IAEA ACTIVTIES ON FUEL IRRADIATION TESTS, POST IRRADIATION EXAMINATION (PIE) AND PIE FACILITIES DATABASE

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For presentation to HOTLAB 2018, 17-20 September 2018
Who we are

- NE
- NS
- NA
- TC
- SG
- MT

Div. of NEFW
- RRS
- WTS
- NFCMS
- DERS

Uranium resources and processing

Nuclear power reactor fuel & NFC facilities

Management of SF from NPPs & radioactive material transportation
IAEA Sub-programme 1.2.2

• Supports activities on nuclear power reactor fuel in order for MSs to understand and address factors affecting the design, fabrication and in-pile behaviour of currently operated and innovative nuclear fuels and materials for power reactors.

• Support IAEA Member States to technically implement new safety standards when operating or upgrading existing nuclear fuel cycle facilities, and to understand and address factors affecting the ageing of these facilities (improvement of I&C, quality control measurements, environmental impact, etc.)

• Activities on irradiation tests and PIE of power reactor fuels are supported by sub-programme 1.2.2.

• These activities are implemented via conferences, CRPs, TMs, publication of technical documents (e.g. TECDOC).
CRPs to Support PIE Techniques of Power Reactor Fuel

  – A survey of ND techniques available in the spent fuel pool and hot cells, as a supplement to IAEA-TECDOC-245
  – Defect surveillance and detection, visual inspection, dimensional measurements, oxide layer thickness and crud measurements, gamma scanning, neutron radiography and X-ray radiography, fission gas determination, etc.

  – A survey of destructive techniques to perform microstructural examinations, elemental and isotopic analyses and measurement of physical, chemical and mechanical properties of irradiated fuel and structural materials, re-fabrication and instrumentation techniques.
CRP(s) that Include PIE of Irradiated Power Reactor Fuel

• CRP T12027 (Reliability of High Power, Extended Burnup and Advanced PHWR Fuels) included two sets of fuel irradiations and PIEs:
  
  – NU fuel bundle in a power reactor for 3 times NU burnup
  – (Th,U)O₂ fuel rods and sibling UO₂ fuel rods in a TRIGA material test reactor

  – Non-destructive and destructive tests at hot cells, including: visual examination, leak testing, profilometry, ultrasonic testing, gamma scanning, fuel element puncturing and fission gas release measurement, microscopic examination and mechanical testing of cladding.
Examples of Hot Cell Examination

Noble Metal fission product precipitates

Cladding inner surface

(a) (b) (c)
TM on PIE Techniques for Water Reactor Fuel


- IAEA-TECDOC-1277 (2002): Advanced PIE techniques for water reactor fuel
- IAEA-TECDOC-CD-1635 (2009): PIE and in-pile measurement techniques for water reactor fuels
- IAEA-TECDOC-CD-1693 (2013): Hot cell PIE and poolside inspection of nuclear fuel

Plan to have a TM in 2020/21 biennium
• Designed as "one stop" resource for technical and statistical information about nuclear fuel cycle activities worldwide: http://inficis.iaea.org

• Includes:
  – World Distribution of Uranium Deposits Database (UDEPO),
  – World Thorium Deposits and Resources (ThDEPO),
  – Nuclear Fuel Cycle Information System (NFCIS),
  – Post Irradiation Examination Facilities Database (PIE),
  – Minor Actinide Property Database (MADB).
A computerized database designed to provide information on commercial civilian nuclear fuel cycle worldwide.

Includes information on:
- Uranium ore processing,
- Conversion,
- Enrichment,
- Fuel fabrication,
- Reprocessing,
- Spent fuel storage,
- Heavy water production,
- Zirconium alloy and Zircaloy tube production facilities.
PIE Database

- Catalogue of PIE facilities (42 hot labs from 22 countries)
- Developed in cooperation with HOTLAB

<table>
<thead>
<tr>
<th>Country</th>
<th>Facility Name</th>
<th>#-of-DE Techniques</th>
<th>#-of-NDE Techniques</th>
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<tbody>
<tr>
<td>Argentina</td>
<td>CELCA</td>
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<tr>
<td>Belgium</td>
<td>LHMA - Laboratory for High and Medium Activity - SCK-CEN, Belgium</td>
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<td>9</td>
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<tr>
<td>Belgium</td>
<td>SCK•CEN - Chemical and Radiochemical Measurements</td>
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</tbody>
</table>

