#### **Radiation Effects on Materials**

# Effects of Radiation on Material

- Gamma, fast neutrons, slow neutrons
  - Cause damage to materials by unique mechanisms
- Oils and soap based greases
  - Oils get stiffer
  - Soap based greases get less viscous
- Plastics
  - Embrittlement if the molecules are complex

# Effects on Plastic

• Plastics

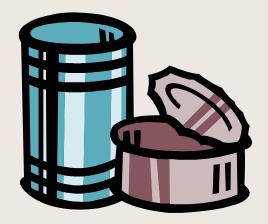
- Embrittlement if the molecules get more complex
- Lose strength if the molecules get shorter
- Decompose to gas



# Effects on Metals

- Ultimate tensile strength↑
- Yield strength  $\uparrow$
- Hardness ↑

• Ductility  $\downarrow$ 



# Effects on Concrete

- Radiation heats the concrete
- Heat drives out water
- Loss of of water had two effects
  - Spalling and cracking of the concrete
  - Lowering of shield effectiveness



#### Pressure Tubes

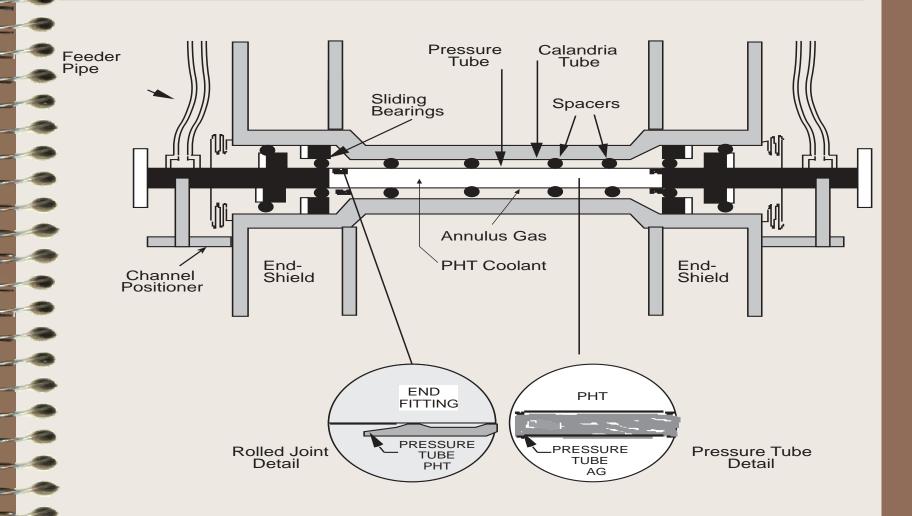
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### 2 Effects

- Pressure tubes get longer
- Pressure tubes get brittle

### Pressure Tube Schematic



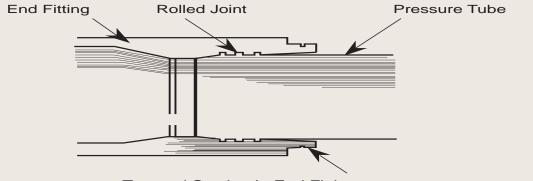
# Delayed Hydride Cracking

- A very bad thing
- Hydrogen in a tube



- Migrates to areas of high stress
- Stays in-solution at high temps
- Forms brittle deuterium hydride when cooled
- Stress occurs at rolled joints

