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Irradiation Assisted Stress Corrosion Cracking Testing Laboratory at INL

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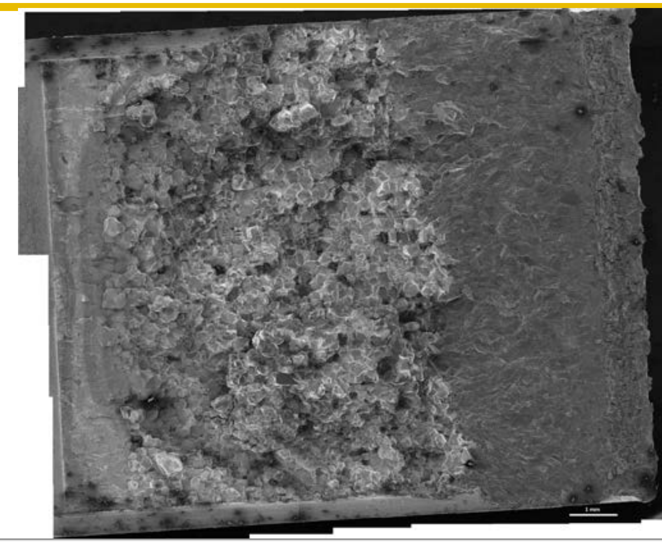
Irradiation Assisted Stress Corrosion Cracking (IASCC)

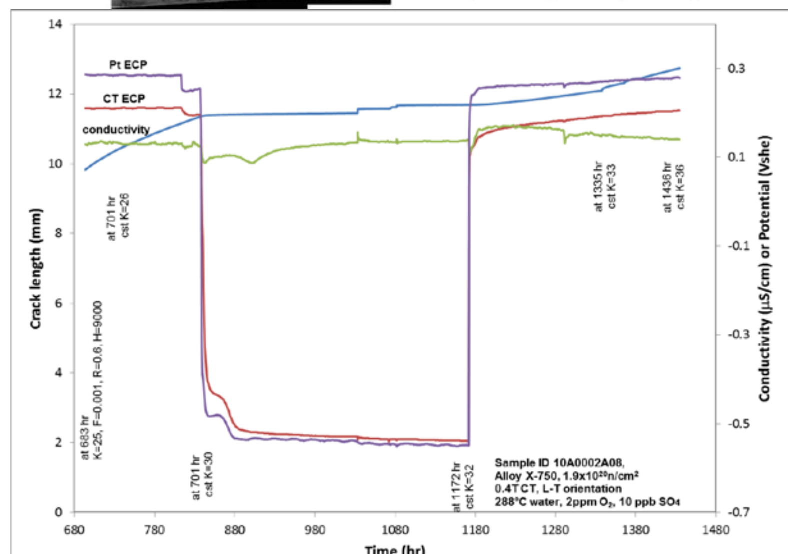
What/Why IASCC?

- Irradiation assisted stress corrosion cracking (IASCC) describes environmentally assisted cracking in reactor structural components that is exacerbated by radiation exposure. It leads to intergranular cracking with little to no ductility of the irradiated components.
- IASCC is one of the main issues of consideration for lifetime extension
- Issue to consider for material development, new manufacturing processes, new environment

IASCC crack growth rate testing requirements?

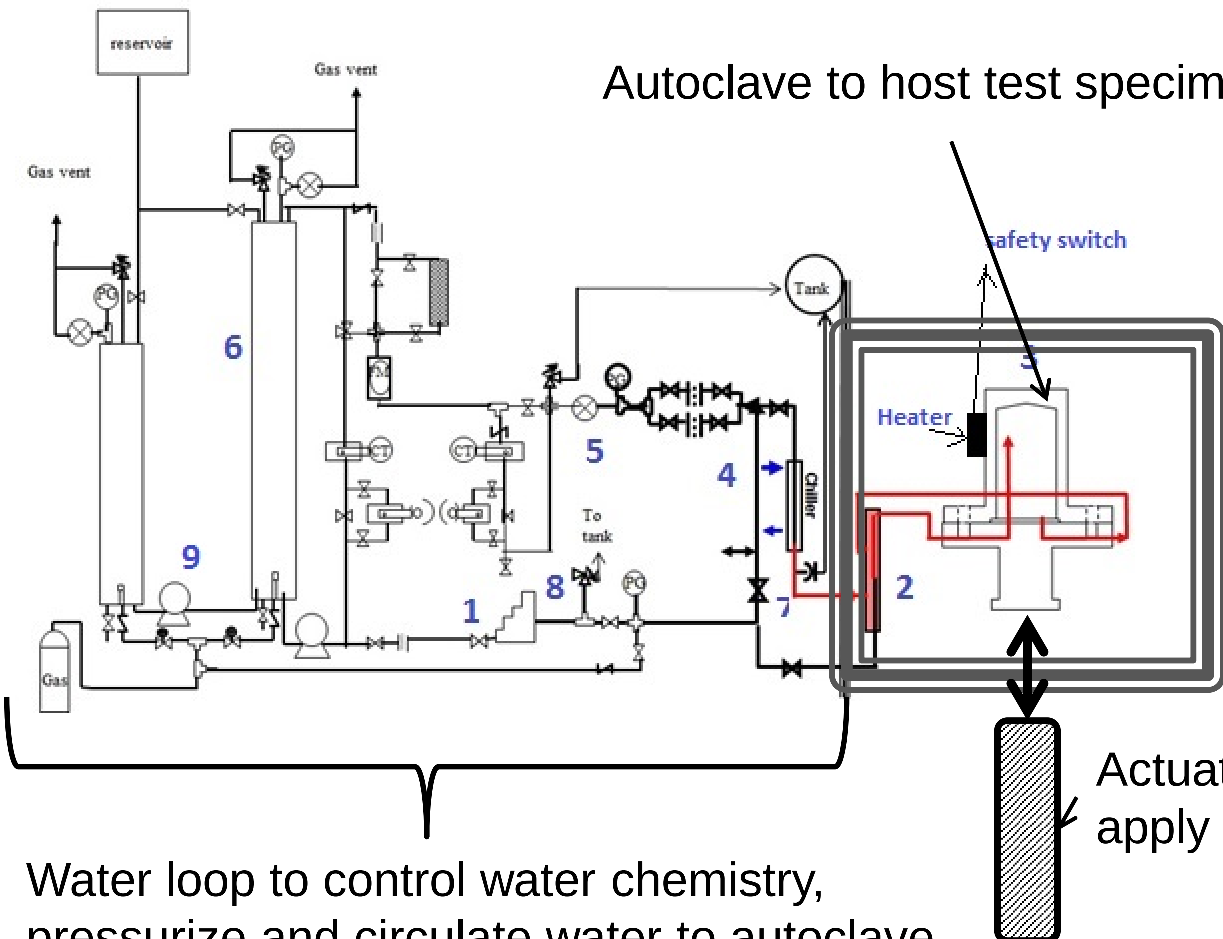
- Long experiments (6 months)
- Water chemistry control important
- Crack growth monitoring required (dcpd)





