Comparison of Inert Matrix Fuel Irradiations at OECD Halden Reactor

Marco Streit
Terje Tverberg
Wolfgang Wiesenack

OECD Halden Reactor Project, Norway

Presented at ARWIF 2005, ORNL, Feb. 2005

Background

Today's large stockpile of Plutonium:

- need adequate treatment for non-proliferation
  a) Waste or transmutation
  b) MOX Fuel to burn in LWRs
  c) IMF (Inert Matrix Fuel) – **higher burn-out in IMF**
- different inert matrices proposed

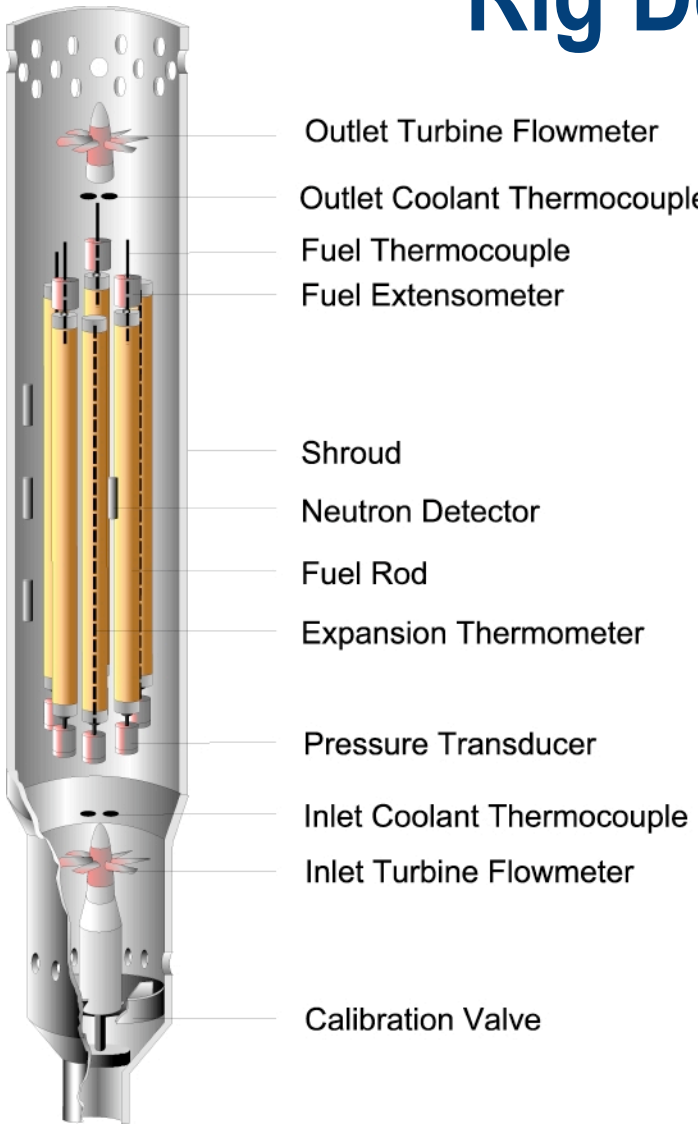
  (YSZ, CSZ, thoria, alumina, spinel, ceria, ..., nitrides, carbides)
- for different reactor types

  (LWR, FR, ADS...)

Aims

- Objectives of IFA-651:
  - To investigate thermo/mechanical behavior of YSZ inert matrix fuel (IMF)
  - To compare fuel performance of IMF and MOX fuel
  - To provide complementary data to those obtained from IFA-652
- Objectives of IFA-652:
  - To investigate thermo/mechanical behavior of CSZ inert matrix fuel (IMF), thoria doped IMF fuel and thoria fuel
  - To compare fuel performance of IMF and thoria fuel
  - To provide complementary data to those obtained from IFA-651
- Of particular interest are:
  - In-pile fuel thermal conductivity
  - Fuel densification and swelling
  - Fission gas release

