RIC 2005
Session G1 -- Materials Issues

Research Activities on Materials Aging Management

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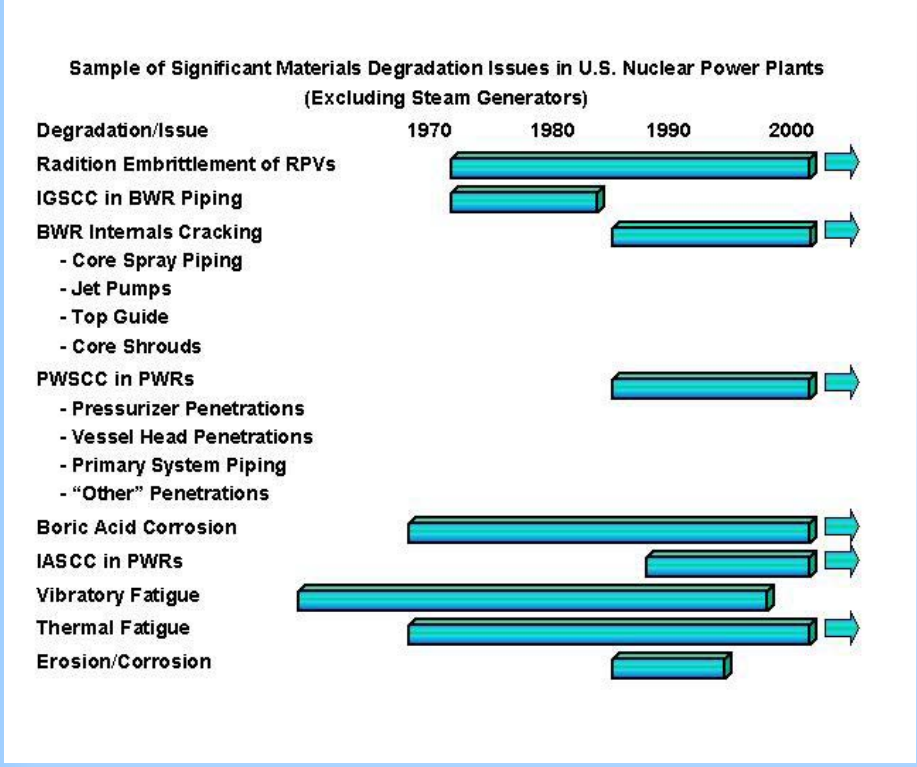
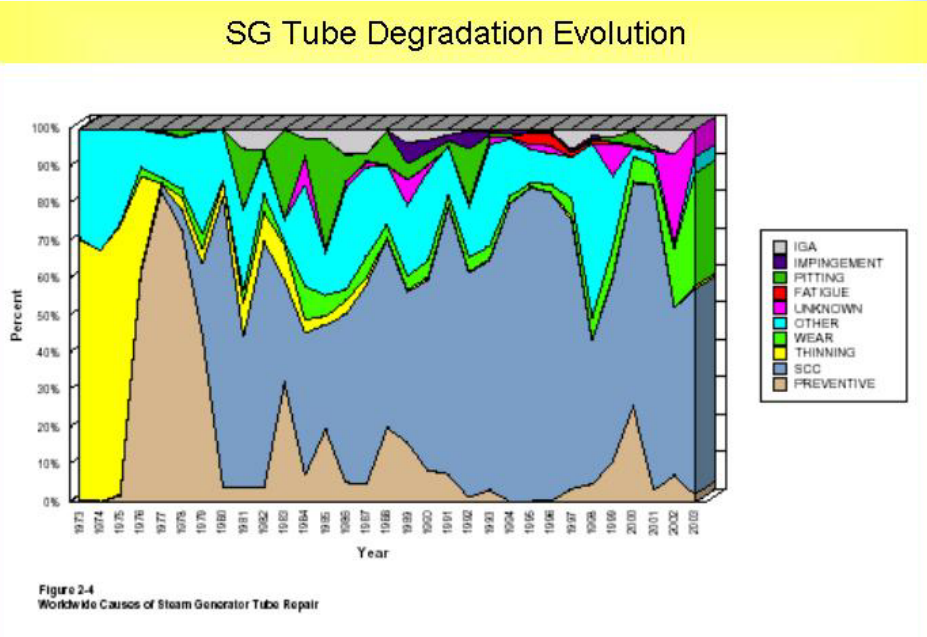
March 8, 2005