Example of crack length and water chemistry as a function of time

IASCC test loop



Autoclave to host test specimen

Actuator apply stress

Water loop to control water chemistry, pressurize and circulate water to autoclave

specimen

Reference electrode

Dcpd leads

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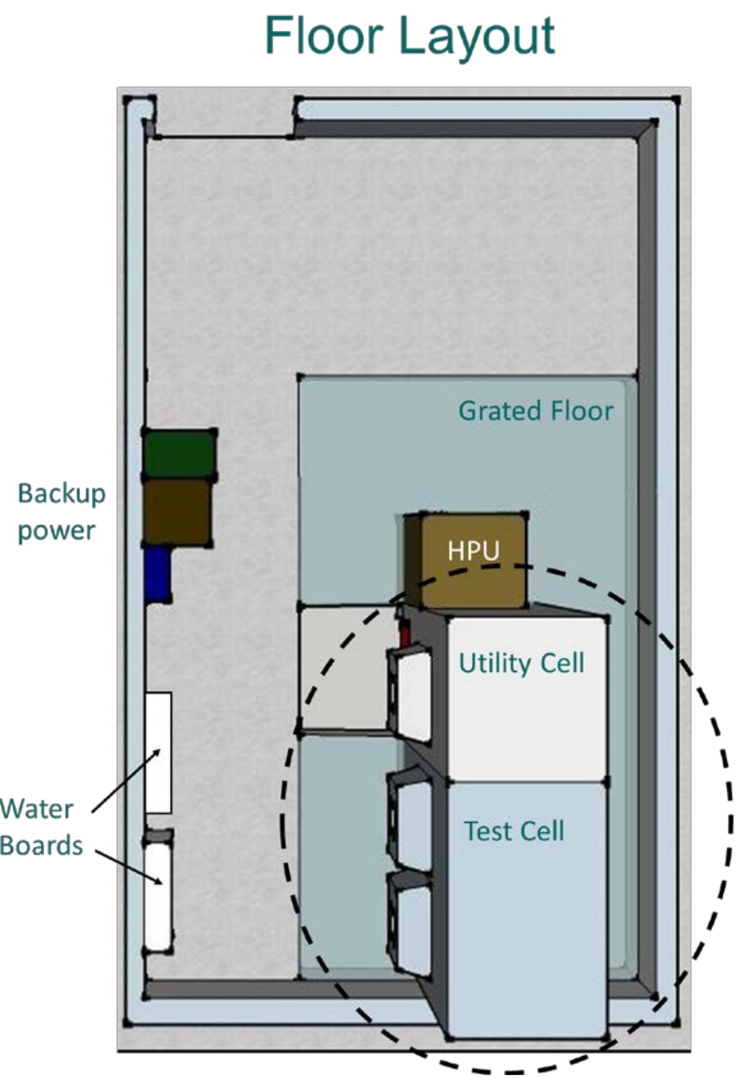
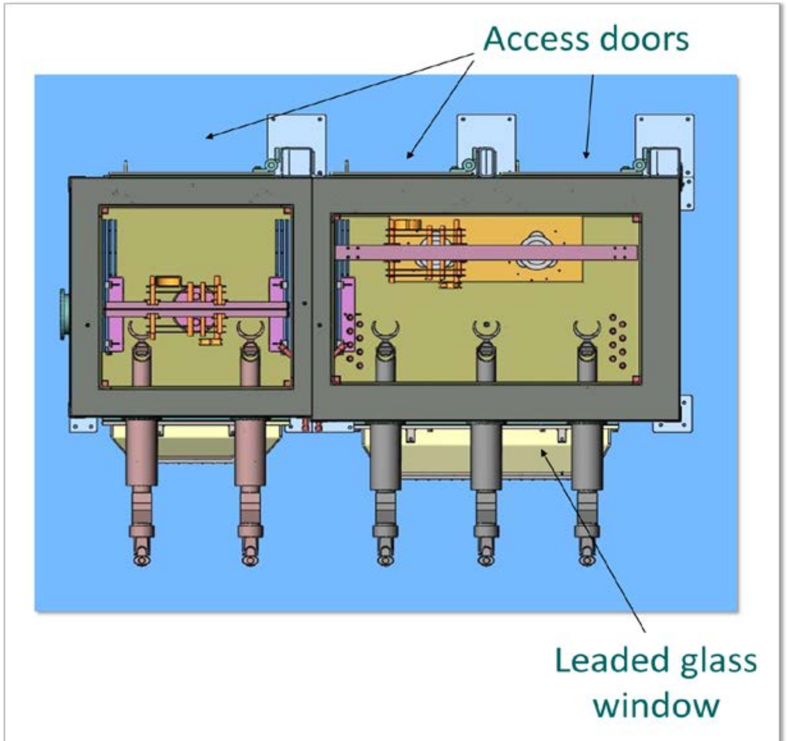
Laboratory layout