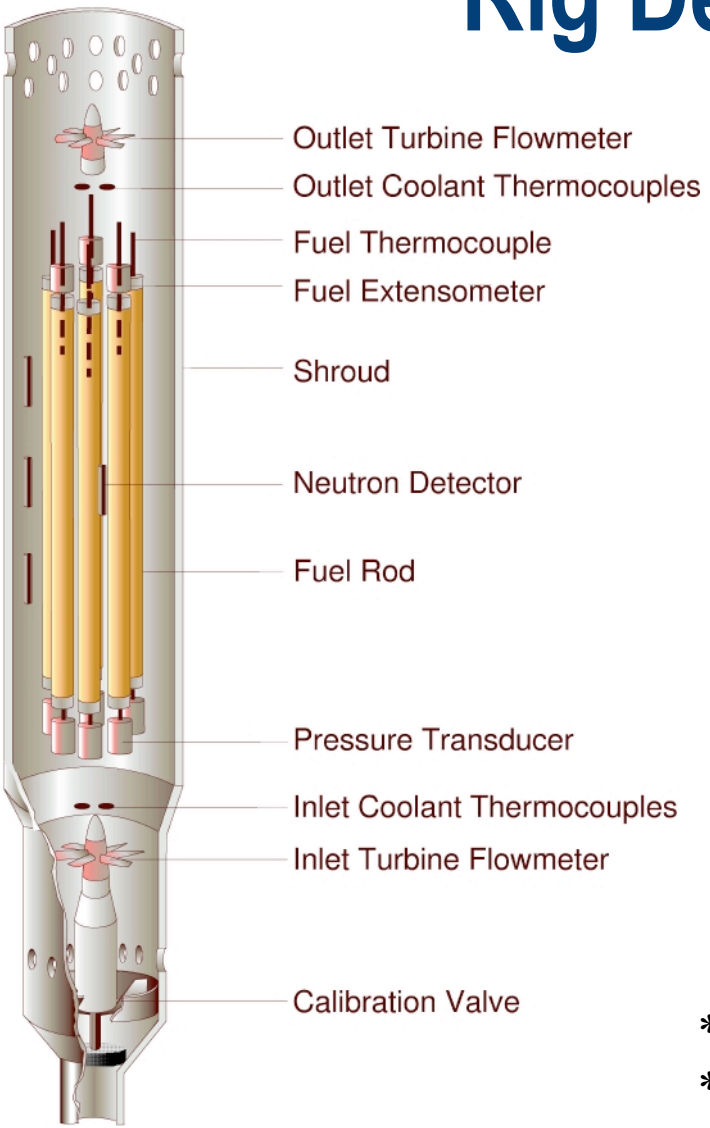
Rig Description (651)



- 1 cluster of 6 rods
- Fissile Material: Pu
- 3 IMF and 3 MOX rods
- TF or ET in all rods
- PF in all rods
- EF in 2 IMF and 1 MOX rod
- Stack length ~ 500 mm for all rods
- 651.2: IMF rod 2 discharged for PIE

**TF : Fuel thermocouple *ET: Expansion thermometer*
**PF: Pressure transducer *EF : Fuel extensometer*

Rig Description (652)



- 1 cluster of 6 rods
- Fissile Material: HEU
- 2 IMF, 2 IMTand 2 thoria rods
- TF in all rods
- PF in all rods
- EF in 1 rod of each fuel type
- Stack length ~ 500 mm for all rod
- 652.1: rod 3 dummy rod
- 652.2: IMT rod 3 loaded
- 652.3: thoria rod 4 discharged

**TF : Fuel thermocouple*

**PF: Pressure transducer *EF : Fuel extensometer*

Rod Description (651)

Rod	Fuel Type	Manufacturer	Instrumentation
1	MOX-SBR	BNFL	TF, PF
2	YSZ IMF-ATT	PSI/KAERI	TF, PF, EF
3	MOX-ATT	PSI/KAERI	ET, PF
4	YSZ IMF-COP	PSI/KAERI	TF, PF,EF
5	YSZ IMF-ATT	PSI/KAERI	ET, PF
6	MOX-ATT	PSI/KAERI	TF, PF, EF

