socket Weld Failures



Source: PIPExp Database Data from 1970-2007

# Thermal Fatigue Failures



Source: PIPExp Database Data from 1970-2007

# Fatigue Qualification and Serviceability

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- Component design and operation will be limited to prevent **fatigue crack initiation**
- Component is designed and operated in a manner that will tolerate fatigue accumulation and crack growth without reducing the structural integrity below acceptable limits - '**damage tolerant**'
- Component design and operation will be limited so that component **failure probability/frequency** is within established component reliability goals.

# Challenges and Directions for the Future

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- Environmental fatigue effects make it more difficult to rely base serviceability on traditional ASME Class 1 analyses
- Synergistic effects of other mechanisms (e.g., corrosion, cast stainless steel thermal embrittlement, etc.)
- Advanced reliability models consider all relevant design, operation and maintenance practices, surveillances, etc, so that ensure that fatigue sensitive components will continue to operate with established reliability goals
- Expand application of damage tolerant and PFM methods for component fatigue qualification and fitness for continued service beyond 60 years.
  - ▶ Component weld fabrication flaw size and density distributions
  - ▶ Uncertainties in material properties, weld residual stresses, and NDE detection and flaw characterization capabilities





# **Questions and Discussions**