Requirements

- Power back up (long experiments)
- Specimen transfer from outside facilities
- Shielding and loading capability for 1T CT specimen (shielding 45000 R/hr source)
- Accessible for regular maintenance



Construction: initial room

Step 1 : relocation of the machine shop

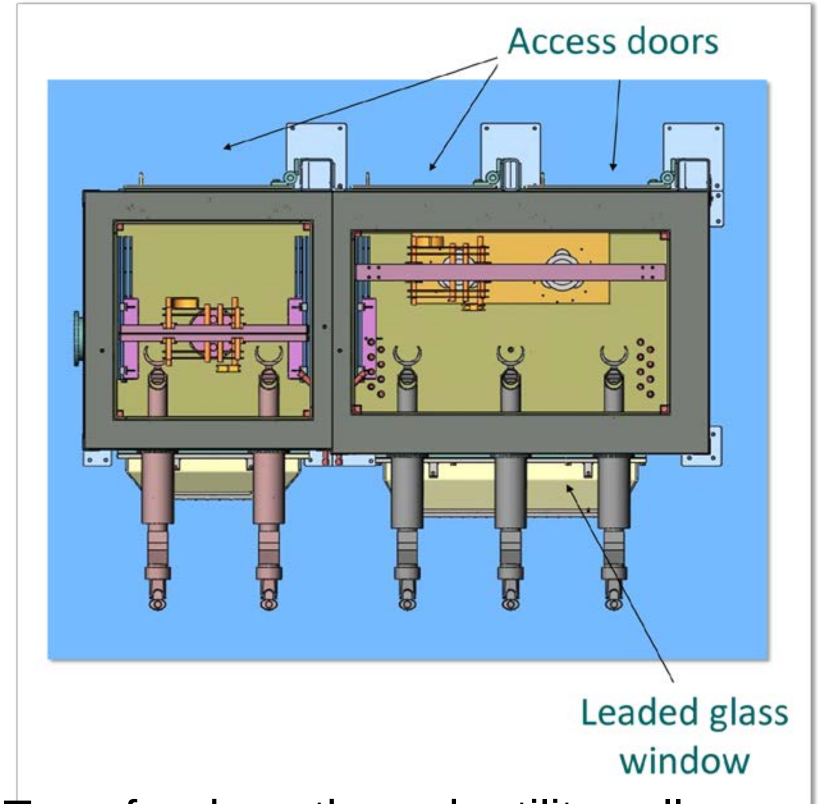
Construction : floor modification

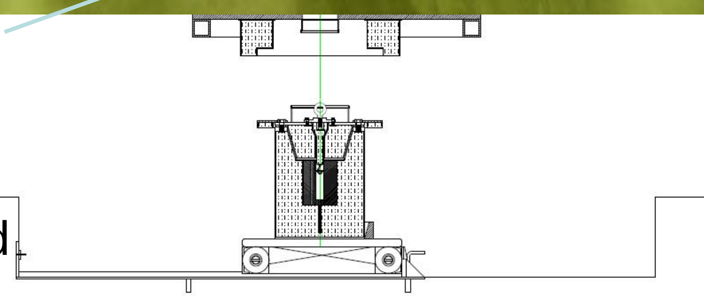
IASCC laboratory

Two independent refreshed testing loops able to maintain BWR or PWR water chemistry:

- Water conductivity and dissolved oxygen content measured at room temperature
- Dissolved gas controlled by gas overpressure in reservoir