Managing Materials Degradation

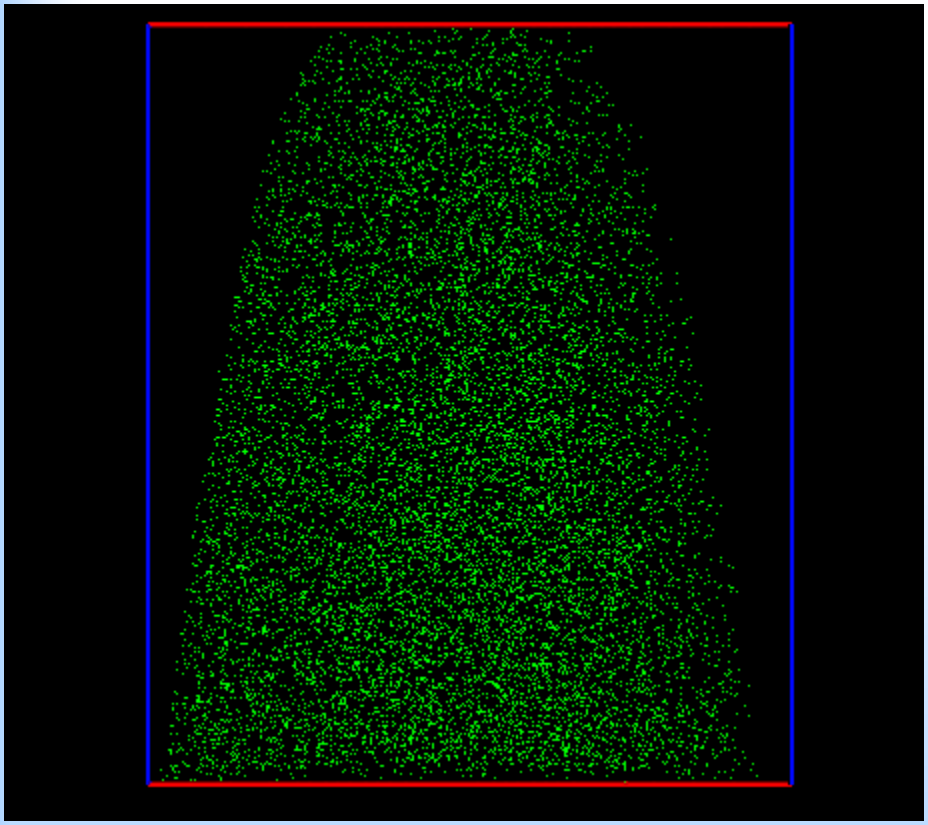
- Degradation of materials in operating reactors has a long history
- Degradation poses technical and regulatory challenges
  - PWR vessel head penetration (VHP) nozzles
  - PWR reactor coolant pressure boundary (excluding VHP nozzles and SG tubes)
  - BWR vessel, internals and piping
  - Steam generator tubes
- Materials degradation will continue

