BEFAST AND SPAR – 34 YEARS OF EXPERIENCE WITH THE STORAGE OF SPENT FUEL AND FACILITY COMPONENTS

Takats Ferenc, TS Enercon, Hungary

H. Issard, AREVA TN, France

A. Jussofie, GNS, Germany

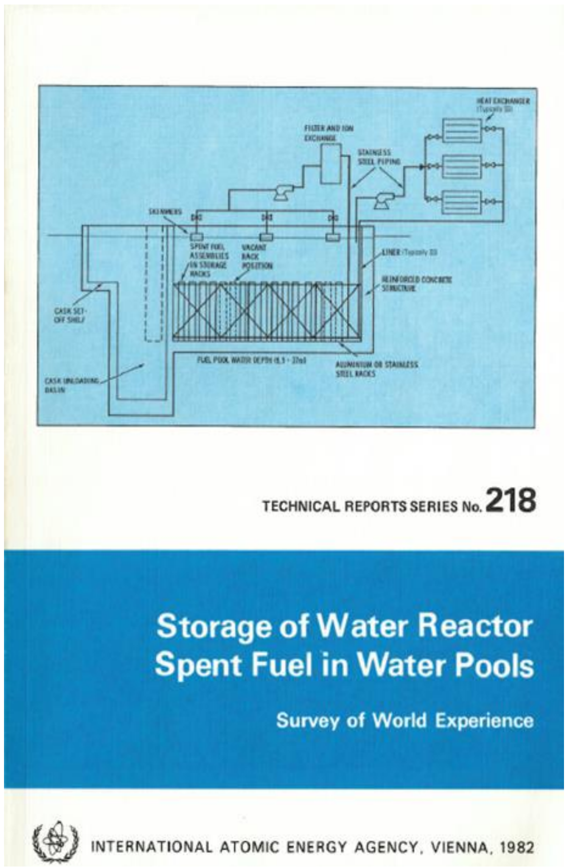
A. Machiels, EPRI, USA

P. Standring, IAEA, Austria

Introduction

- Spent fuel management has always been one of the most important stages in the nuclear fuel cycle, and its importance is common to all countries with nuclear reactors
- In order to demonstrate safety in storage, a good understanding of the processes that might cause deterioration of the spent fuel and storage system are needed
- Since 1981 the IAEA has been developing a technical knowledge base on the long term behaviour of power reactor fuel and storage system materials

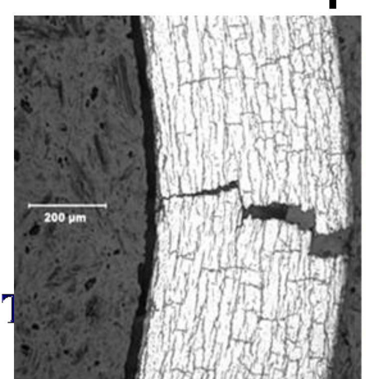
Introduction, the beginning

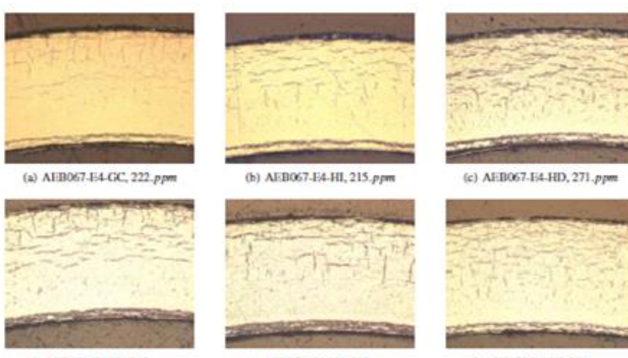


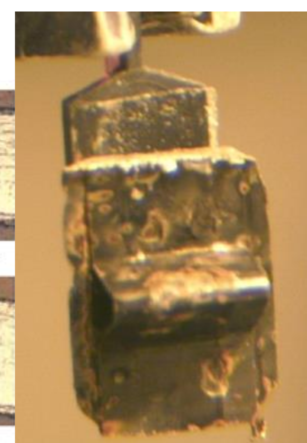
- OECD/IEA discussions in 1977
- 1978: BEFAST transferred to NEA
- 1979: IAEA questionnaire
- Responses published in 1982 in Survey of water reactor spent fuel storage experience
- 1981: the IAEA established a CRP on BEFAST