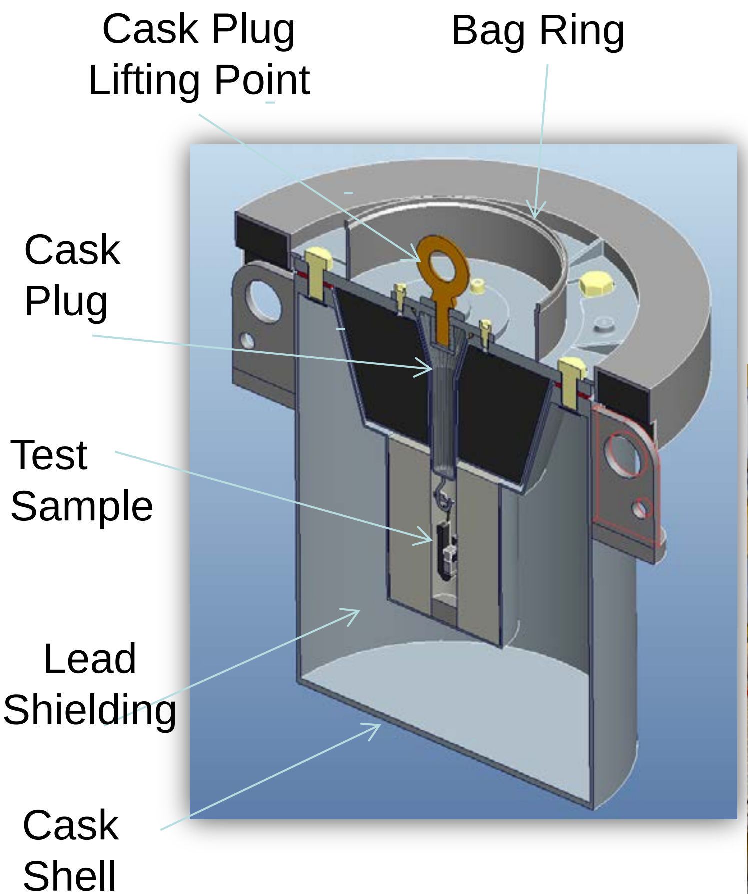
Utility/transfer cell





- Transfer done through utility cell
- Transfer cask : GE 100
- Served by 2 manipulators
- Additional decontamination performed as needed

Transfer cask

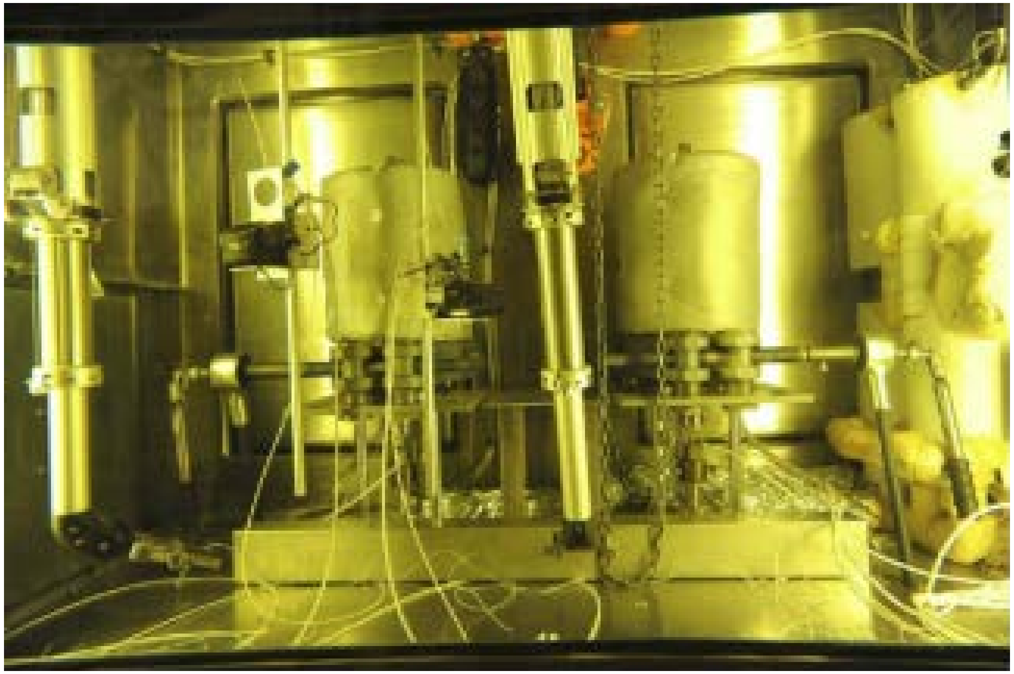


Modified GE 100
Custom made bag rind, plug,

Specimen transfer :
- **Cask lowered in the pit**
- **Cask mates with the cell.**

Test cell

Served by:
- Three manipulators
- Travelling chain hoist
- Camera

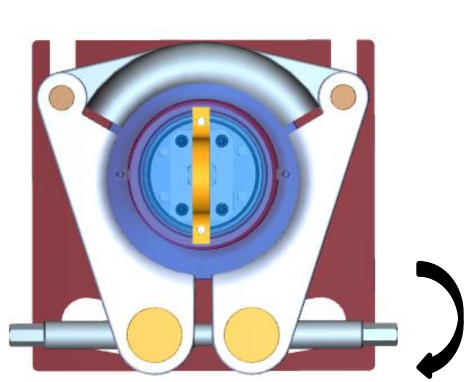


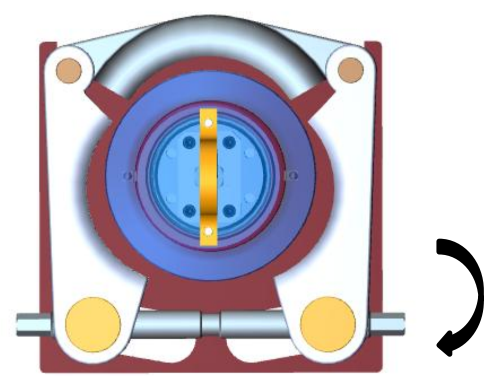
Two autoclaves rated for BWR and PWR testing conditions.