N.B. Fill gas pressure is 10 bar of He (at room temperature) for all rods

**SBR : Short Binderless Route*
**ATT : Attrition milled*
**COP: Co-precipitated*

**TF : Fuel thermocouple*
**ET: Expansion thermometer*
**PF: Pressure transducer*
**EF : Fuel extensometer*

Rod Description (652)

Rod	Fuel Type	Manufacturer	Instrumentation
1	CSZ IMF-SPR	IFE	TF, PF
2	CSZ IMF-SPR	IFE	TF, PF, EF
3	IMT-SPR	IFE	TF, PF
4	Thoria-SPR	IFE	TF, PF,EF
5	Thoria-SPR	IFE	TF, PF
6	IMT-SPR	IFE	TF, PF, EF

N.B. Fill gas pressure is 10 bar of He (at room temperature) for all rods

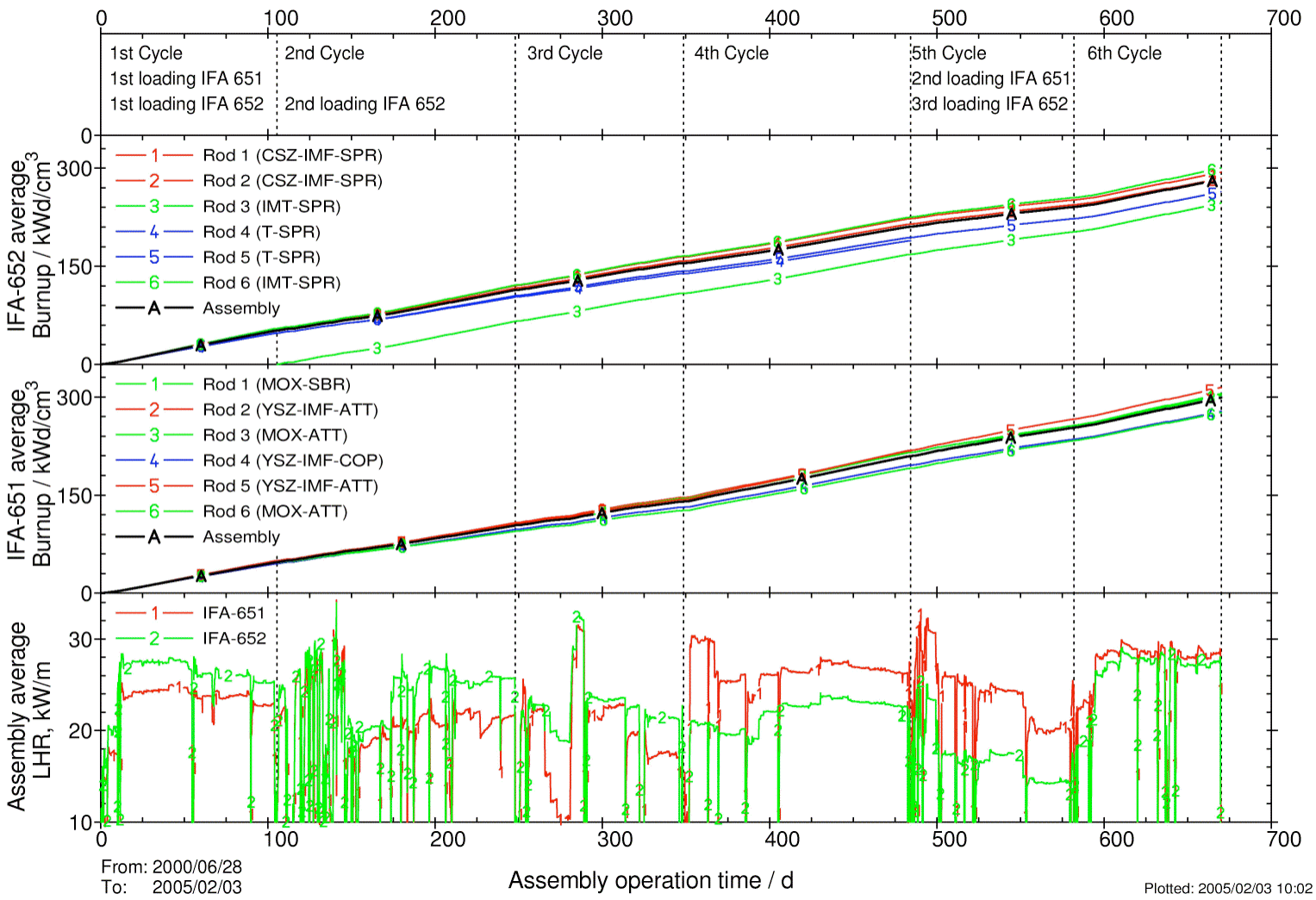
