



FUEL

AREVA NP Proprietary - © AREVA NP Mai 2008 - All rights reserved

Future Industry Hotlab Needs - AREVA NP View -

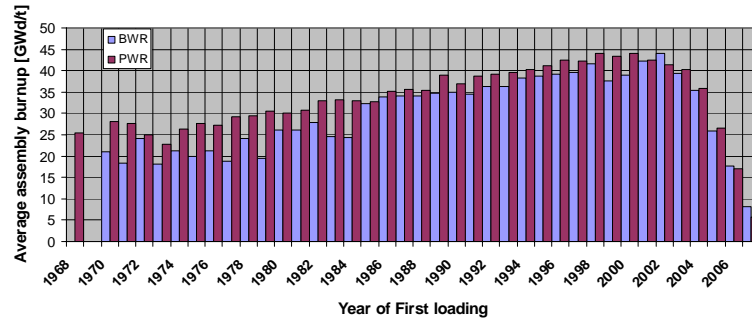
W. Goll, J. Thomazet, H. Schnabel

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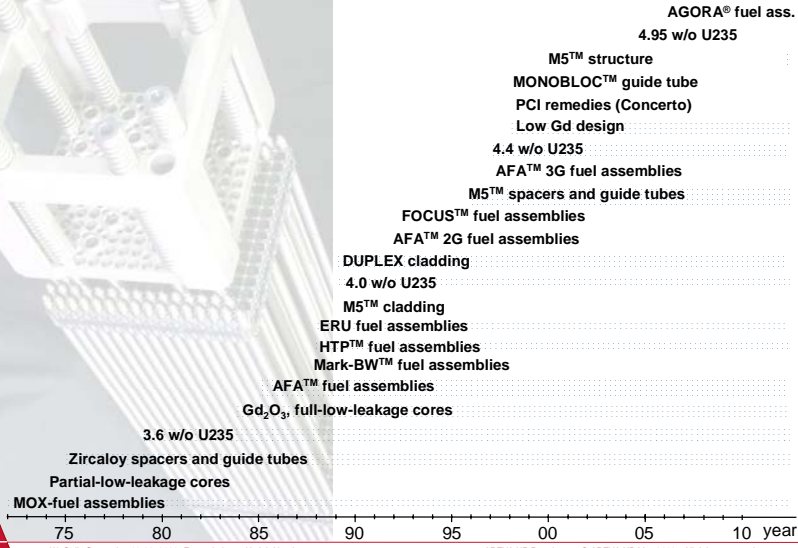
45th Annual Meeting of the 'Hot Laboratories and Remote Handling' Working Group, Kendal, England, 22-23 Sept. 2008

- > *Introduction*
- > *Milestones in the development of AREVA NP Fuel Assemblies*
- > *Areas of hot cell support and examples of achievement*
 - *Fuel assembly*
 - *Water chemistry*
- > *Future trends*
- > *Conclusions*

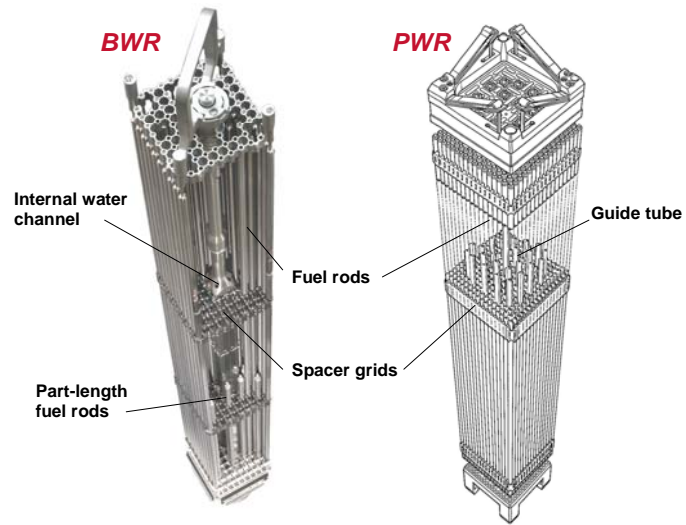
Average Assembly Burnup Achieved as of 2007/12/31



Milestones in the Development of PWR Fuel Assemblies of AREVA NP



Design of Modern AREVA NP Fuel Assemblies

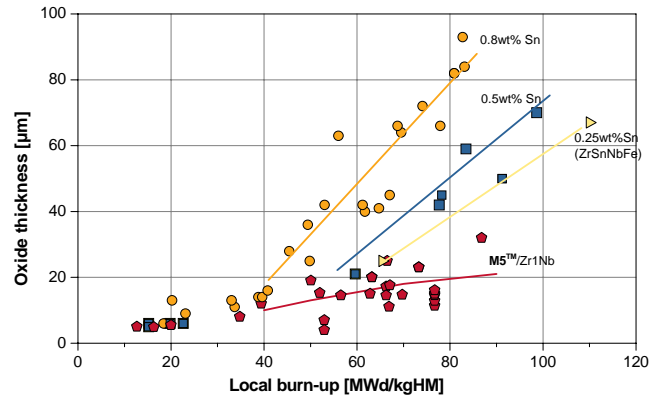


Objectives of Hotcell Work for the Fuel Manufacturer

- > Provide data for design and modelling
- > R&D, development of advanced materials
- > Provide rodlets for test or for further examinations (E.g. RIA, LOCA, PCI)
- > Investigation of incidents or special cases, i.e. new or unexpected phenomena
- > Fuel backend studies