Managing Materials Degradation





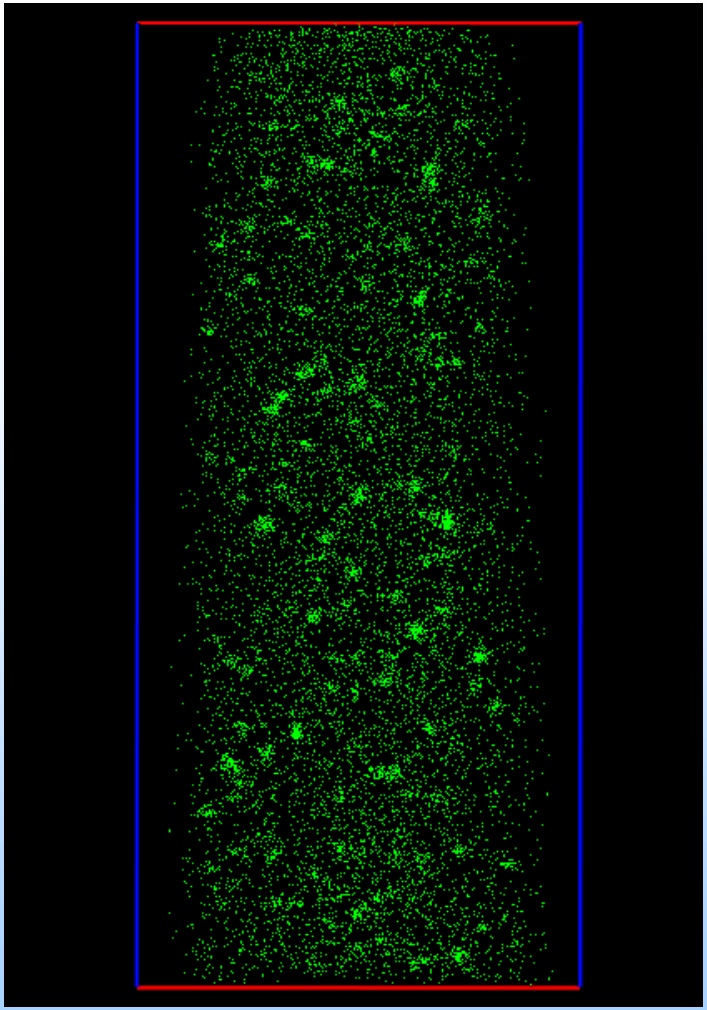
Embrittlement of RPV Steels



Each dot in these atom maps is an atom

Cu
P

10 nm



Unirradiated

Fluence: 1.4 x 10^{19} n cm^{-2} (E >1MeV)
Temperature: 288°C.

Before service in the nuclear reactor, all the copper atoms are uniformly distributed. After service, a high number of ~2-nm-diameter copper-enriched precipitates are present which make the weld brittle.

The composition of the weld from the Palisades nuclear reactor was Fe- 0.11 wt% C, 0.18% Si, 1.27% Mn, 0.04% Cr, 1.20% Ni, 0.20% Cu, 0.017% S, 0.014% P, 0.003% V and 0.55% Mo.

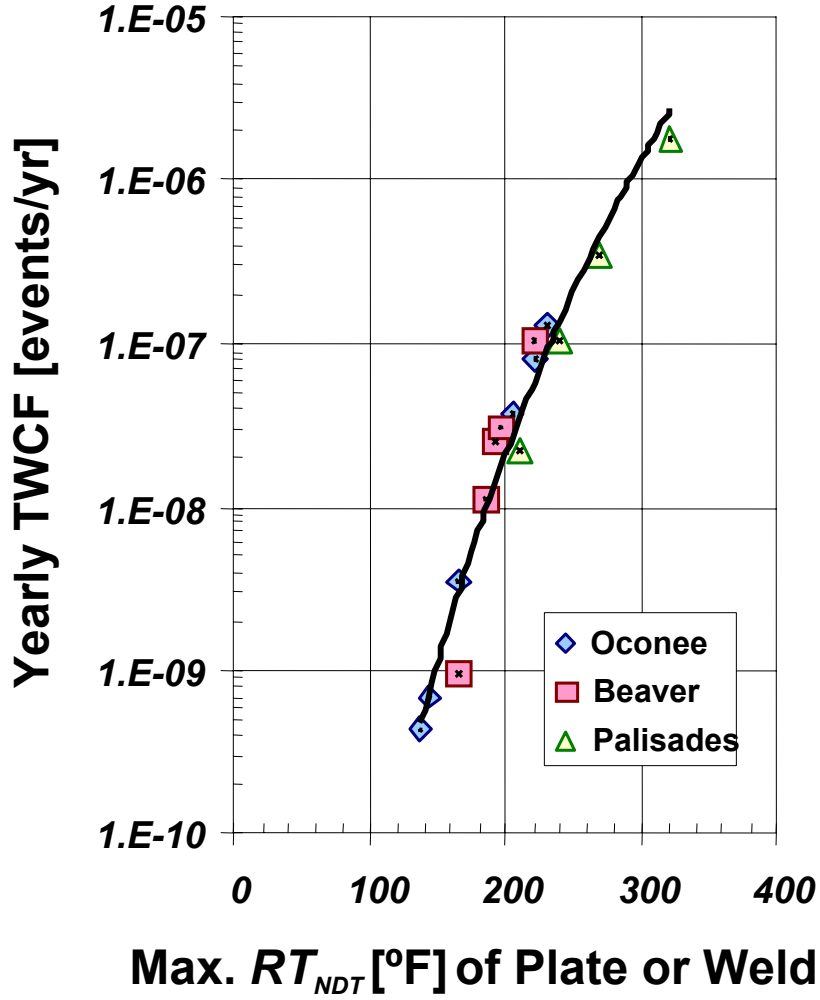
Atom probe tomography by
M.K. Miller, Metals and Ceramics Division

