

# Graphite: An Enabling Material For ThorCon Molten Salt Fission Reactor



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Graphite – Molten Salt Interaction  
Workshop

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Two 500 MWe ThorCon liquid fission power plants

# ThorCon Is a Thermal Spectrum, Molten Fluoride Salt Reactor Contained in a Can

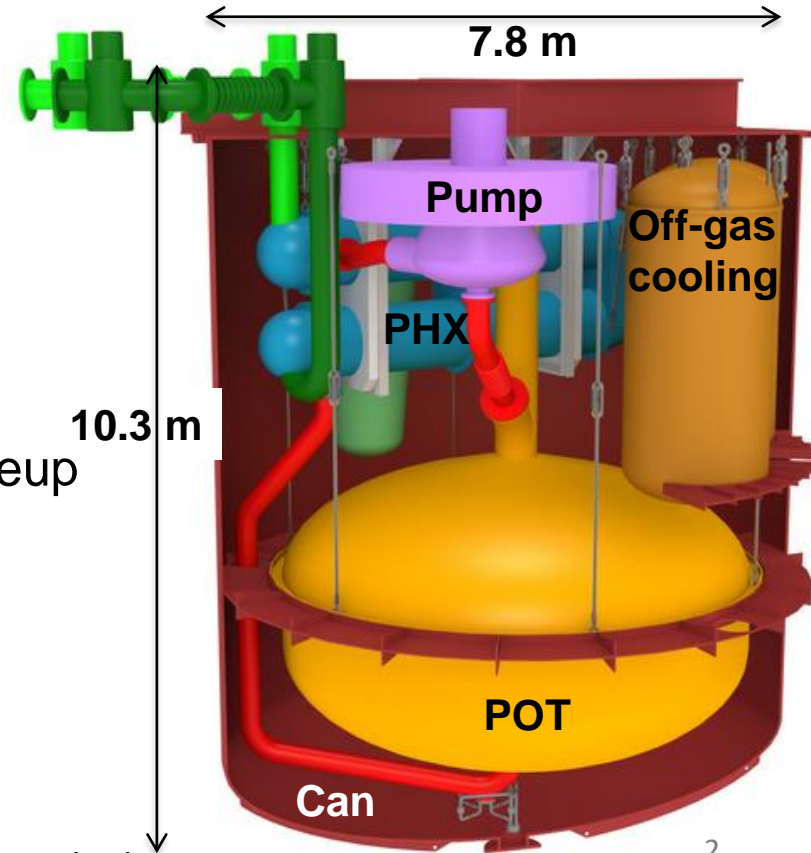
## ❖ Pot (Vessel) (316 SS)

- ◆ Pressure: 3.5 bar (0.33 Mpa)
- ◆ NaF-BeF<sub>2</sub>-UF<sub>4</sub> (72-16-12 mol %)\*
- ◆ Temperature: inlet/outlet 564/704°C
- ◆ Graphite moderator (4 y lifetime) with channels for molten salt flow
- ◆ Converts some U-238 to Pu-239 (makeup fuel is added continuously)

## ❖ Pump

- ◆ Fuel-salt pumped at ~ 3300 kg/s
  - 14 sec loop time

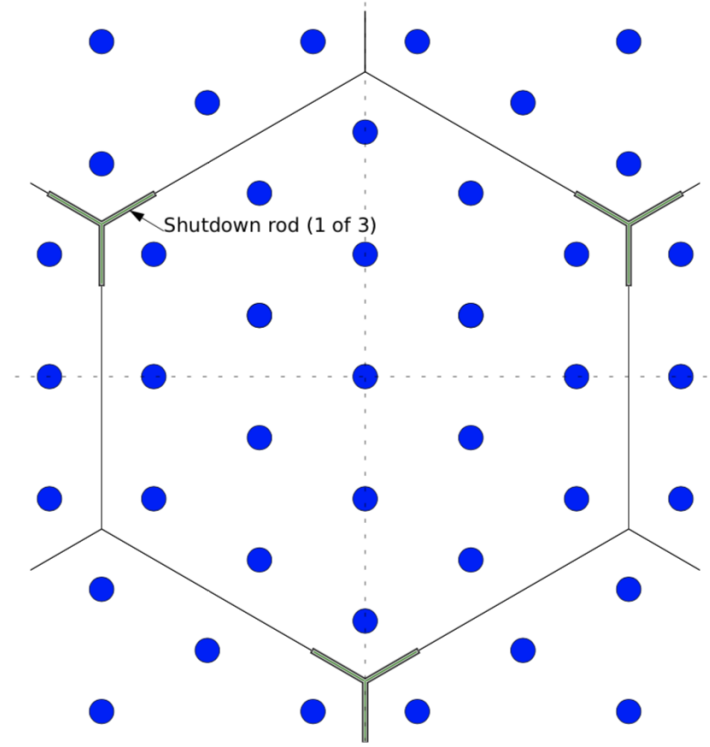
## ❖ Primary Heat Exchanger (PHX)



