Metallic Fast Reactor Fuels

Background

- **The first fuels used for the LMR's (Liquid Metal-cooled fast Reactors) in the 50's and early 60's were metallic (EBR-I, EBR-II).**

- **In the late 60's, world interest turned toward ceramic fuels.**

- **Development of metallic fuels continued into 70's because EBR-II continued to be fueled with U-5 Fs**

Nb	**0.01 %**
Zr	**0.1 %**
Pd	**0.2 %**
Rh	**0.3 %**
Ru	**1.9 %**
Mo	**2.4 %**
U	**95 %**

- **Events in the 80's caused a reassessment of reactor technology**

1. **Cancellation of CRBR** ***(fuel cycle costs)***
2. **Three Mile Island/Chernobyl** ***(Public Safety Demands)***
3. **Radioactive Waste "logjam"**

- **1983 IFR (Integral Fast Reactor) Concept Start**

The Integral Fast Reactor (IFR)

- **Na Cooled Fast Reactor**

  -Ambient-pressure cooling system

- **Metallic Fuel (U-Pu-Zr)**

  -High thermal conductivity
  -Superior compatibility with coolant

- **Innovative Process for Recycling Fuel**

  -Pyrometallurgical processing ("pyroprocessing")
  -Simple, compact, economical process

- **Passively Inherently Safe**

  -Safe shutdown relies only on laws of physics
  - No complicated engineered safety systems
  -Long times availible foe operator response

- **Over 29 y of Operating Experience With the IFR Prototype, EBR-II**

  -High capacity factor, over 75%
  -Low personnel exposures
  -No component failures

Advantages of the IFR Concept

- **Improved Reactor Safety**

  - Proven passively inherently safe

  On 4/3/86 reactor shutdown w/o operator or mechanical intervention in two tests:

  1.) Loss of flow without scram from full power(simulated conditions in Chernobyl accident)

  2.)Loss of heat sink without scram from full power (simulated conditions existing in TMI-2)

  - In both tests, inherent feedbacks enabled the reactor to respond to the abnormal events and return to a safe and coolable state

  1.) Thermal expansion of the core
  2.) Doppler reactivity feedback

  - Atmospheric pressure of primary coolant

  - Large thermal inertia of Na pool

  - High thermal conductivity of metallic fuel

1.) Low fuel temperature
2.) less stored energy

-Large margin between operating temperature (340-510 °C) and Na boiling temperature (900°C)

Advantages of the IFR Concept (cont.)

- **Improved Nuclear Waste Management**

  - Actinide elements absent from high-level waste produced
  - Capability to recycle LWR spent fuel
  - Reduces waste volume

- **Efficient Utilization of Fuel Resources**

  - Initial plants will be fissile self sufficient
  - Later plants can be operated as Pu breeders

- **Potential Economic Parity With Other Energy Sources**

  - Limited safety-grade construction
  - Very long plant life (low pressure, low corrosion)
  - Reduced fuel cycle costs via reprocessing
  - Flexible deployment: large or small, modular plants

- **Proliferation Resistant**

- No separation of Pu (tied up with U and non-fissile actinides)

- Fuel processed and refabricated remotely due to presence of fission products

IFR Operations Proven in EBR-II

- **Personnel exposure is 1-2% of LWR's**
- **EBR-II annual capacity factor (75-80%) over the average for operating commercial plants in the U.S. (≈70%)**
- **EBR-II steam generators have operated without leaks for over 25 years of continuous service**

Metal Fuel is the Foundation of the IFR Concept

- **Key factor contributing to passive safety characteristics**

- **Metal fuel fabrication is simple and compact**

- **Compact, simple pyroprocessing of metallic fuel promises dramatic improvements in fuel cycle economics**

- **Pyroprocessing facilitates significant improvements in waste management**

Performance of IFR Fuel Has Been Demonstrated Successfully

- **Ongoing tests of U-Pu-Zr and U-Zr fuels have now achieved burnups of 20 a/o, well in excess of their design target burnup level of 100,000 MWd/T (10 a/o burnup), assuring excellent fuel cycle economics**

- **Metal assemblies have been operated for up to 223 days *beyond* cladding failure without any degradation, providing utility operators with assurance of reliable, efficient plant operation**

- **EBR-II was fully converted for operation with the IFR-type fuel alloys (U-Zr and U-Pu-Zr)**