Each autoclave is equipped with:
- Two heat exchangers
- A servo hydraulic actuators (up to 100kN of load) located underneath the hotcell
- Two thermocouples (inside) plus two thermocouples on the outside surface
- Platinum leads for dcpd crack growth measurement
- Platinum flag and reference electrode for ECP measurement

Autoclaves

- Rating : 3250 psi, 750ºF (400ºC)
- Useable space: 5” ID, 12” tall (capability for one 1T CT specimen or smaller CTs in series)
- Sealing : clamping system.

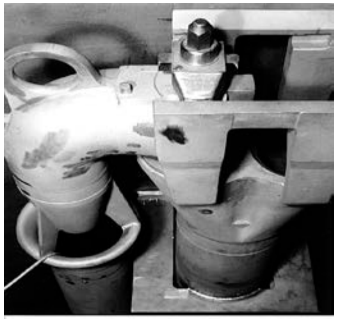




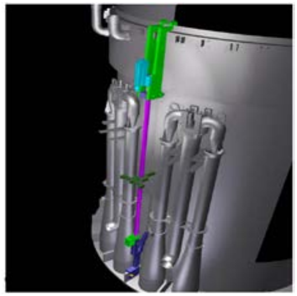
Post test analysis : SEM

NEOSCOPE : bench top SEM with most electronic is located outside the cell

EPRI Pilot Project: Irradiation and PIE of Alloys X-750 and XM-19



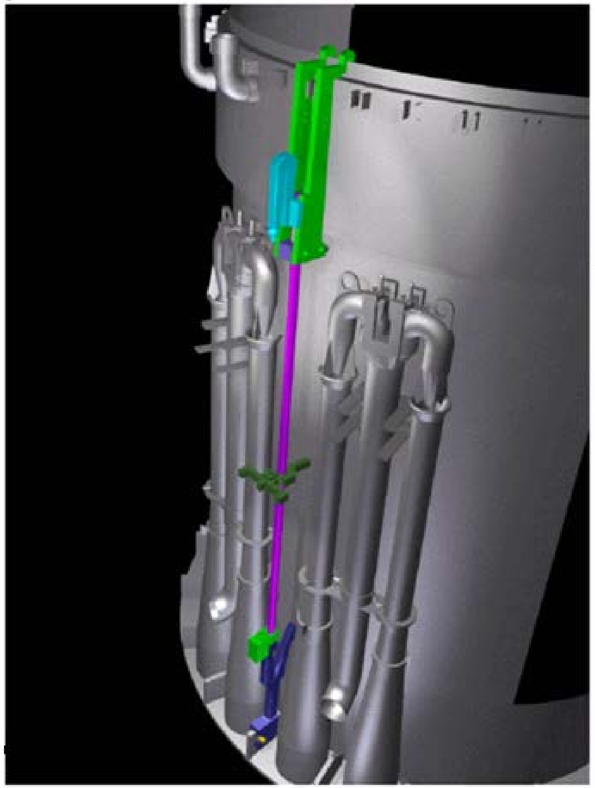
- **Alloys X-750 (HTH) and XM-19 (SA) are used in many structural applications in BWRs ranging from original equipment to modifications and repair hardware**
  - SCC and fracture toughness data in BWR water chemistry conditions are rather limited, particularly when exposed to neutron irradiation
- **A multi-year program (target completion 2018) is in place to examine the SCC and fracture toughness behavior of these materials under a variety of BWR conditions, both un-irradiated and irradiated**



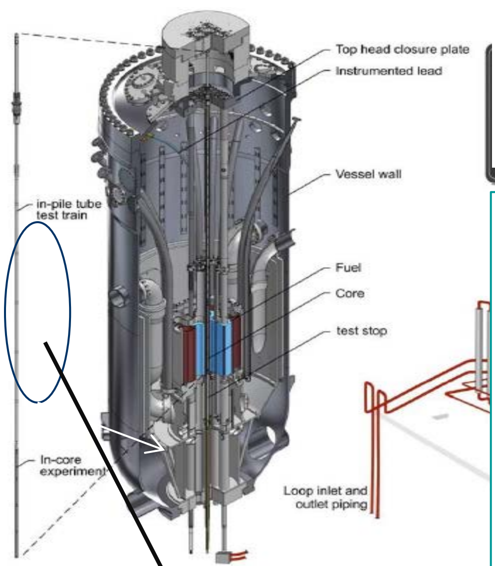
Program Overview

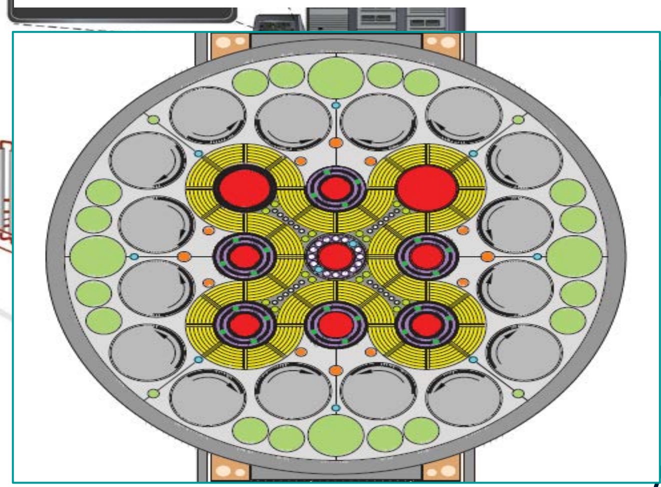
- **Material**
  - **X-750, o**btained from core shroud upper support bracket
  - **XM 19**
- **Irradiation**
  - Three target fluences :
    - 5×10^{19}, 2×10^{20} and 1×10^{21} n/cm^2
  - Temperature control: 288ºC, water cooled