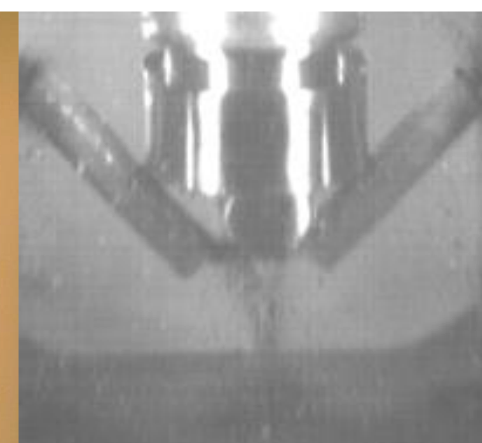
Objectives of the CRPs

- to survey the existing experience in spent fuel storage
- to investigate spent fuel by destructive examinations before and after extended storage periods
- to investigate potential cladding degradation mechanisms
- to evaluate suitable NDT methods for surveillance
- to investigate the behaviour of spent fuel pool equipment









Investigations

Long-term behaviour	B-I	B-II	B-III	S-I	S-II	S-III	Surveillance	B-I	B-II	B-III	S-I	S-II	S-III	Facilities & Operation	B-I	B-II	B-III	S-I	S-II	S-III
Material aspect (cladding & components)	X			X	X	X	Monitoring; Wet + Dry			X	X	X	X	Capacity enhancement		X				
Degradation mechanisms and models	X	X		X	X	X	Fuel conditions		X	X	X	X	X	Changing modes Wet – Dry		X	X	X	X	
Validation - experiment - experience		X	X	X	X	X	Different reactor types		X	X	X	X	X	Handling of heavily damaged fuel		X	X		X	
														System performance	X	X	X	X	X	

Participants

Country	B – I	B – II	B - III	S - I	S - II	S - III	Country	B – I	B – II	B - III	S - I	S - II	S - III	Country not existing now	B – I	B – II
Argentina		X			X	X	Japan	X	X	X	X	X	X	CSSR	X	
Austria	X						Korea, Rep		X	X	X	X	X	GDR	X	X
Canada		X	X	X	X		Russia			X	X			FRG	X	X
EC					X	X	Slovakia			X		X	X	USSR	X	X
Finland	X	X	X				Spain			X	X	X	X			
France			X	X	X	X	Sweden	X		O	O	O				
Germany			X	X	X	X	Switzerland						O			
Hungary	X	X	X	X	X	X	UK		X	X	X	O	O			
Italy		X					USA	X	X	X	X	X	X			

O - Observer

Achievements

- On-going review and assessment of the results from national plans on the research of materials used in spent fuel storage has been undertaken
- The results from national research efforts on potential fuel materials deterioration over long-term storage of fuel have been compiled
- National experience on spent fuel storage has been reported
- Relevant results from surveillance programmes have been reviewed and assessed
- Operating experience on spent fuel handling and its potential impact on spent fuel integrity have been shared.

Results

- Degradation mechanisms in Zr-based alloy clads
  - Wet storage:
    - Uniform Corrosion
    - Pitting, galvanic, and microbiologically-influenced corrosion
    - Hydriding
  - Dry storage:
    - Air Oxidation
    - Thermal Creep
    - Stress Corrosion Cracking (SCC)
    - Delayed Hydrogen Cracking (DHC)
    - Hydride Re-orientation
    - Hydrogen Migration and Re-distribution

Performance in storage remains excellent with no generic failure mechanism identified or experienced

Results

- Degradation mechanisms in SS-based alloy clads
  - Intergranular Stress Corrosion Cracking (IGA)
  - General corrosion

  SS clad AGR SF >30 years of wet storage experience. Storage performance is good provided the fuel is stored in the presence of corrosion inhibitor.
- Degradation in Magnesium-based (MAGNOX) cladding
  - Wet storage
  - Dry storage

  MAGNOX SF >50 years' experience. Requires optimum storage chemistry to be maintained.