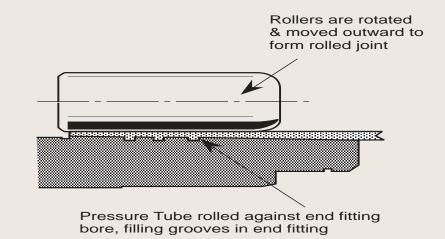
#### **Rolled** Joints



**Tapered Section In End Fitting** 

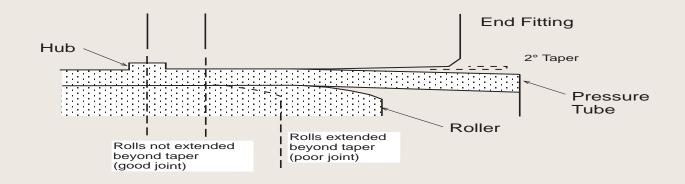
Rolling

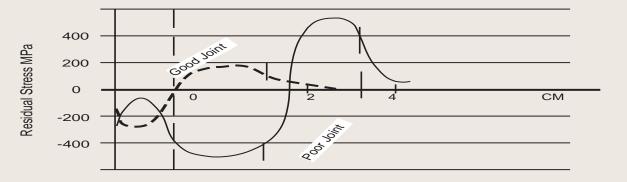
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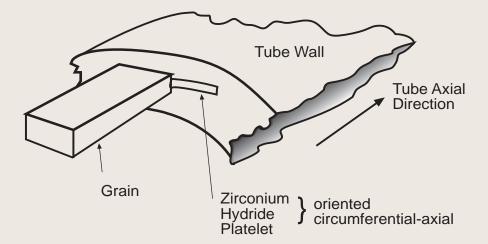
#### Stresses at Rolled Joints





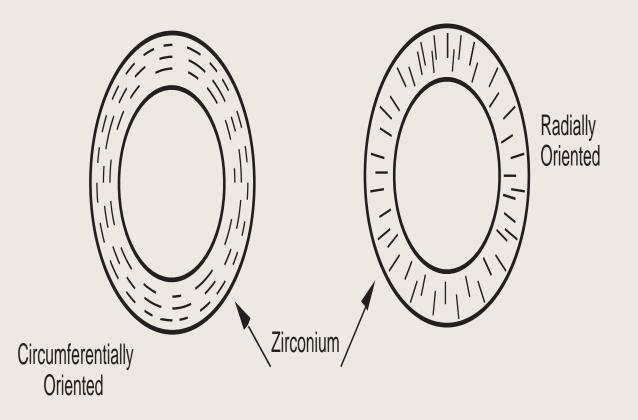


# Zirconium Hydride Platelets

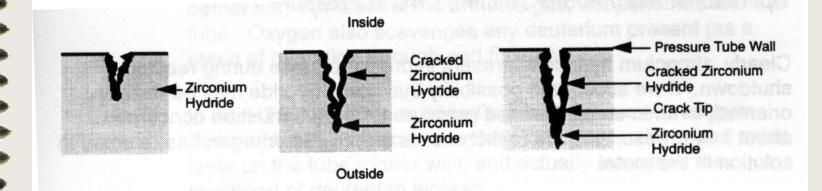




#### **Platelet Orientation**



#### Crack Growth

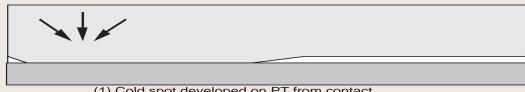


# What is done

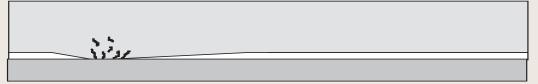
- Sampling to keep track of H<sub>2</sub> in tubes
- Warm up and pressurizing procedure
  - Don't apply full pressure on a cold tube
  - Warm up quickly to dissolve hydrogen

## Blistering

#### PROBABLE SEQUENCE OF CRACK DEVELOPMENT FROM PRESSURE TUBE (PT)/CALANDRIA TUBE (CT)



 Cold spot developed on PT from contact with CT causing H<sub>2</sub>/D<sub>2</sub> diffusion to cold spot



(2) Blister develops and cracks from volume expansion of hydride



(3) PT sags, blister indents the calandria tube and PT contacts at another spot down the tube



(4) Cracks, developed from blisters, link up and grow to an unstable size.

# For You to Do

- Read the section on radiation damage pp. 41-52
- Answer questions p. 53