Chapt. 10 Fuel Element Performance

10.1) Important Features

Oxide fuel characteristics

- ***Temperature ($T_{max} \approx 2800$ °C)***
  - ***Sintering***
  - ***Grain growth***
  - ***Diffusion***
- $\dfrac{\Delta T}{\Delta x}$
  - ***Stress***
  - ***Pore closing***
  - ***FP redistribution***

10.1.1) Oxide Fuels- (started ≈ 1955) (Fig/Table)

Most important properties of mixed oxides depend on the O/M ratio

$$q = \frac{N_{pu}}{\sum N_{\text{heavy metal}}}$$

$$x = \frac{N_{ox}}{\sum N_{\text{heavy metal}}}$$

for example...... $(U_{1-q}Pu_q)O_{2\pm x}$

Hyperstoichiometry   O/M > 2.00

Hypostoichiometry   O/M < 2.00

Disadvantages of Oxide Fuels

1.) **Low U density (larger core)**

2.) **Low thermal conductivity**
(requires thin rods, produces high T)

Why not use UC, UN, UP, US, etc.?

10.1.2 Fission Properties

Burnup

$$\beta = \frac{\text{Number of Fissions}}{\text{Initial Number of Heavy Metal Atoms}}$$

Rule of Thumb

$$1 \text{ at\% B.U.} \approx 10{,}000 \frac{MWd}{MtU} \quad @\ 200 \frac{MeV}{fission}$$

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Fissioning of 1 g of fissile material ≈ 1MWd

Maximum burn up with no Pu credit;

- ***Natural U*** $\quad 6650 \ \frac{MWd}{MtU}$
- ***15% enriched*** $\quad 142{,}500 \ \frac{MWd}{MtU}$

Major Differences Between LWR & LMFBR Fuels

	LWR	LMFBR
Ave neutron energy, eV	**0.03**	**500,000**
Fissile isotope	^{235}U	^{239}Pu
σ_f**, barns**	**550**	**1.8**
Neutron flux, (rel)	**1**	**300**
Power density, (rel)	**1**	**3 (why?)**
Burn up, %	**3**	**10**
Enrichment, %	**3**	**15**

Differences Between LWR and LMFBR Fuel Assemblies

	LWR	LMFBR
Damage to clad	1	100
Fuel pin diameter, mm	11	6
Core fuel fraction	-	Higher
Cladding	-	Hotter
Size of Core	-	Smaller (no moderator needed)

See Table 10.2 and figures 10.1 thru 10.4