**SPR : Standard Powder Route*

**TF : Fuel thermocouple*

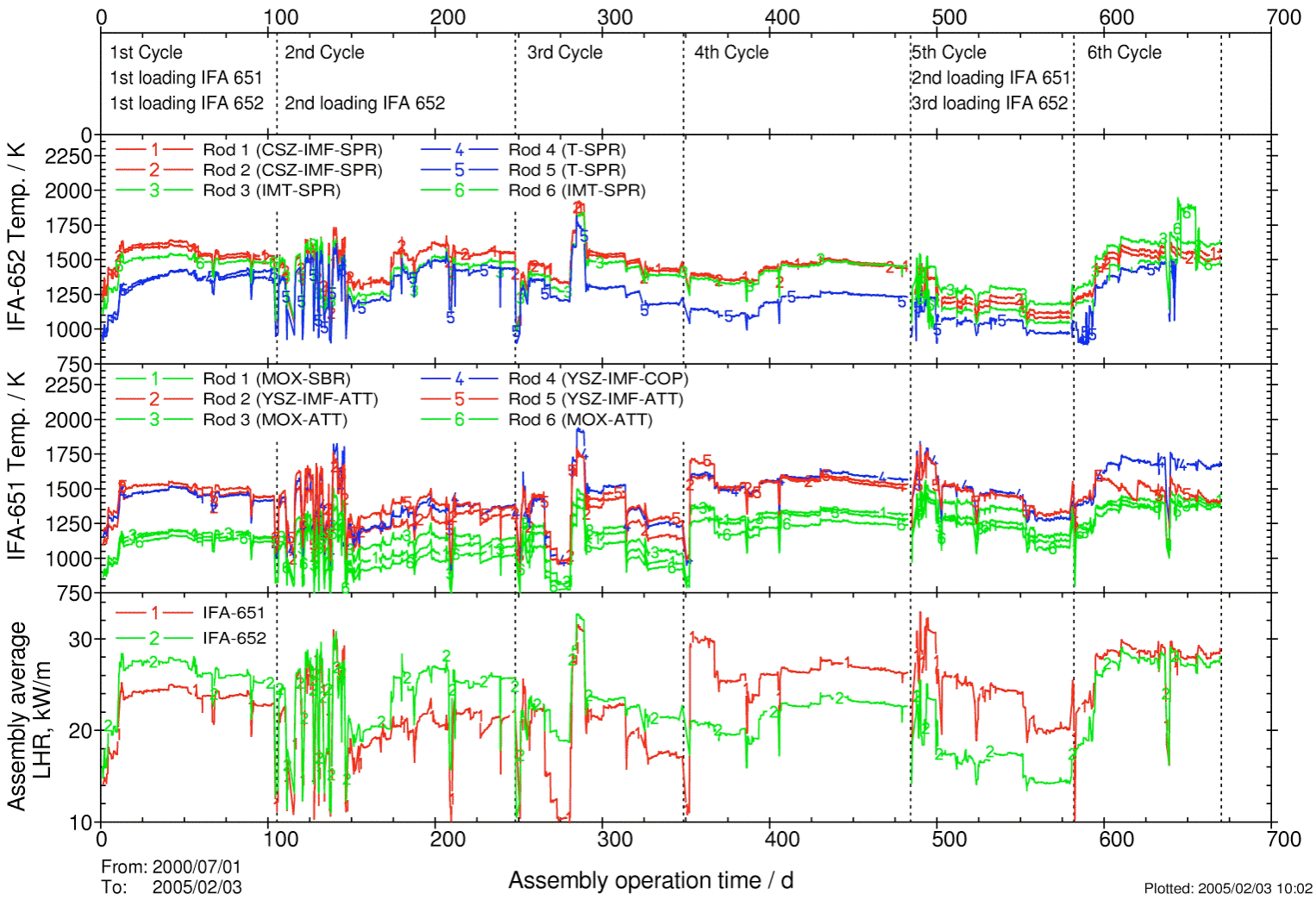
**PF: Pressure transducer*

**EF : Fuel extensometer*

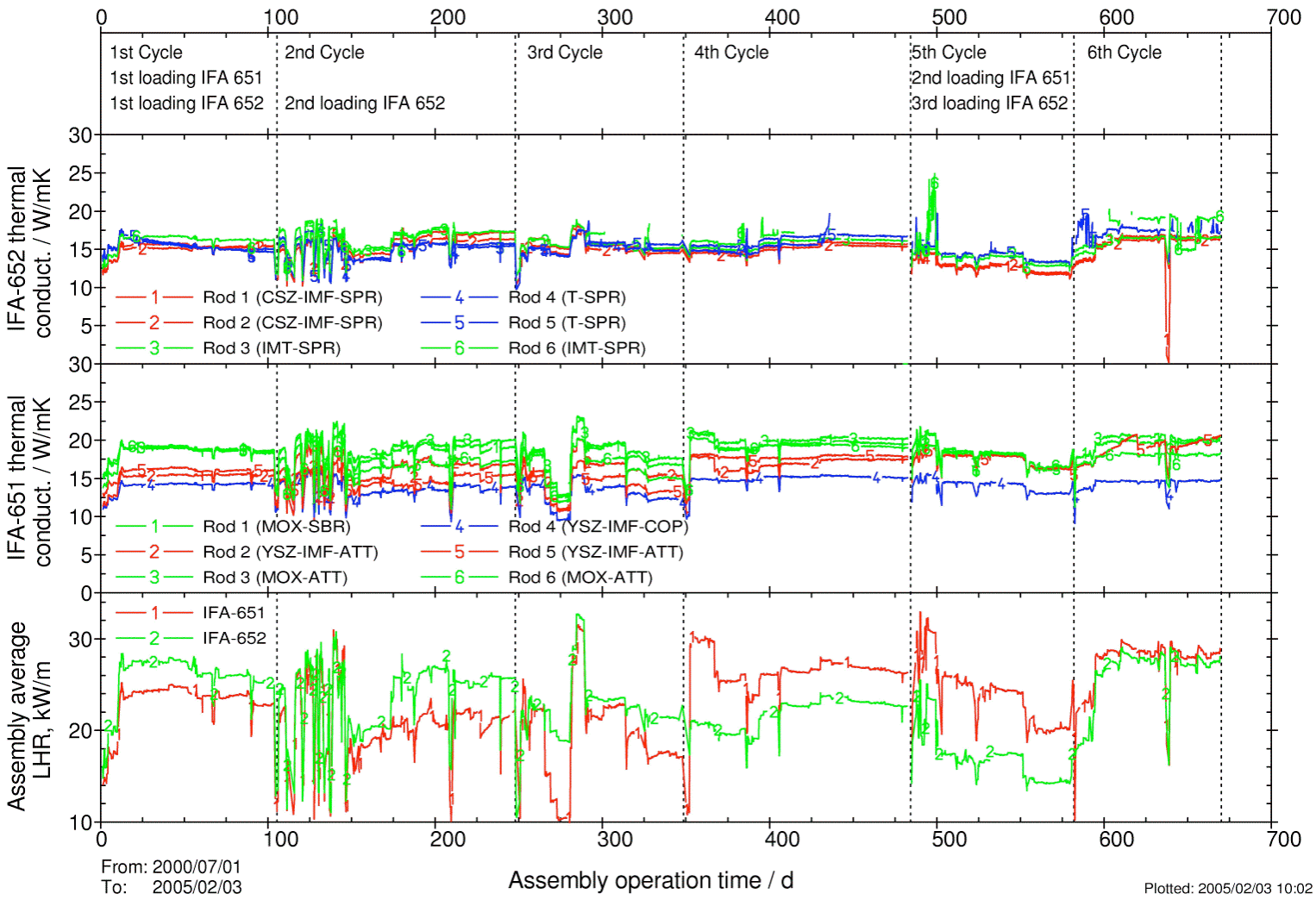
Burnup & Power History



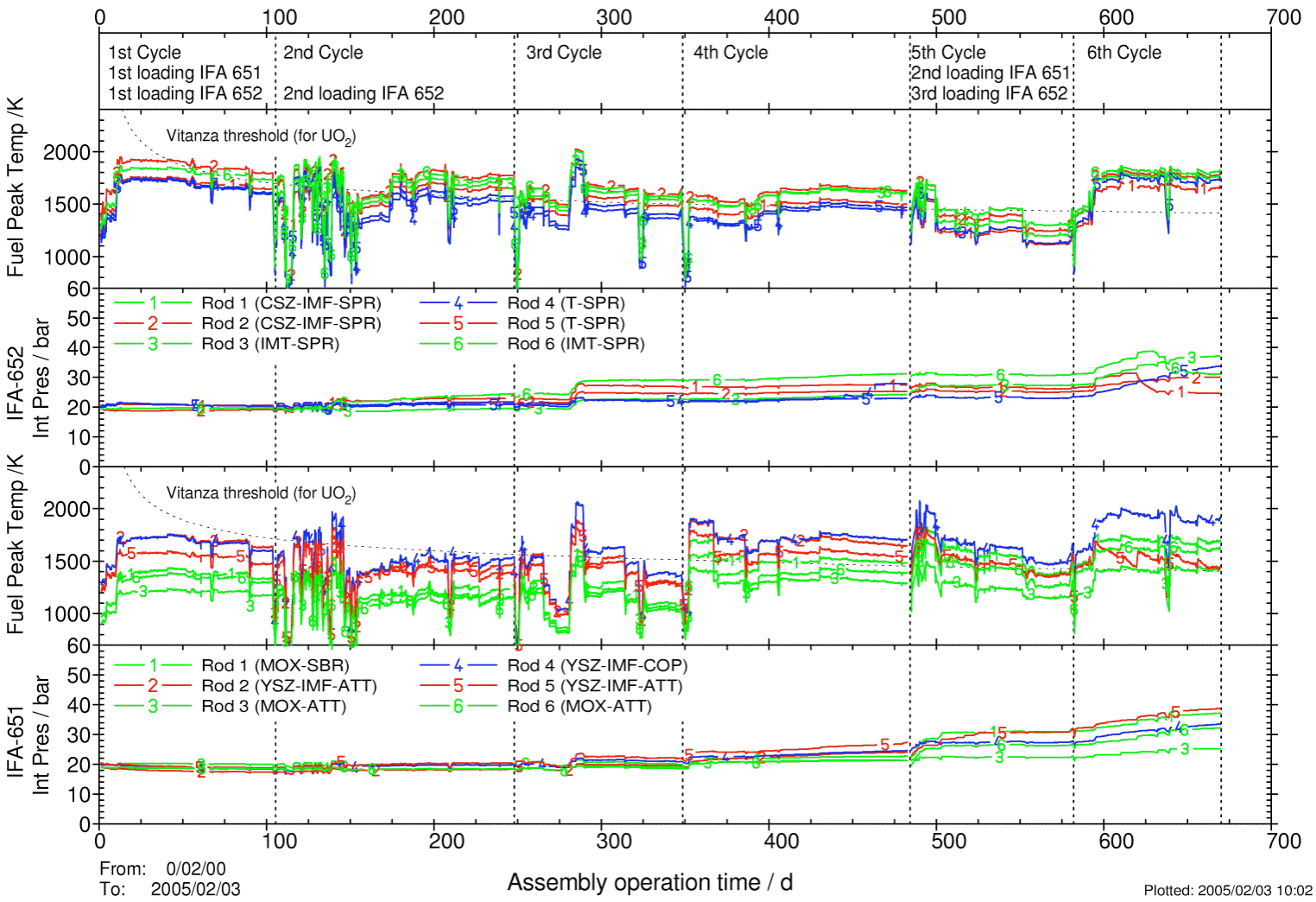
Fuel Temperatures



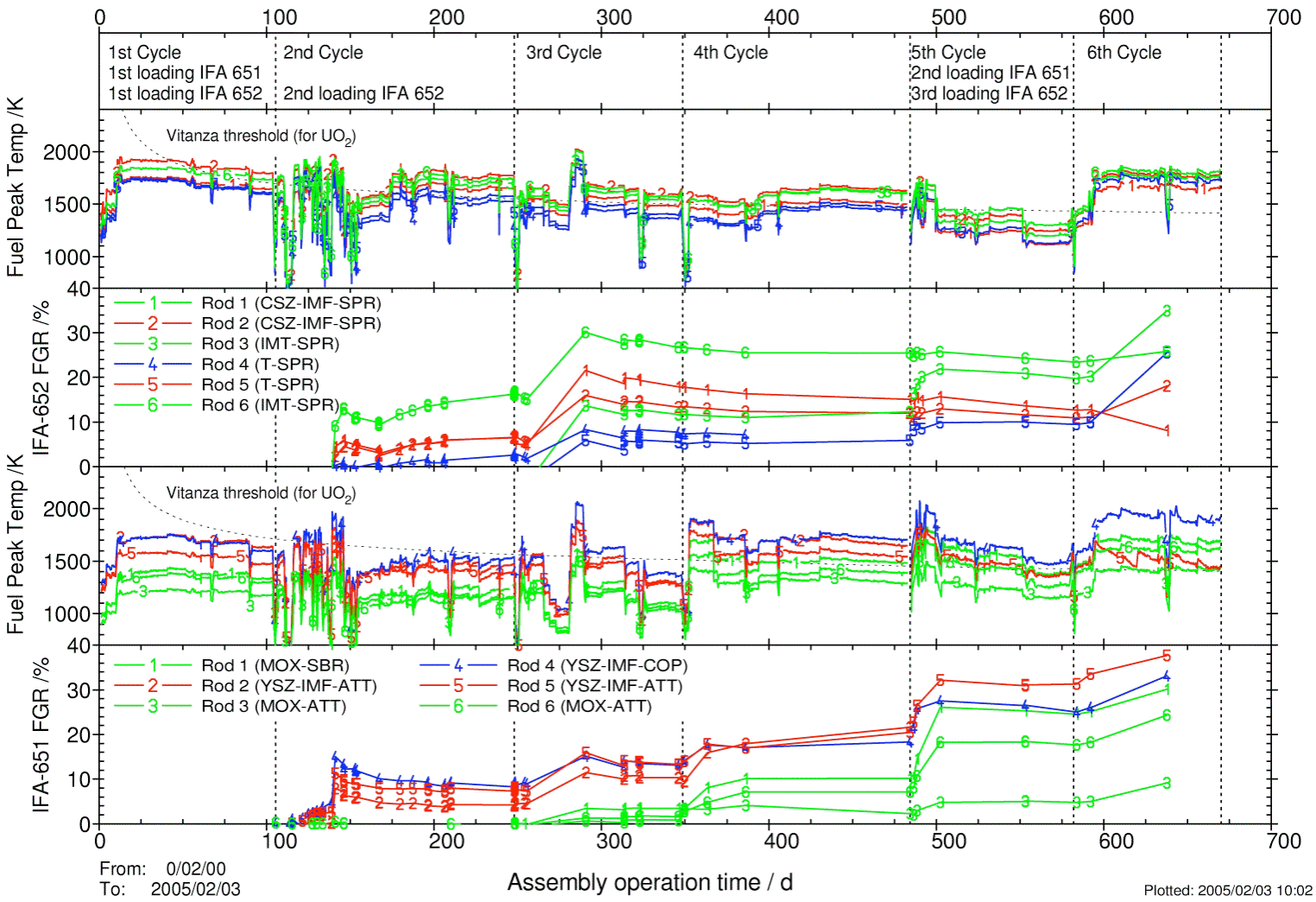