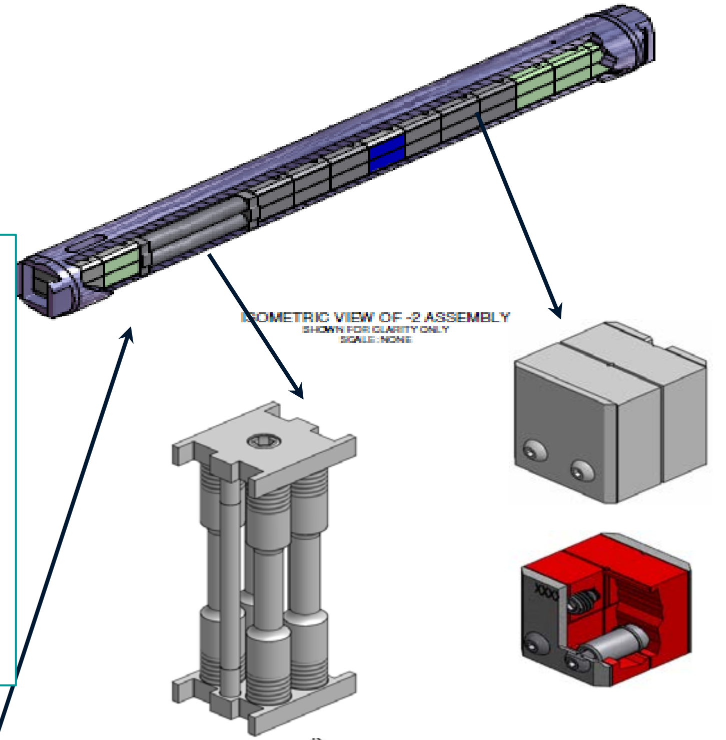
- **Post Irradiation Examination (PIE)**
  - SCC and IASCC crack growth rate
    - K dependency, ECP dependency
  - Fracture toughness
  - Tensile properties
  - Microstructure characterization

