Fatigue in Operating Nuclear Power Plants Components after 60 years

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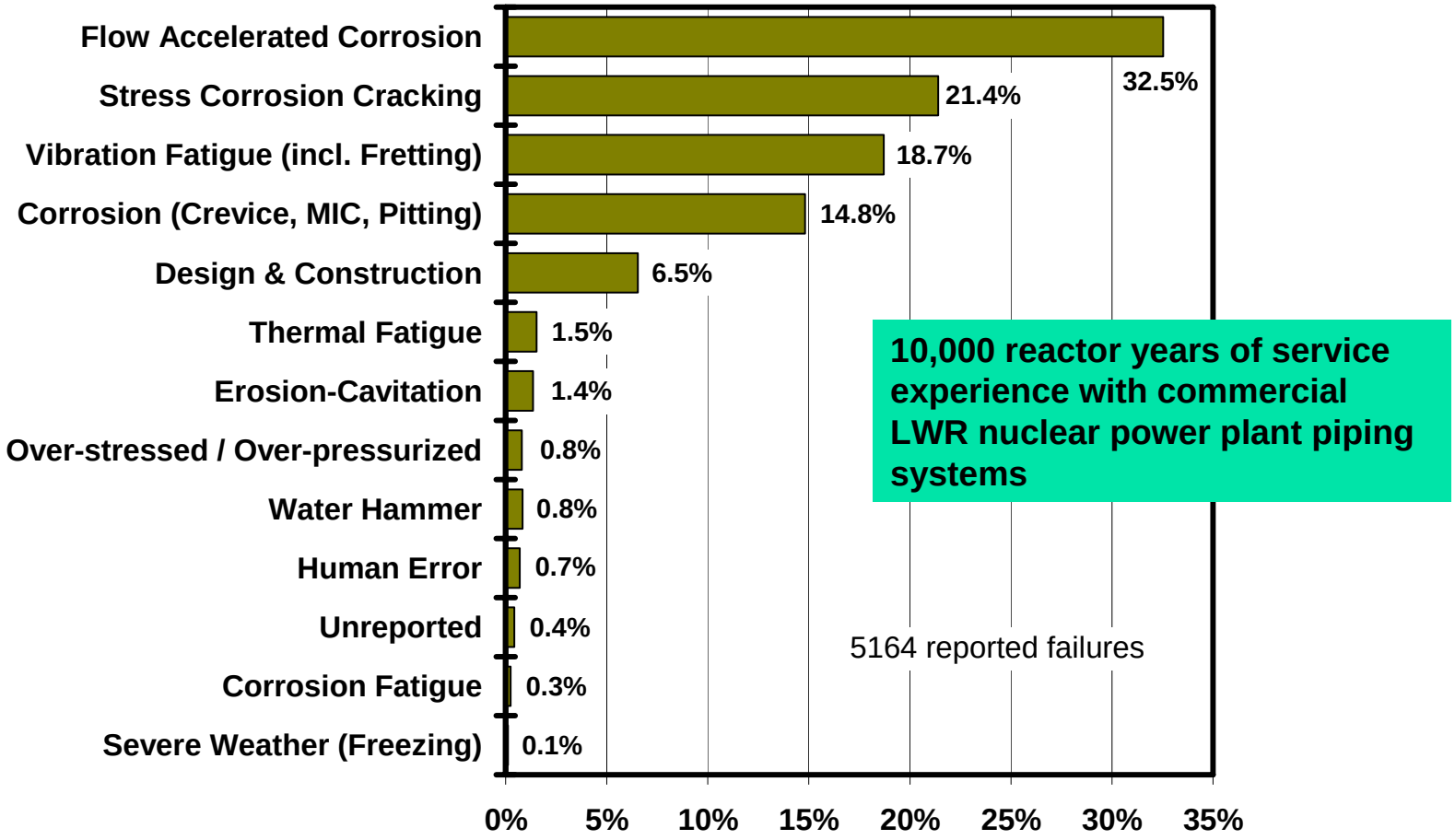
Summary

