Thermal Limits

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Aim of the presentation

Reviewing the thermal criteria and limits in design nuclear reactors used to perform core reactor analysis simulations.

Overview

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- Safety margins in design nuclear reactors

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- Design criteria to avoid fuel damage

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- Thermal limits

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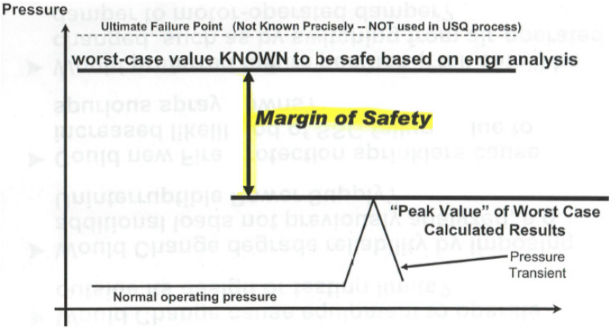
- Safety margins in design nuclear reactors
- Design criteria to avoid fuel damage
- Thermal limits
- Code simulations considerations

Safety Margins

The thermal hydraulic design of the reactor is made to ensure that the reactor core meets the requirements for steady state and transient operation without breaking the design basis.



Safety Margins

- Cooling water.
  A system to transfer heat from structures, systems, and components important to safety, to an ultimate heat sink, shall be provided.
- Reactor coolant makeup.
  A system to supply reactor coolant makeup for protection against small breaks in the reactor

Acceptance Criteria for Core Cooling

Peak cladding temperature.

The calculated maximum fuel element cladding temperature shall not exceed 2200° F.

Maximum cladding oxidation.

The calculated total oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation.

Maximum hydrogen generation.

The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount.

Coolable geometry.

Calculated changes in core geometry shall be such that the core remains amenable to cooling.

Long-term cooling.

After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value.

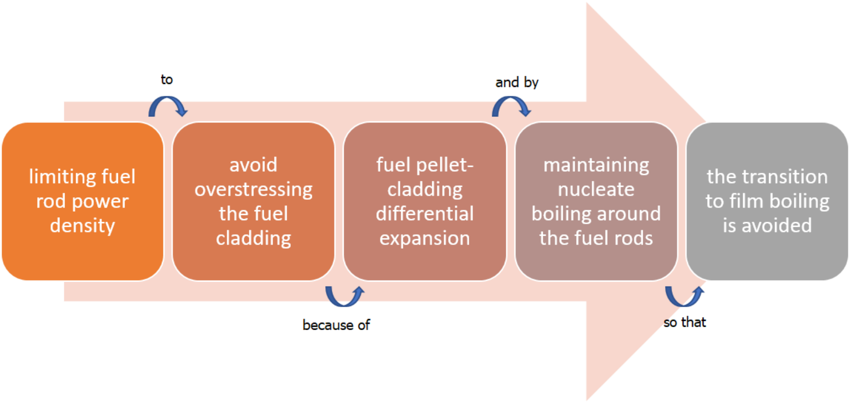
Thermal Limits

Thermal limits are provided for normal operation and transient events to maintain the integrity of the fuel cladding.

Operational states		Accident conditions	
Normal operation	Anticipated operational occurrences	Design basis accidents	Design extension conditions

Thermal Limits

This objective is achieved by



Thermal Limits

LHGR

Linear heat generation rate

It is heat flux integrated over every square centimeter of cladding surface for one linear foot of fuel rod.

CPR

Critical Power Ratio

It protects against fuel damage resulting from the loss of nucleate boiling

Critical Heat Flux.

- it is the physical phenomena where the liquid phase change happens due to a certain quantity of heat forming bubbles on the clad metal surface and heating water surround it.
- Some correlations developed from appropriate steady-state and transient-state experimental data are acceptable for use in predicting the critical heat flux (CHF).

Code Simulation Considerations

To detect critical heat flux conditions:

only the single phase and nucleate boiling regions are considered;

a thermal coupling between fuel and coolant is needed;

these can be accurately modelled by a correlation, and

Some of them used in TH analyses are:

- Hench-Levy
- Barnet correlation

Schedule

The Hench-Levy correlation was developed by GE.
This correlation is divided into two ranges one for 1000 psia of pressure and other for pressure other than 1000 psia.

$$
(q_c''/10^6) = \begin{cases} 1. & \text{for } x \leq x_1 \\ 1.9 - 3.3x - 0.7\tanh^2(3G/10^6) & \text{for } x_1 \leq x \leq x_2 \\ 0.6 - 0.7x - 0.09\tanh^2(2G/10^6) & \text{for } x \geq x_2 \end{cases}
$$

$$
x_1 = 0.197 - 0.108(G/10^6)
$$

$$
x_2 = 0.254 - 0.026(G/10^6)
$$

$$
q_c''(P) = q_c''(1000)\left[1.1 - 0.1\left(\frac{P-600}{400}\right)^{1.25}\right]
$$

Thank You !!

Any Questions??