Shearing and dissolving irradiated fuel elements down to nuclear data

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Orano Cycle
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The La Hague facility allows the separation of products from used fuel assemblies, in order to

- recycle valuable materials (U, Pu) for energy purposes
- minimize the amount and radiotoxicity of ultimate waste
- ensure the high quality of ultimate waste packages for long term storage
Types of fuels

Processed and/or to be processed fuels
- UOX PWR & BWR
- MOX PWR & BWR
- URE PWR
- UNGG
- RTR both French and foreigner
- RNR PHENIX

Associated range of burn up and enrichment
- LWR up to 62 GWd/t (enr. up to 4.55%)
- RTR up to 700 GWd/t (enr. up to 93.5%)

Cooling time
- Reception from 6 months
- Processing from 3 years (LWR) or 5 years (RTR)
Calculate the inventory of used fuels
Nuclear characterisation

Applications
- Preparing the reception of used fuel assemblies
- Optimizing the process beforehand
- Monitoring the process in-line
- ...

Physical quantities of interest
- Masses
- Activity
- Decay heat
- ...

Prioritise:
- Reception
  - e.g. Decay heat
    - Only 25 radionuclides
- Monitoring
  - e.g. Cs137 Activity

Priority for radionuclides e.g.
- Cs137

Concentration (# atoms)
Quantities driving the process
Specific feature

Just as everywhere in the nuclear energy field
✓ Radioprotection
✓ Criticality safety
✓ Decay heat
✓ Gaseous emissions of the plant

But with specific features
✓ Separated materials
✓ Long cooling times

Hence, specific expectations on nuclear data
Quantities driving the process
Effect of material separation

Uranyl: Wide range of isotopes 232-238U
✓ Criticality safety
✓ Radioprotection, only few ppm 232U, yet strong contributor

Plutonium oxide: Wide range of isotopes 236-244Pu
✓ Criticality safety
✓ Decay heat:
  contrib. ~ 5% of full assembly at CT=6 months,
  becomes 100% for separated PuO$_2$

Also in-between steps: for example, FPs + MAs solution
✓ Represents approx. 4% of total assembly mass, yet is responsible for
  most of its decay heat
✓ And yet, we have solution of exclusively FPs + MAs : high specific heat
Quantities driving the process
Effect of time scale

Short lived RNs do not come into account
✓ CT > 6 months before reception
✓ CT > 3 years before processing
✓ Final waste containers ~ 1My

Yet contribution of actinides becomes prominent at longer times
✓ For radioprotection
✓ And decay heat

Partial contribution to assembly total decay heat*

* PWR UOx, e_f=3.7%, BU=45 GWd/t
Specificities
How to prioritise?

The work to do

✓ To do it simple
✓ To do it quickly
✓ To do it right!
✓ Based on the importance/contribution

Example

Decay heat for fuel assemblies

“A methodology for fast and accurate decay heat calculations for in-pool used fuel assemblies developed at Areva La Hague reprocessing facility”

PHYSOR 2014 –Kyoto, Japan,
How to prioritise?
Example for decay heat assessment

For used fuels with a cooling time higher than 6 months, decay heat mostly depends upon only 25 isotopes.

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The methodology to prioritise radionuclides and nuclear data needs to be

- Based on physical quantities of interest
- Comprehensive, i.e. based on all the industrial applications
- Based on the occurrence of the radionuclides in all the applications
- Validated considering its integral impact

In collaboration with CEA, work is under way

- Identify improvement possibilities for the calculation of our radionuclides of interest
- PhD work carried out by A. Rizzo at CEA/Cadarache (2018)
- Results presented in papers and international conferences
Conclusions

The importance of being integral

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\[ 1 + 4 = 5 \]
\[ 2 + 4 = 6 \]
\[ 2 + 3 = 5 \]

Still validated
With new ND evaluations

INTEGRAL
Validated
DETAILED
DETAILED
... 
DETAILED
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JEFF Stakeholders Workshop – 6-7 June, 2019 – A. Launay
Confidentiel Orano