\*Being revised

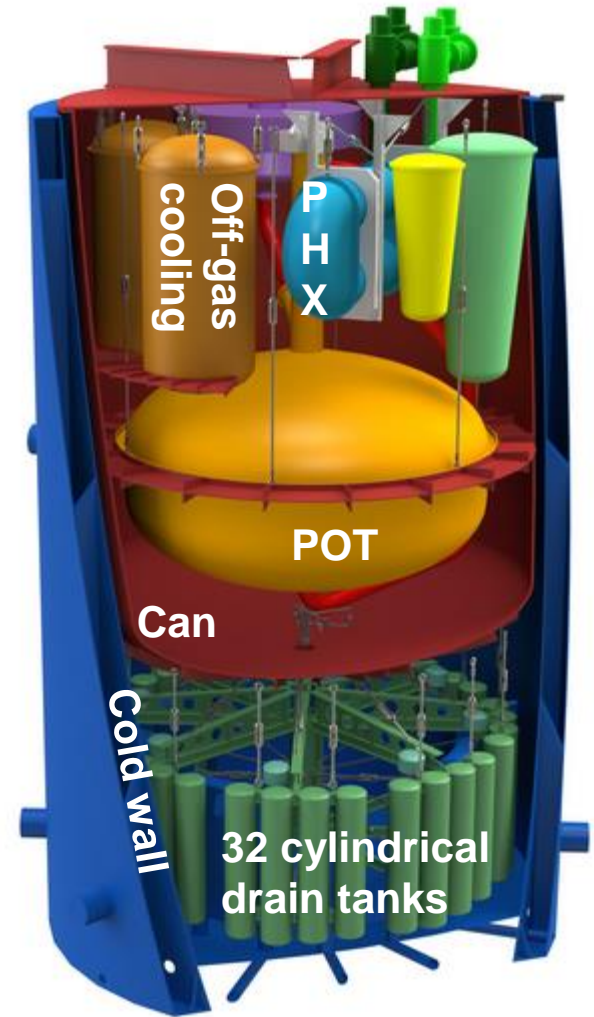
# Control of ThorCon Is Achieved via:

- ❖ Negative temperature coefficient ( $-6$  to  $-2$  pcm/K)
  - ◆ Increased temperature reduces reactivity
- ❖ Drop of any one of 3-control rods
- ❖ Drain of fuel-salt to drain tank
  - ◆ Loss of heat sink or loss of flow that results in a temperature rise of  $\sim 120\text{K}$
- ❖ Redox control
  - ◆ Minimized corrosion (general & localized)
  - ◆ Avoid carbide precipitation ....
- ❖ Removal of Xe (transient response) via Off-gas system