Outputs, TECDOCs

- BEhaviour of spent Fuel Assemblies in Storage (BEFAST)
- Spent fuel Performance Assessment and Research (SPAR)

1987

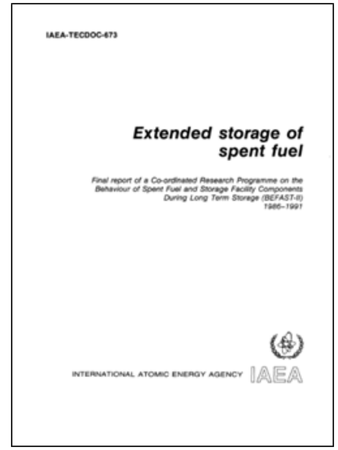

IAEA-TECDOC-414

BEHAVIOUR OF SPENT FUEL ASSEMBLIES DURING EXTENDED STORAGE

FINAL REPORT OF A CO-ORDINATED RESEARCH PROGRAMME ON THE BEHAVIOUR OF SPENT FUEL ASSEMBLIES DURING EXTENDED STORAGE (BEFAST, PHASE 1, 1981–1986) SPONSORED BY THE INTERNATIONAL ATOMIC ENERGY AGENCY

A TECHNICAL DOCUMENT ISSUED BY THE INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1987

1992

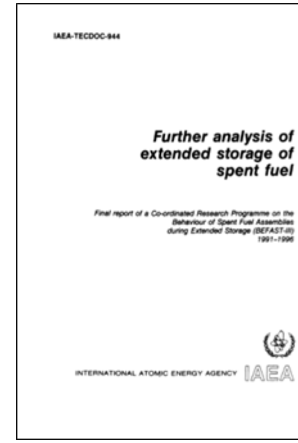

IAEA-TECDOC-673

Extended storage of spent fuel

Final report of a Co-ordinated Research Programme on the Behaviour of Spent Fuel and Storage Facility Components During Long Term Storage (BEFAST-II) 1986–1991

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

1997

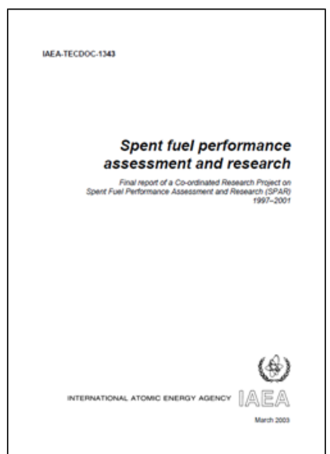

IAEA-TECDOC-944

Further analysis of extended storage of spent fuel

Final report of a Co-ordinated Research Programme on the Behaviour of Spent Fuel Assemblies during Extended Storage (BEFAST-III) 1991–1996

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

2003


IAEA-TECDOC-1343

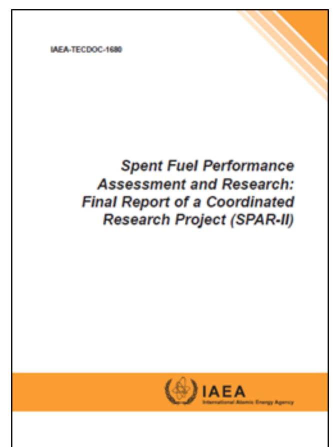
Spent fuel performance assessment and research

Final report of a Co-ordinated Research Project on Spent Fuel Performance Assessment and Research (SPAR) 1997–2001

INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

March 2003

2012


IAEA-TECDOC-1680

Spent Fuel Performance Assessment and Research: Final Report of a Coordinated Research Project (SPAR-II)

IAEA International Atomic Energy Agency

2015


Spent Fuel Performance Assessment and Research

Final report of a Co-ordinated Research Project on Spent Fuel Performance Assessment and Research (SPAR-III) 2009-2014

DRAFT

TS ENERCON Engineering and Consulting

Summary document

Behaviour of Spent Fuel During Storage

Consolidated findings from the Coordinated Research Project Reports on Behaviour of Spent Fuel Assemblies in Storage (BEFAST) and Spent Fuel Performance Assessment and Research (SPAR)
1981—2014

- The process of consolidating the findings from the CRPs started in 2014
- Information which is most relevant in the context of today's implementation of the technology

Main Conclusion

- A review of degradation mechanisms in both wet and dry storage has not revealed any time limiting failure mechanisms in fuel cladding or fuel assembly structures provided that recommended storage environments are maintained.
- **Thus it can be concluded that interim spent fuel is safe in both wet and dry conditions.**

Thank you for your attention!