Results from Updated PTS Analyses are Encouraging for a Rule Revision

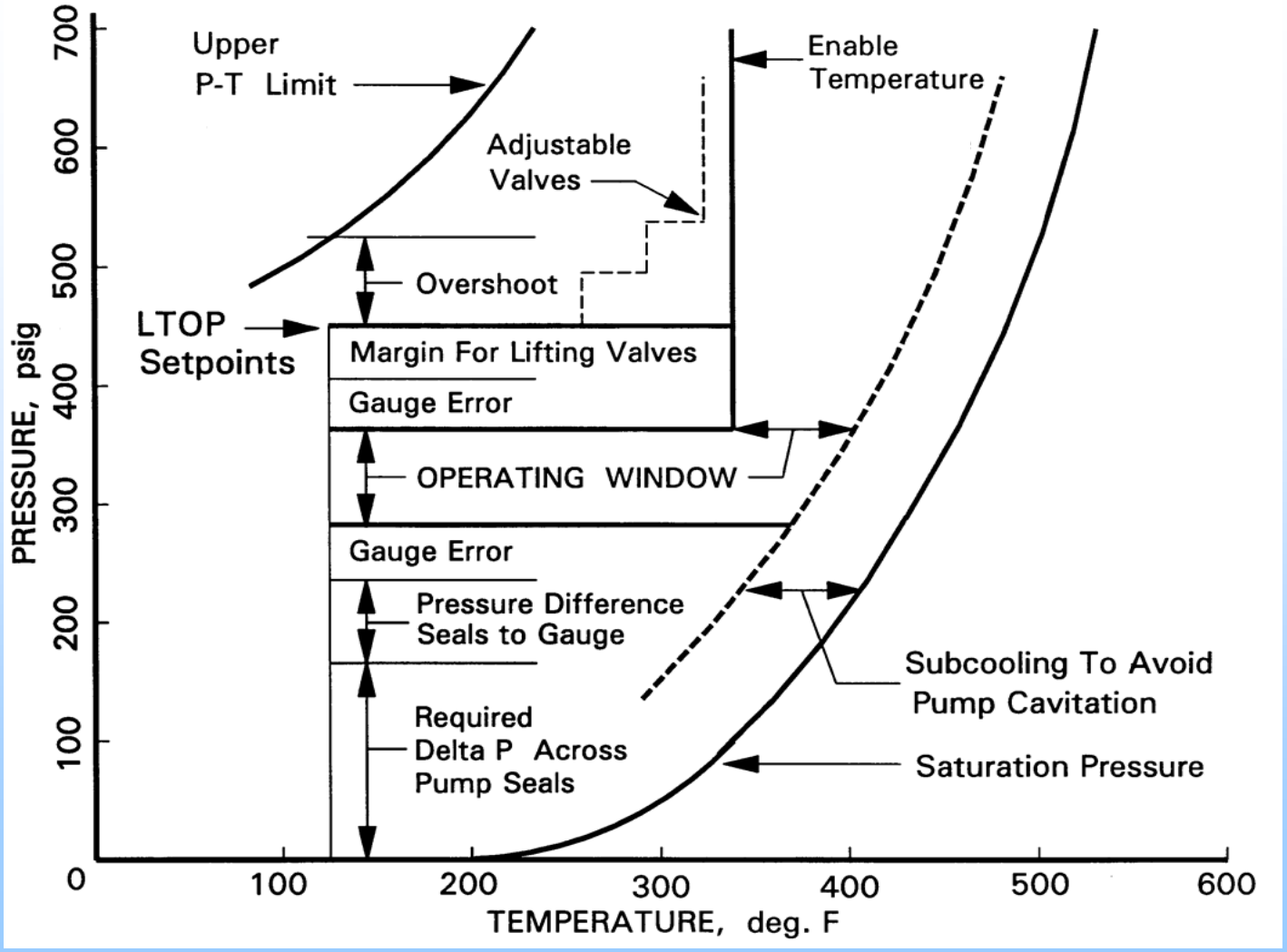
- Plant used in 1980s PTS study
- Babcox & Wilcox design

- High embrittlement plant
- Westinghouse design

- High embrittlement plant
- Combustion Engineering design



Pressure-Temperature Limits Can Create Operational Problems



Managing Materials Degradation

- Materials degradation will continue to evolve
  - Natural consequence of aging reactor materials
    - Temps ≤ 325°C, irradiation flux, aqueous environments
  - New forms of old problems, as well as new mechanisms
- Inspection and monitoring procedures and techniques must also evolve
  - Techniques tailored to known degradation
  - Broad-scope techniques to identify emerging degradation
- Materials data
  - Characterize current and replacement materials for known degradation
  - Scoping experiments to identify new degradation

Summary

- Materials will continue to degrade with time and operation
- Well coordinated NRC program addressing issue
- Industry involvement
- National and international technical communities are involved, and are cooperative
- Programs addressing currently identified degradation
- Research program addressing
  - Potential new degradation mechanisms
  - Inspection and monitoring techniques
  - Mitigation and repair strategies
- Aggressively handling degradation as it emerges