Accident Tolerant Fuels: Planned Activities at the IAEA

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Summary

We plan two Coordinated Research Projects within our Fuel Engineering Programme in response to the accident at Fukushima

- FUMAC
  - Fuel Modelling under Accident Conditions
- ACTOF
  - Accident Tolerant Fuel
- Activity on 5% Enrichment Limit
CRPs on the IAEA web-site: http://cra.iaea.org/cra/index.html

- Duration about 4 years
- Members are not individuals but organizations
- Group plan is based on the organizations’ proposals
CRP series on fuel modelling (1982-2012)

Joint NEA-IAEA International Fuel Performance Experimental (IFPE) Database

Blind exercises

CRP D-COM
1982-1984
published in 1987

CRP FUMEX
1993-1996
published in 1998

CRP FUMEX-2
2002-2007
published in 2012

CRP FUMEX-3
2008-2012
published in 2013
CRP FUMEX-3
as a part of the fuel modelling IAEA programme

34 organizations from 21 countries and ITU/JRC/EC

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Data from the Halden Reactor Project (observer) and from CRP participants → ≈1500 datasets in the NEA-IAEA Int’l Fuel Performance Experimental Database (http://www.oecd-nea.org/science/wprs/fuel/ifpelst.html)
FUMEX-2 example: fission gas release prediction

FUMEX-2, IAEA-TECDOC-1687, 2012

Vitanza threshold - the temperature of 1% FGR, experimentally derived up to around 40 MWd/kgU
**CRP FUMEX → SMoRE (Accelerator Simulation and Theoretical Modelling of Radiation Effects)**

**Reasons:**
- Economically driven growth of conventional fuels burn-up
- Introduction of new fuels for advanced and innovative nuclear systems
- Insufficient basic understanding of radiation damage mechanisms

**Nuclear Technology Review, IAEA, Vienna, 2007**

**SMoRE Objectives:**
- Enhancement of simulation capabilities of accelerators for materials testing
- Contribution for better physical understanding of high-dose radiation effects
1. Belgium: SCK.CEN (L. Malerba) – Fe-Cr potentials, their use in MD and MC, EPA experiments;
2. China: CIAE (Sh. Zhu) – CLAM irradiation up to 85 dpa, temp. effects, triple beam H/He synergy;
3. France: CEA (F. Willaime), EdF (G. Monnet) – MSM in Fe, Fe-Cr, ODS, Jannus triple beam, DD;
4. India: BARC (P. V. Durgaprasad) – MD, DD in Fe, Fe-Cr, small-punch tests of T91;
5. Japan: Kyoto University (A. Kimura) – Al-added-ODS, phase stability, He-trapping, dual beam;
7. Korea, Rep: KAERI (J. Kwon) – MD, DD in F/M steels, TEM, atom probe, EPA, nano-indentation;
8. Netherlands: JRC-Petten (L. Debarberis) – Fe-Cr ODSs (non-irradiated), EPA, SANS, TEP, TEM;
9. Poland: IAE (W. Szteke) – small-punch testing of non-irradiated AS;
10. Russia: IPPE (V. Pechenkin), Kurchatov Institute (A. Ryazanov) – F/M steels, neutrons, MSM, RIS;
11. Slovakia: Bratislava University (V. Slugen) – ODS MA956, ODM751 and Eurofer comparisons, EPA;
12. Spain: Madrid University, Institute of Fusion (J. Perlado) – Fe-Cr potentials, defect formation energies;
13. Switzerland: PSI (M. Pouchon) – micro-pillar nano-indentation, analysis and modelling;
14. Ukraine: KIPT (V. Voyevodin) – high-dose ion irradiation, comparisons with neutrons, MSM;
15. USA: LLNL (M. Fluss), LANL/UCB (P. Hosemann) – ODS MA956, MA957 and K3; micro-studies;
   Rad. Effects Consulting (F. Garner) – chief consultant of the project;

NEA / OECD – observer, with many participating members, discussions at WPMM.
CRP SMoRE: timetable of related events

- **2006**
  - 17th Alushta Conference on radiation material science / Ukraine (initial idea)

- **2007**
  - SMINS-1, AccApp’07, TWGFPT recommendation and CM-1 in IAEA (CRP draft)

- **2008**
  - TM in KIPT/Ukraine and WPMM of NEA/OECD (team composition)
  - RCM-1 (work plan)

- **2009**
  - AccApp’09 in IAEA and CM-2 at the ICFRM (samples distribution)

- **2010**
  - RCM-2 (discussions of intermediate results and work plan adjustments)

- **2011**
  - AccApp’11 and DIANA-1 (individual reports and feedback)
  - RCM-3 (results and conclusions)

- **2012**
  - 20th Alushta and NuMat-2 (final report arrangements)

- **2013**
  - CRP finalization, IAEA publication as a Nuclear Energy Series Report
Mid-term initiatives, linked to the post-Fukushima IAEA Nuclear Safety Action Plan:

- **CRP “Fuel Modelling in Accident Conditions”, FUMAC, 2014 – 2018** (analysis of fuel behaviour, collection of data, enhancement of codes)
  - TM “Fuel behavior and modeling under LOCA and RIA conditions”, Oct 2011, Japan
  - Cooperation agreement with the NEA/OECD on IFPE Database, 2012, IAEA-NEA
  - TM “Modelling of water-cooled fuel including design basis and severe accidents, Oct 2013, China
  - FUMAC Consultancy and RCM-1 in March and Nov 2014, IAEA

- **CRP “Analysis of options and experimental examination of Accident Tolerant Fuels for water-cooled reactors”, ACTOF, 2015 – 2019**
  - TM “Accident Tolerant Fuel and in-core structural materials”, Oct 2014, USA
  - ACTOF Consultancy and RCM-1 in 2015, IAEA
Thanks for your attention, and welcome to the IAEA projects!