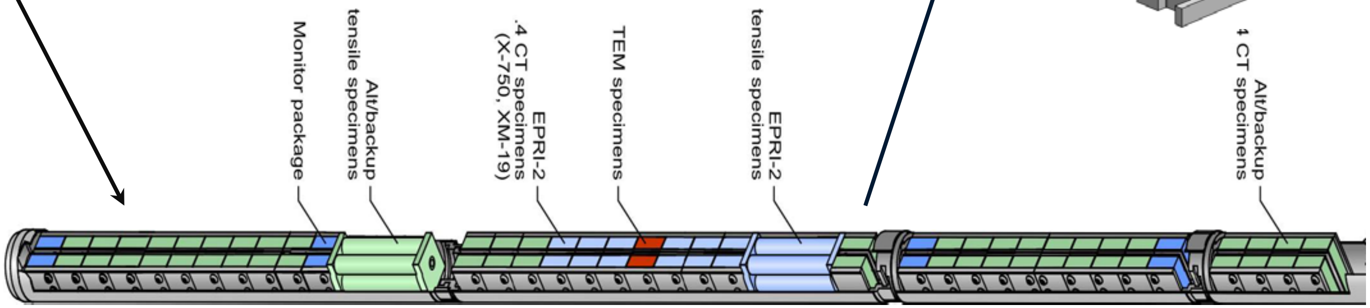


- Controlled chemistry
- Temperature control
- Isolated from coolant









EPRI-2 Experiment... 1st in Loop 2A, Feb 2013

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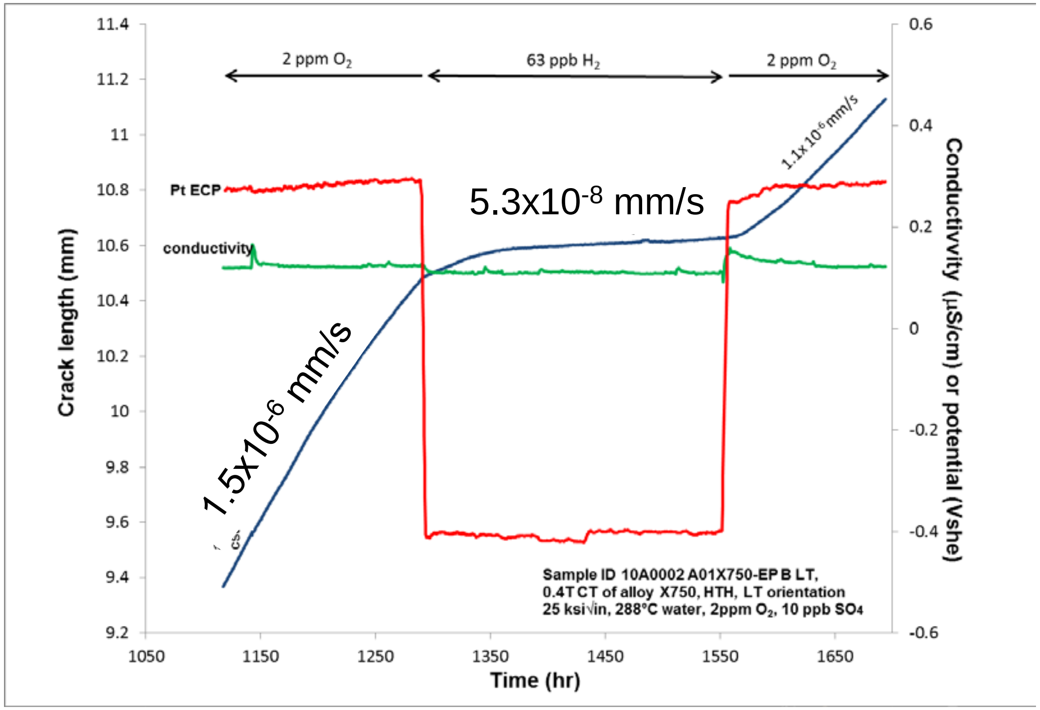
Un-irradiated X-750 (HTH) SCC CGR



- K = 25 ksi√in
- High CGR
- Strong effect of corrosion potential on CGR

Unirradiated crack growth rate	
NWC*	8.8 – 18 X 10^{-7} mm/s
HWC	1.3 – 13 X 10^{-8} mm/s

* With 0-10 ppb sulfate

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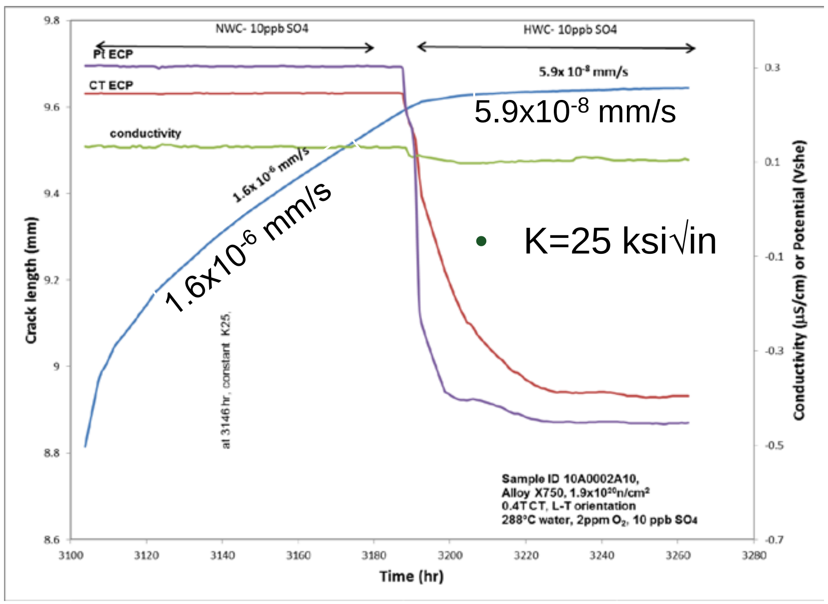
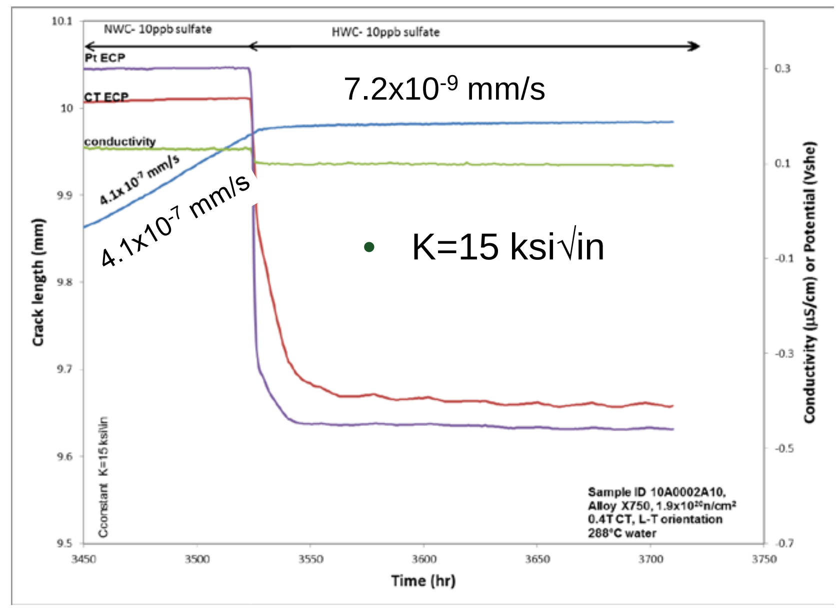
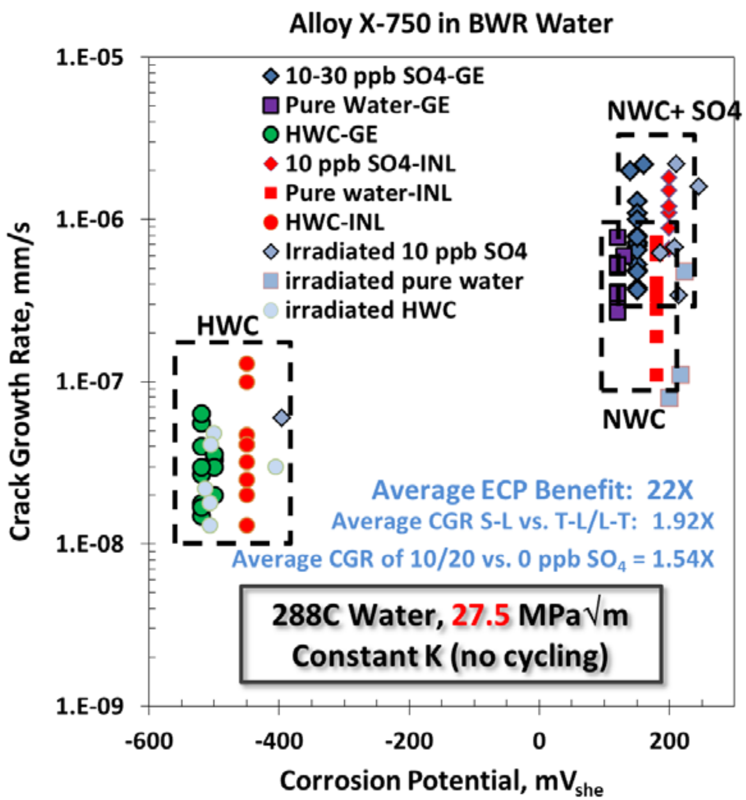
Irradiated X-750 (HTH) ($1.93x10^{20}n/cm^2$) IASCC CGR Testing