- Each facility data includes:
  - General & cell characteristics
  - Acceptance information
  - Available NDE, DE and other techniques
  - Availability of rod re-fabrication & instrumentation
  - Available Storage and conditioning capabilities
  - Reference documents.
### General
- Facility Name
- Country
- Address
- Contact Person
- Second Contact Person
- Phone
- Email
- Web Address
- Additional Information

### Cell Characteristics
- Purpose
- Gamma Activity Limit (Concrete) (TBq)
- Gamma Activity Limit (Steel) (TBq)
- Gamma Activity Limit (Lead) (TBq)
- Cell Atmosphere
- Largest Cell Width (m)
- Largest Cell Length (m)
- Largest Cell Height (m)

### Acceptance Information
- Acceptance Type
- Transfer Mode
- Maximum Cask Weight (t)
- Max. Fissile Enrichment (%)
- Failed Rod Acceptance
- Accepted Casks
- Comment
- Acceptance Condition
- Maximum Cask Length (m)
- Max. Fissile Weight (kg)
- Protective Tube

### Available Techniques
- Technique
  - Visual Examination
  - Length and Diameter
  - Gamma Scanning
  - Oxide Thickness
  - Oxide Thickness
  - Rod Puncture
  - Optical Microscopy
  - Image Analysis
  - Micro Gamma Scanning
  - TEM

### Storage and Conditioning
- Intermediate Storage | Yes
- Encapsulation for Reinsertion | No
- Encapsulation for Other | No
- Connection to Reprocessing | No
- Connection to Long Term Storage | No
- References |
Administration Page

List of PIE Facilities in Admin Page

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Country</th>
<th>Publish?</th>
<th>Operation</th>
<th>Data Status</th>
</tr>
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<tbody>
<tr>
<td>AREVA NP GmbH NTCRH-G Hot Cells</td>
<td>Germany</td>
<td>Yes</td>
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<td>ATALANTE-alpha workshop, lab., analyses, transuranien, reprocessing studies</td>
<td>France</td>
<td>Yes</td>
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<tr>
<td>Bhabha Atomic Research Centre - PIE Division</td>
<td>India</td>
<td>Yes</td>
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<td>Canadian Nuclear Laboratories</td>
<td>Canada</td>
<td>Yes</td>
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<td>REVIEW</td>
</tr>
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</table>

- Data update directly by contact points (Coordinators)
- Operation – Add, Delete, Edit
- Status – OK, Edit, Review
- Role: Administrator, Coordinator, Reviewer
- Note:
  - No updates for few years
  - Need to reactivate the updating process
Present Situations

• Irradiation tests and PIE are necessary to demonstrate the acceptable performance of power reactor fuels and to justify the specified maximum burnup for a new design.

• The cost of fuel irradiation tests and PIE is continuously increasing, while the availability of facilities for such activities has steadily decreased in the last decades, resulting in a need for their more efficient use via international collaboration.

• Current collaboration to maintain PIE facilities database could be extended to allow MSs’ access to existing facilities. Example → IAEA’s ICERR scheme
Objective:

- To facilitate MSs gain timely access to relevant nuclear infrastructure (e.g. facilities, resources) based on research reactors and their ancillary facilities
ICERR: Scheme

• Designated ICERRs:
  – MSs’ organizations that meet designation criteria (logistic, technical, sustainability criteria)
  – Limited to specific areas for which the designation is requested
  – Designation period of 5 years

• Facilitator: IAEA
  – Designate dedicated ICERRs (awarded by DG)
  – Promote enhancing utilization of facilities
  – Foster the collaboration among ICERRs
  – Maintain a network (ICERRNet) that is a gateway to exchange information between ICERRs, Affiliates, IAEA and other MSs

• Affiliate (users):
  – Use a facility on contractual basis (commercial or in-kind) through bilateral arrangements
Conclusions

• Traditionally, IAEA has supported irradiation tests and PIEs for power reactor fuels via various activities. As part of it, IAEA maintains PIE facilities database.

• Next step for further collaboration in this area may include facilitating MSs’ access to existing facilities for training or research purpose.

• Link: https://infcis.iaea.org/
Thank you!

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