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

U.S. Failures by Degradation Mechanisms

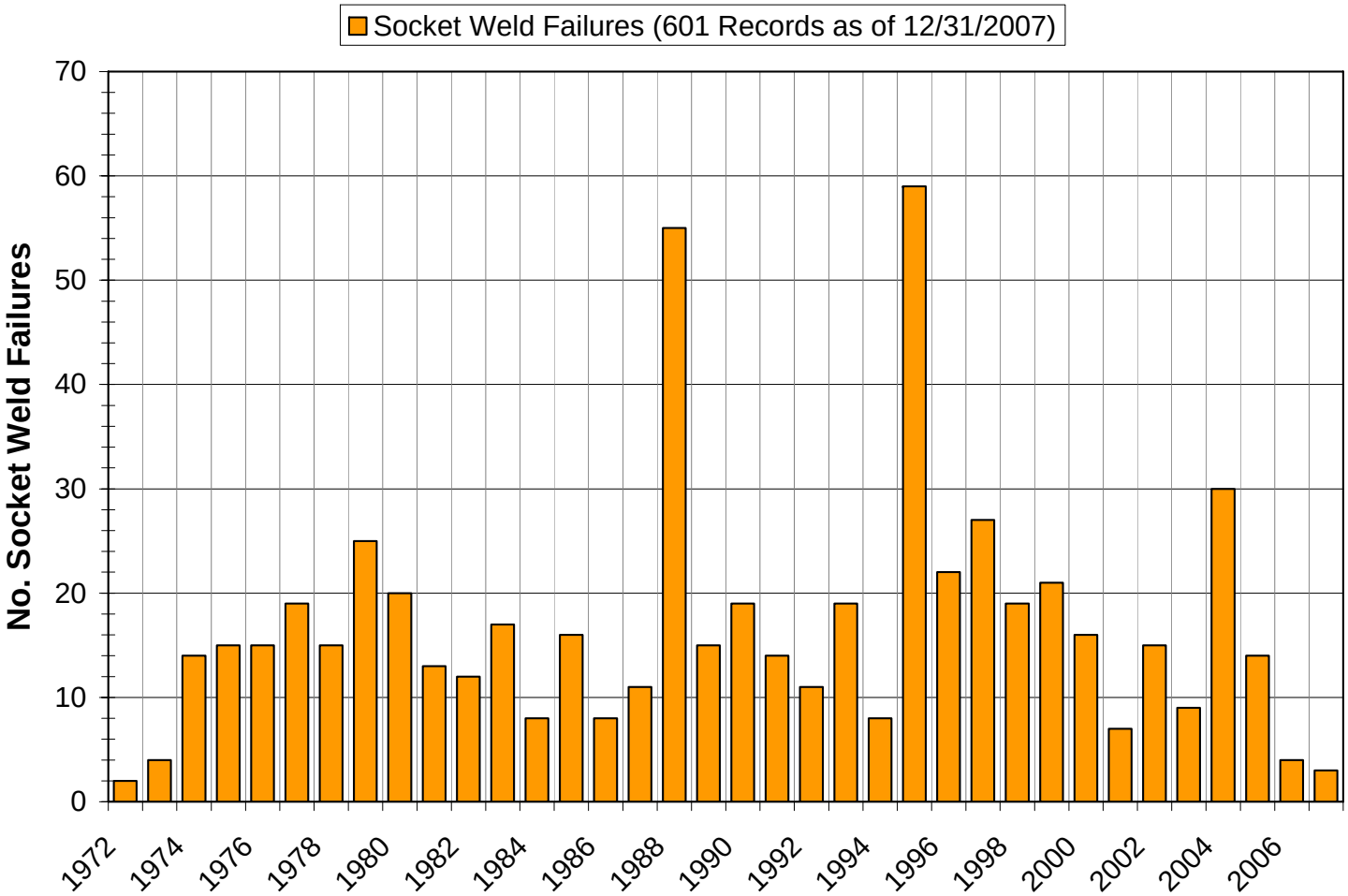


Source: PIPExp Database Data from 1970-2007

Fatigue Failure Experience

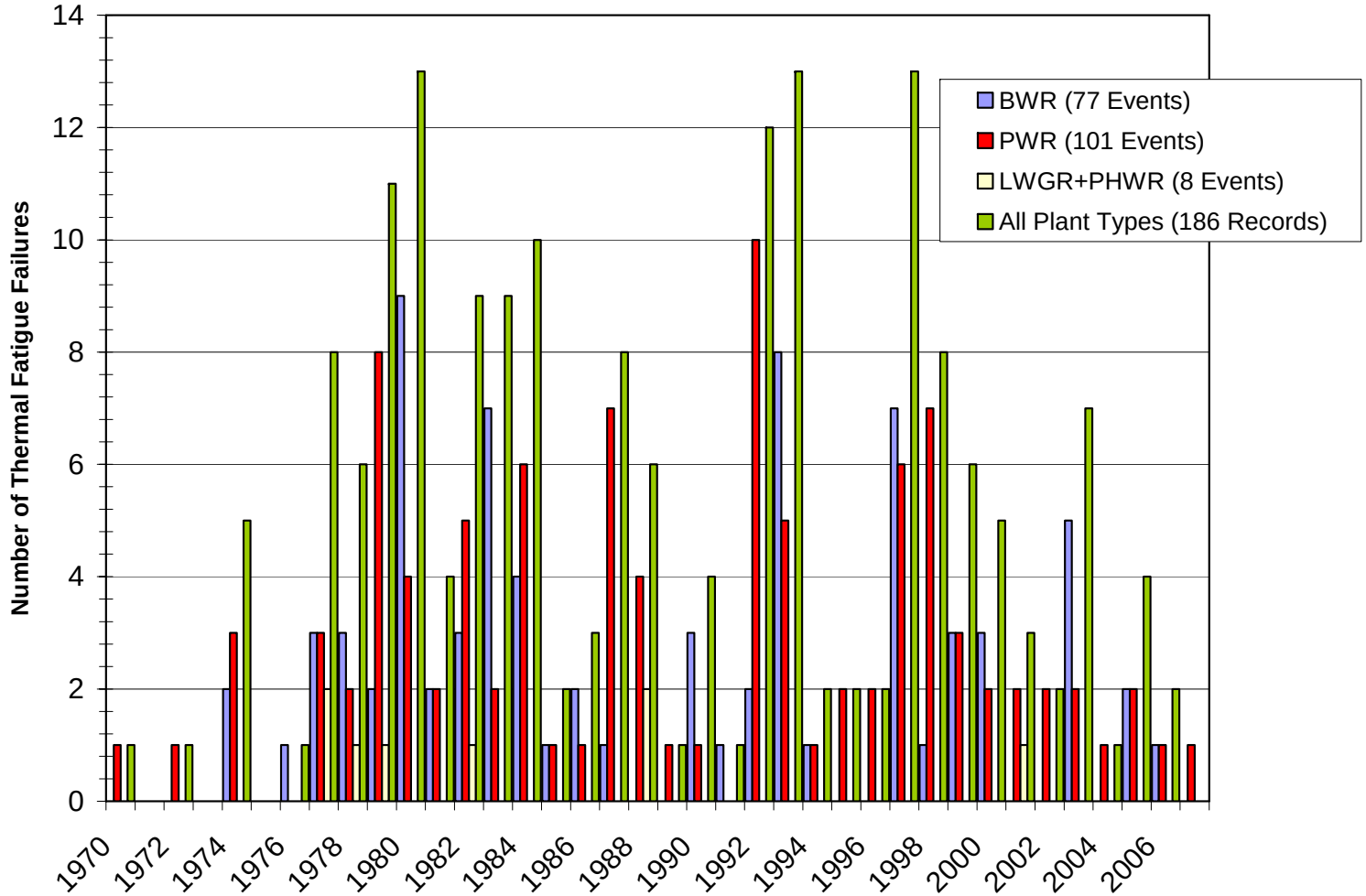
- Fatigue accounts for 21% of all reported failures in domestic operating NPPs
- Vibration Fatigue
  - 90% of the reported fatigue failures
  - Most all in small bore socket weld connections
- Thermal Fatigue
  - 2% of all reported failures
    - Thermal Stratification
    - Turbulent Penetration Effects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

- 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

- Environmental fatigue effects make it more difficult to 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 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 fabrication and repair welds' flaw size and density distributions and uncertainties
  - Uncertainties associated with: material properties, weld residual stresses, NDE detection and flaw characterization capabilities, crack initiation, and crack growth rates

Questions and Discussions