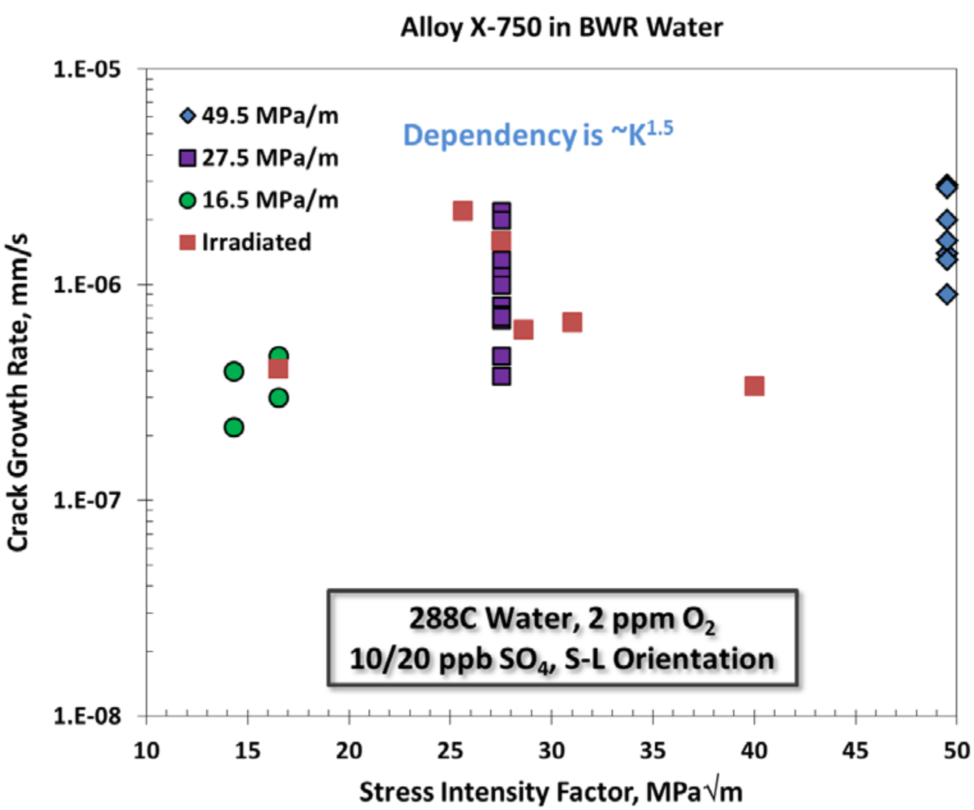
Unirradiated crack growth rate	
NWC*	8.8 – 18 X 10^{-7} mm/s
HWC	1.3 – 13 X 10^{-8} mm/s

X-750 (HTH) Summary Results



- No significant changes in CGR after 1.9 x 10^{20} n/cm^2 irradiation
- Effectiveness of HWC mitigation retained

X-750 (HTH) Summary Results



- K dependency after 1.9×10^{20} n/cm^2 irradiation similar to that of unirradiated X-750

Summary

- IASCC testing laboratory operational
- Program assessing the effect of fluence on the evolution of SCC and fracture toughness of X-750 (HTH) and XM-19 under a variety of BWR conditions is underway
- The X-750 (HTH) specimens irradiated to the fluence of 1.93 X 10^{20} n/cm^2 (intermediate fluence) did not exhibit an increased CGR compared to unirradiated X-750 (HTH) tested in either NWC or HWC conditions

Questions ?