

Accident Tolerant Fuels: Planned Activities at the IAEA

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International Atomic Energy Agency

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

The screenshot shows the IAEA Coordinated Research Activities (CRA) website. The header includes the IAEA logo and navigation links. The main content area is titled 'Coordinated Research Activities' and features a grid of images and text. A sidebar on the left contains links such as 'About Us', 'How to participate', 'Information Letter', 'Resources', 'Explore CRPs', and 'Proposal Forms'. The 'Proposal Forms' link is circled in red. The main content area also includes a 'Stories' section with several articles about CRPs, each with a title, a brief description, and a 'Read More' link. The articles include 'Nanoscale Radiation Engineering of Advanced Materials for Potential Biomedical Applications (F23028)', 'NEW CRP: Plasma-Wall Interaction for Irradiated Tungsten and Tungsten Alloys in Fusion Devices (F43021)', 'Heavy Charged-particle Interaction Data for Radiotherapy (F43017)', and 'NEW CRP: Identification of High Confidence Nuclear Forensics Signatures for the Development of a National Nuclear Forensics Library'.

CRP series on fuel modelling (1982-2012)

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

Blind exercises

IAEA-TECDOC-415

DEVELOPMENT OF COMPUTER MODELS FOR FUEL ELEMENT BEHAVIOUR IN WATER REACTORS

SURVEY REPORT
OF A CO-ORDINATED RESEARCH PROGRAMME
ON THE DEVELOPMENT OF COMPUTER MODELS
FOR FUEL ELEMENT BEHAVIOUR IN WATER REACTORS
SPONSORED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
AND PREPARED BY
J.H. GITTUS



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

CRP D-COM
1982-1984
published in 1987



IAEA-TECDOC-998

Fuel modelling at extended burnup

Report of the Co-ordinated Research Programme on
Fuel Modelling at Extended Burnup — FUMEX
1993–1996



INTERNATIONAL ATOMIC ENERGY AGENCY IAEA

January 1998

CRP FUMEX
1993-1996
published in 1998

IAEA-TECDOC-1687

Fuel Modelling at Extended Burnup (FUMEX-II)

Report of a Coordinated Research Project 2002–2007



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CRP FUMEX-2
2002-2007
published in 2012

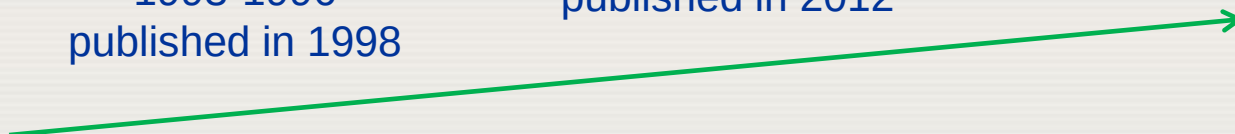
IAEA-TECDOC-1697

Improvement of Computer Codes Used for Fuel Behaviour Simulation (FUMEX-III)



IAEA
International Atomic Energy Agency

CRP FUMEX-3
2008-2012
published in 2013



CRP FUMEX-3

as a part of the fuel modelling IAEA programme

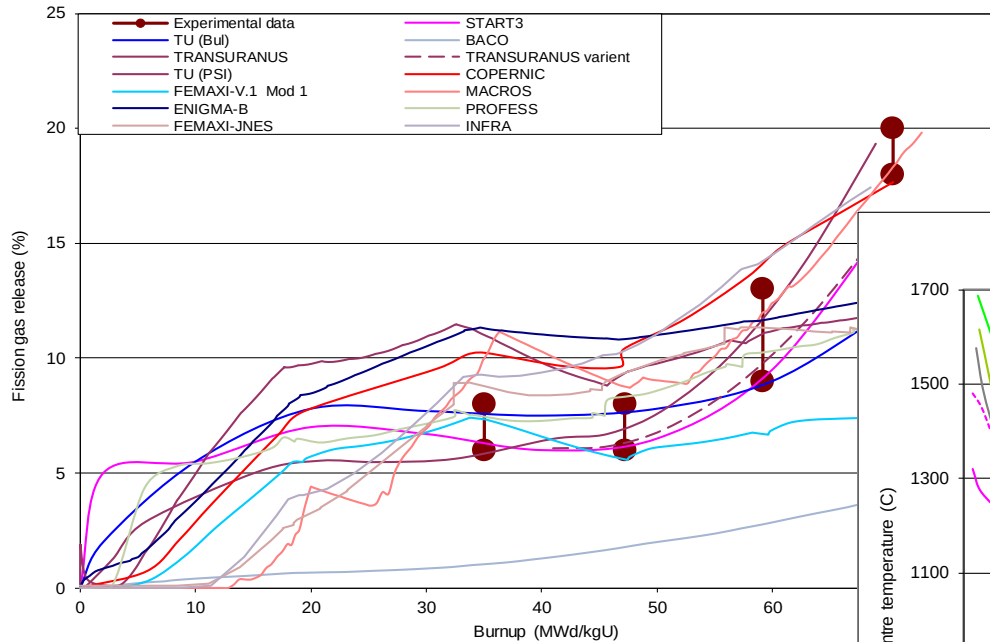
34 organizations from 21 countries and ITU/JRC/EC