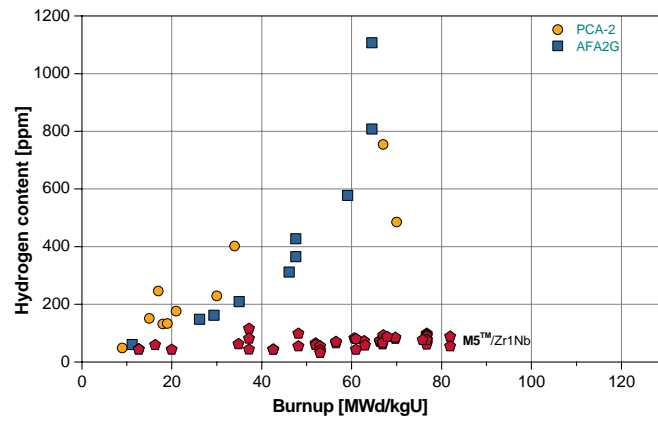
- > *Fuel rod (reactor operation and transient tested rodlets):*
 - *Dimensions (length, diameter),*
 - *Fission gas analysis,*
 - *Fuel density*
 - *Microstructural information (grain, porosity, rim, distribution and characterization of fission products)*
 - *Thermal annealing experiments*
 - *Isotopic analysis*
- > *Rod cladding*
 - *Corrosion behaviour*
 - *Hydrogen concentration*
 - *Mechanical data (strength, thermal creep, ...)*
 - *Crud characterization*
- > *FA structural data (spacer, guide tube, water channel, fuel channel)*
 - *Corrosion behaviour*
 - *Hydrogen concentration*
 - *Mechanical data*
- > *Control rods*
 - *Swelling*
 - *Mechanical data*

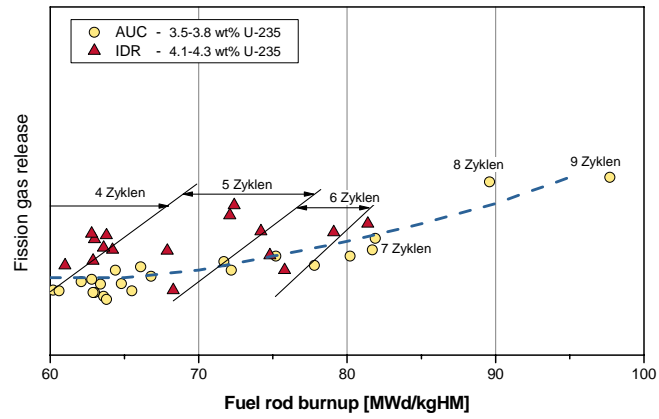
Improvement of Corrosion Resistance -PWR Cladding Corrosion (from metallographies)-



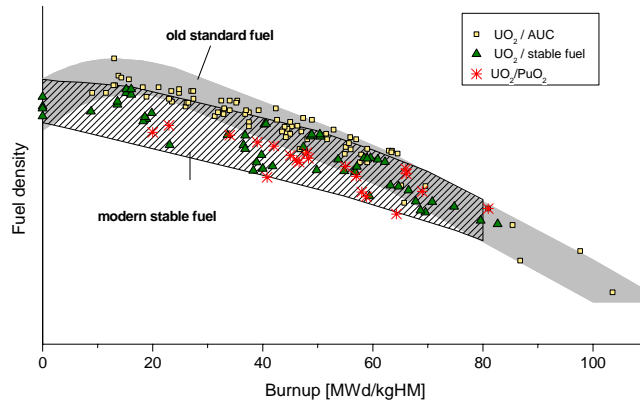
• Corrosion resistance is mainly determined by Sn and Nb