Fuel Thermal Conductivity



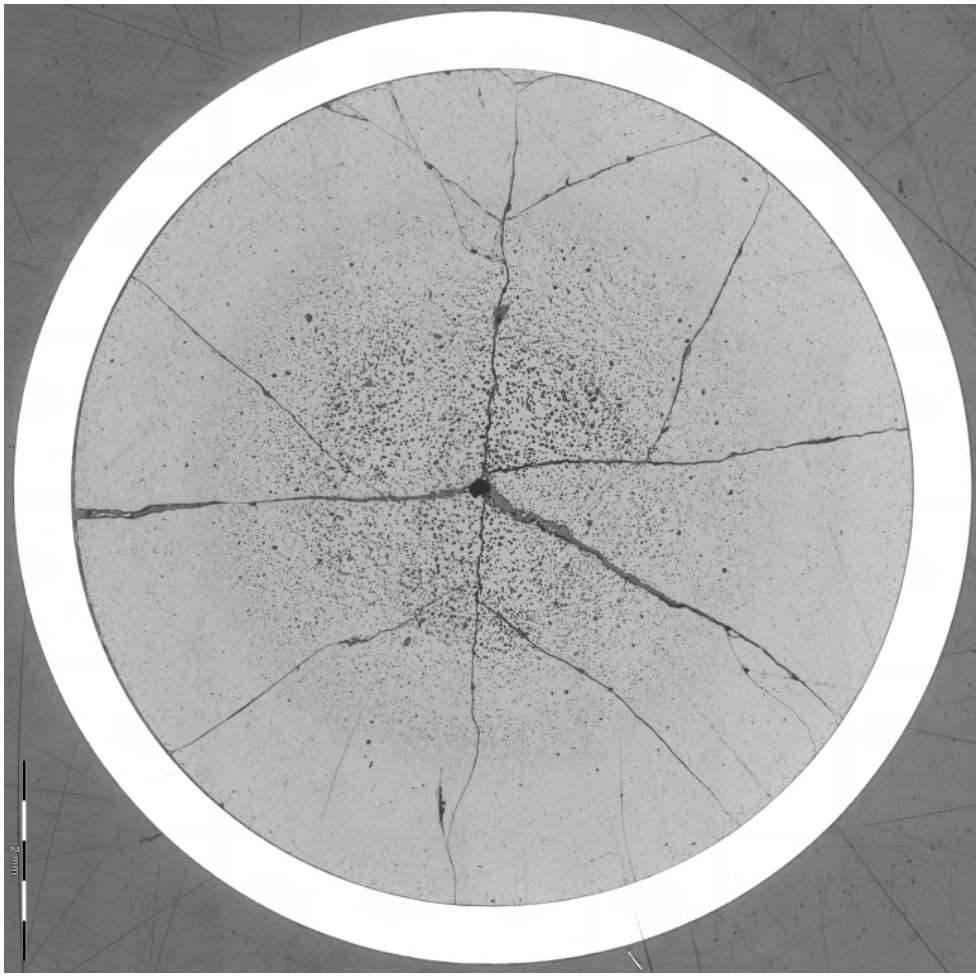
Measured Rod Pressures



Fission Gas Release



PIE Results Of IFA 651 Rod 2



- No defects on cladding
- No diameter change
- 4.6% fuel swelling
- 0.8% axial densification
- FGR found: 18%
  (21% predicted)
- Ceramography:
  - Totally cracked pellet
  - 4 different zones
  - Forming of central void
  - Gap nearly closed

Conclusions

- All IMF rods show higher temperatures (150-300°C) than MOX or thoria rods.
- IMF rods show earlier FGR than MOX rods.
- More similar FGR behavior at higher burnups
- The assemblys average burnups were at end of 6th cycle:
  - ~299 kWd/cm^3 (IFA-651)
  - ~283 kWd/cm^3 (IFA-652)
- 1 rod (1 IMF, 1 T) of each IFA discharged for PIE
- Result of measured FGR in the IMF rod 2 in good agreement with prediction
- Irradiation will continue till burnups of 450 - 500 kWd/cm^3


Thank you for your attention !