Argentina	2	India	1
Belgium	1	Italy	2
Brazil	2	Japan	3
Bulgaria	2	Korea	1
Canada	1	Romania	1
China	3	Russia	2
Czech Rep	1	Switzerland	1
Finland	1	UK	2
France	1	Ukraine	1
Germany	2	USA	2
Hungary	1	ITU/JRC/EC	1

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>)

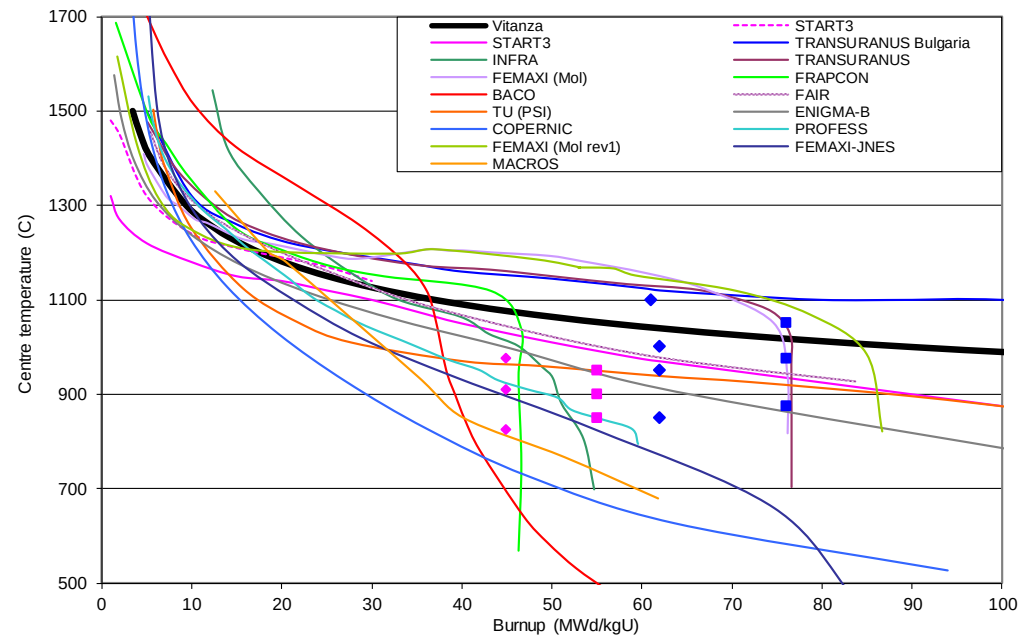
FUMEX-2 example: fission gas release prediction

Case 27(2d) FANP idealised



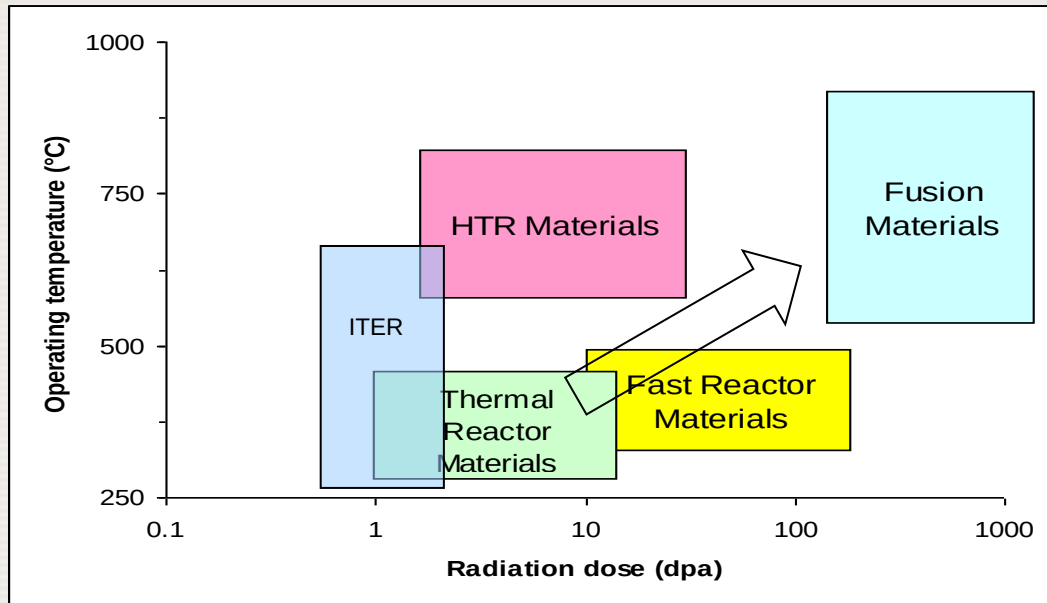
FUMEX-2, IAEA-TECDOC-1687, 2012

Case 27(1) Onset of FGR calculations



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

CRP SMORE: membership (19 members from 15 countries) and contributions

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, tripple beam H/He synergy;
 3. France: CEA (F. Willaime), EdF (G. Monnet) – MSM in Fe, Fe-Cr, ODS, Jannus tripple 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;
 6. Kazakhstan: INP (O. Maksimkin) – F/M and AS, comparison with BN-350, martensite degradation;
 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



CRP FUMEX → FUMAC → ACTOF

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!***