Reduction of Hydrogen Uptake - PWR Cladding Data (as measured) -



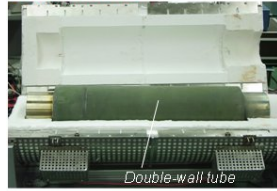


Optimization of the Fuel Density Behaviour

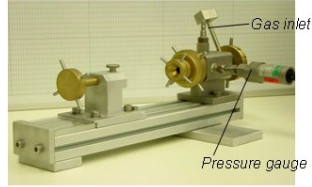


Long Term Thermal Creep Tests on Irradiated Samples

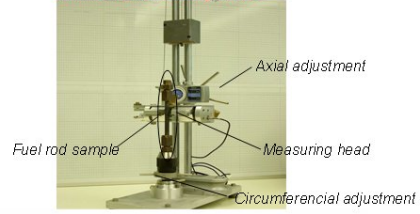
Electrical furnace



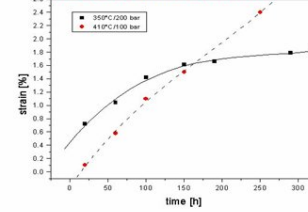
Gas filling station



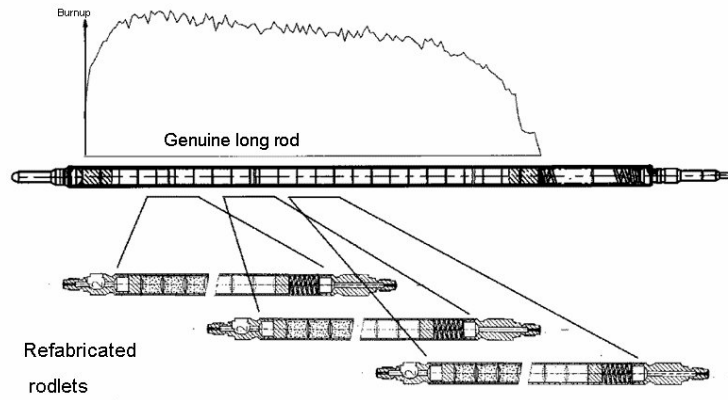
Diameter measuring device



Results of qualification tests

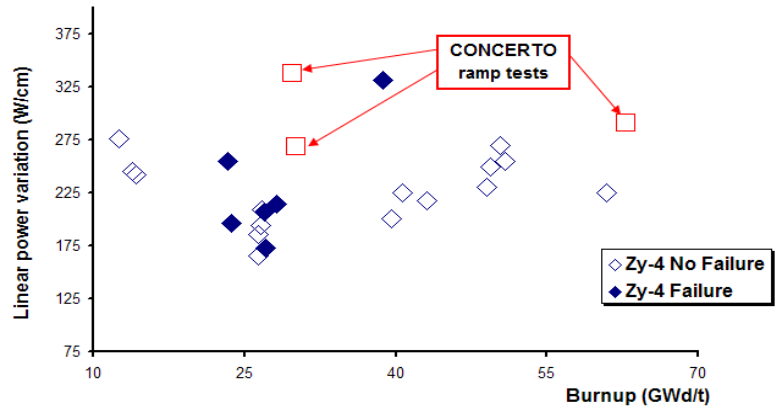


Refabrication of Rodlets for Transient Testing

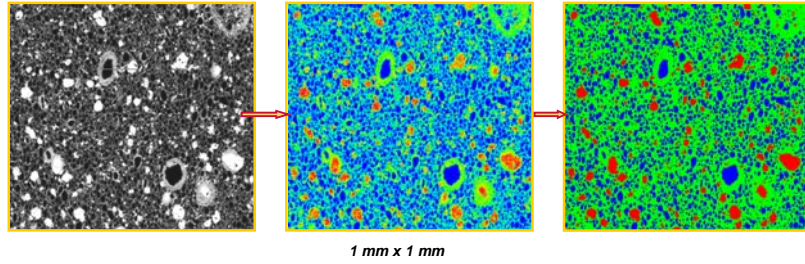


In-pile and Power Ramp Tests Performance PCI Resistance – PWR conditions

> Ramp testing in the OSIRIS reactor:



MOX microstructure: X-Ray mapping and image analysis



« On the characterization of plutonium distribution in MIMAS MOX by image analysis »

G. Ondinet et al., IAEA-TECDOC-1416, October 2004, p 221

- > Further optimization of AREVA NP's FAs is a continuous task (Budget!).
- > Technical and economical optimization of the lab techniques is a continuous task, too.
- > Burnup increase tends to saturate due to limited potential of a further U235 increase. Tendency of an increase of the plant power for different customers, opening up of operational margins by improved fission gas retention, optimization of structural behaviour with regard to corrosion and mechanical behaviour.
- > Growing importance of coolant chemistry topics (power increase, dose rate reduction, life time of components); techniques, such as Li and B measurements in the oxide, characterisation of the crud (chemical composition, porosity,...)
- > Refabrication of rodlets for transient testing and their subsequent analysis remains interesting (e.g. mechanical properties of cladding and fuel).
- > PCI remedies in the new operational conditions (burnup, power increase)
- > MOX fuel in the new operational conditions (burnup, power increase)

- > *In the last two decades, burn-up and reliability of PWR and BWR fuel could be increased considerably. It would not have been possible without comprehensive analysis performed in hot cells all over the world.*

- > *In future, hot cell work will be needed to further optimize the fuel for the existing fleet of reactors, but also for the advanced LWRs still to come. As their basic technique remains essentially unchanged, existing hot cell techniques can also be utilized for a while.*

- > *For the near future, a lowering of budget for hot cell investigations can be expected. As a result, all doers, i.e. fuel manufacturer and hot cells, will have to focus on more economic processes.*