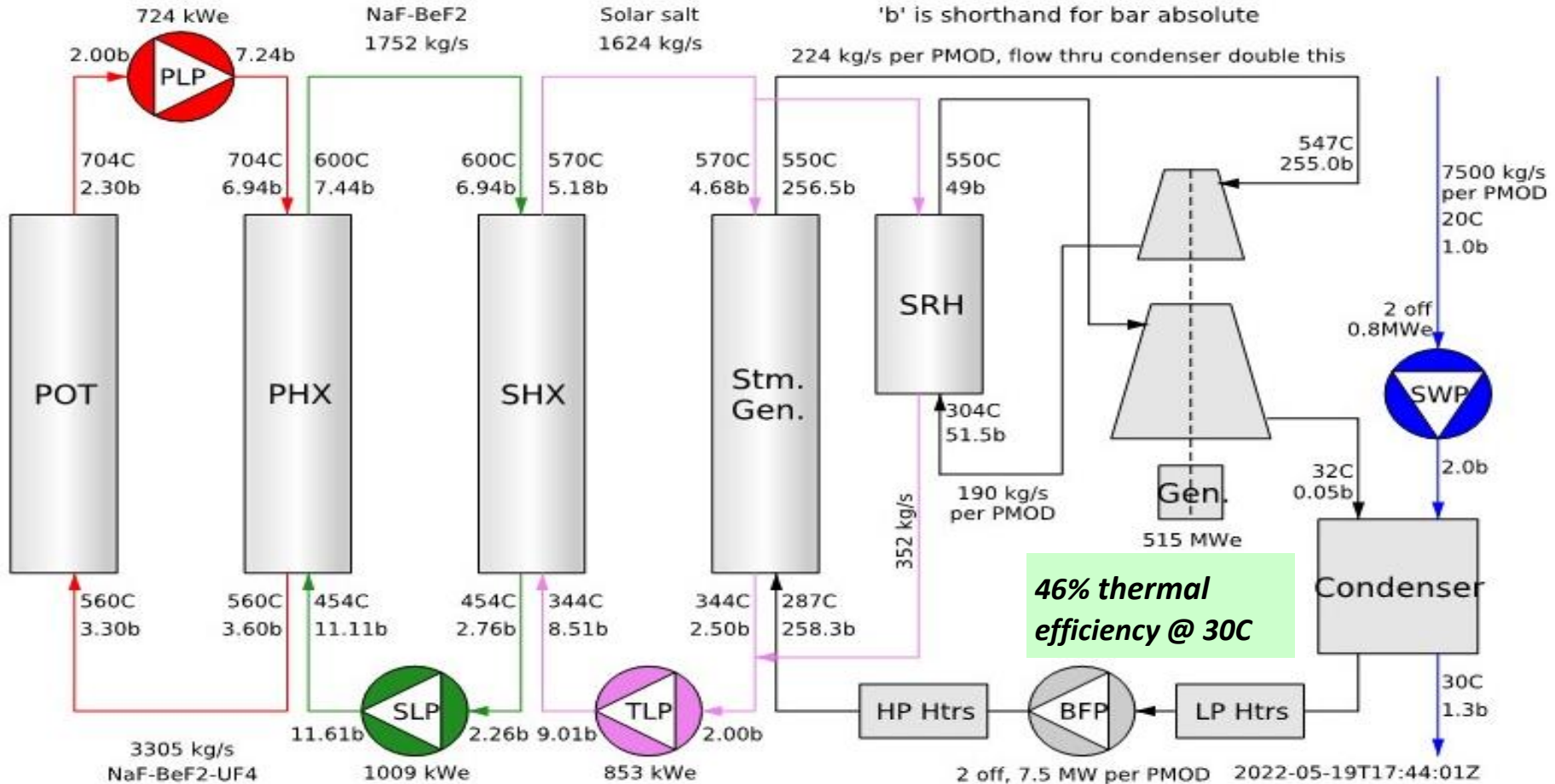


# Cooling Is Achieved By Housing Can Unit Within A Cold Wall

- ❖ Cold wall (25 mm 316 SS/500 mm water/25 mm 316 SS) continuously absorbs heat
  - ❖ Radiated from the Pot
  - ❖ Radiated from the drain tanks
- ❖ Cold wall is cooled by natural water circulation



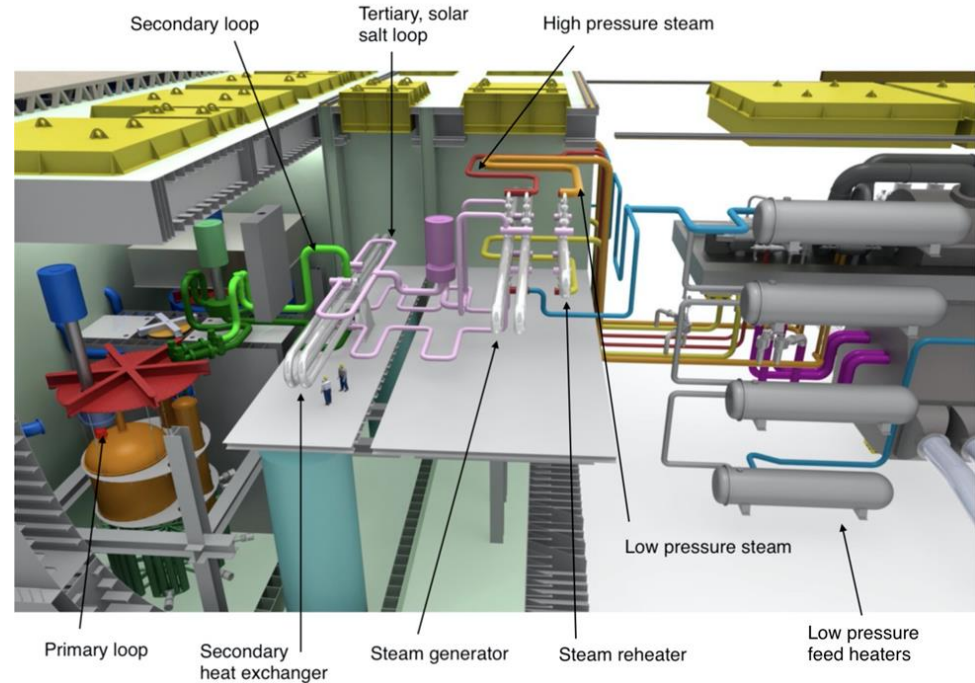
# ThorCon Employs Three Salt Loops



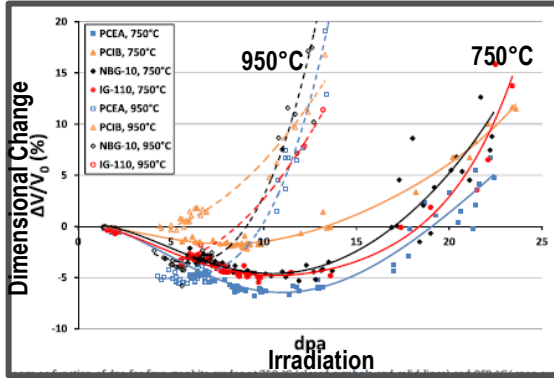


# Via These Salt Loops, ThorCon Generates Power

- ❖ Via a single reheat, super-critical steam cycle
- ❖ Each 335 tonne Can produces  $557 \text{ MW}_{\text{th}}$  energy
  - ◆  $2 \times 557 \text{ MW}_{\text{th}} \rightarrow 500 \text{ MW}_{\text{e}}$



# Graphite Enables Fissioning, But Salt Intrusion Limits Lifetime



Heijna et de Groot et Vreeling, J Nuc Materials 492(2017) 148-156

704°C Molten Fluoride Salt  
NaF-BeF<sub>2</sub>-UF<sub>4</sub> (72-16-12 mol %); 3.5 bar

Neutrons

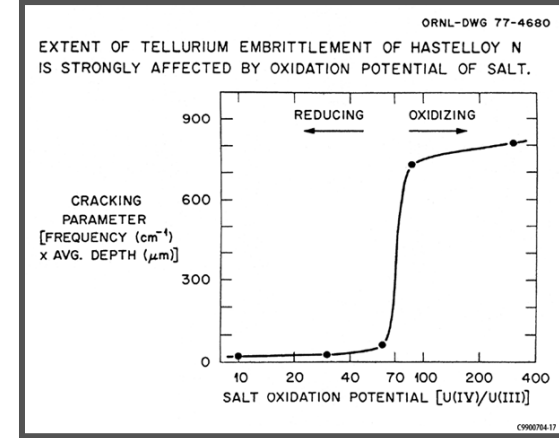
Temperature



Redox Control Window

Windes et al., INL/EXT-14-31720, 2014

564°C



J. R. Keiser, ORNL/TM-6002, 1977.

Evolving microstructure, pore size, surface chemistry

Evolving fluoride salt chemistry

Chosen Redox Window

Fluoride Salt Intrusion Into Graphite

# In Summary, The Complex Interplay Of Irradiation, Salt Chemistry et *Current Graphites* Warrants An Understanding

- ❖ What are the “Goldilocks” chemistry ranges for the various graphite moderated molten fluoride fission reactors?
- ❖ Do past conclusions provide useful guidance to the present?
  - ◆ Salt ingress (ORNL-3122, 1981, indicates for LiF-BeF<sub>2</sub> at 600°C)
    - Pure LiF-BeF<sub>2</sub> based fluoride do not spontaneously wet graphite
    - Residual HF and metallic Zr used for salt treatment can increase wetting by ~30%
      - What are the useful engineering impurity limits?
  - ◆ Graphite pore size (ORNL 4812, 1972, indicates)
    - Pore size <1 μm has capillary force that excludes *non-wetting* fuel salt
      - Stability of non-wetting?