EUROPEAN COMMISSION
DIRECTORATE-GENERAL
JOINT RESEARCH CENTRE
Directorate A – Strategy and Work Programme Coordination

CDP Theme

Nuclear decommissioning and waste management

Background on JRC Research

The JRC has a more than 25 years long history of R&D on high-level radioactive waste management, supporting the EU-Member States needs and priorities with the output from its unique array of infrastructures, facilities, analytical instruments, knowledge base and staff competence[1]. A broad spectrum of experimental activities is carried out, taking stock of a continuous effort to develop state of the art and innovative investigation techniques.

The key scientific-technological challenge in this domain is the implementation of the disposal of spent nuclear fuel and high-level wasteforms (e.g. vitrified waste) in a geologic repository. The aim of the scientific investigations performed by JRC is to increase confidence in the safety of disposal solutions. The scientific data and knowledge generated feeds the modelling of the long-term processes and reduces uncertainties in the associated Safety Assessment. In the case of geological disposal the goal is to demonstrate the very long-term stability of the "waste package" and thereby the safety of disposal concepts in different formations (e.g. granite, salt, clay). Short term experiments under accelerated conditions are designed and conducted to understand relevant material corrosion mechanisms in groundwater and/or to assess the evolution and resistance of the waste form against radioactive decay effects and damage. Modular concepts for multiple spectroscopic characterizations of surfaces under controlled conditions have been developed and are available for testing. Facilities for the synthesis of tailor-made materials (e.g. thin films with well controlled compositions) are used to prepare specimens for single effect experimental studies. Confidence in the safety assessment is deepened by the development of state of the art and innovative analysis methods to determine relevant

[1] The policy support to the Commission Services and the Member States focuses on the implementation of the Nuclear Waste Directive (Council Directive 2011/70/Euratom of 19 July 2011, establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, http://eur-lex.europa.eu/legal content/EN/TXT/?uri=CELEX:32011L0070&qid=1397211079180). This includes establishing implementation guidance for the Member States, and supporting DG ENER in review and assessment of the Member States notifications and progress reporting.

"difficult" isotopes (e.g. ^{79}Se, ^{14}C) present in low concentration in spent fuel systems. Improving accuracy in general is becoming a major issue as EU-Member States are getting close to start operating the repositories. The data obtained is used as input in models and codes to predict the long-term evolution (e.g. up to 1 million years) of the waste-loaded repository site. Other radioactive waste forms for which technical solutions are still not fully defined (such as graphite materials and poorly defined legacy wastes), and nuclear fuel cycle back-end solutions based on fuel recycling and minimization of long-lived radiotoxic content in the waste are also investigated.

Ongoing key projects and research

With several countries now planning interim storage of fuel for longer than 100 years, JRC is refocussing R&D efforts onto spent fuel management issues, including handling, transportation, long-term interim storage and retrievability thereafter. Ageing processes that may cause mechanical degradation of spent fuel rods are characterised; bending and impact load resistance tests are performed to assess consequences of hypothetical spent fuel handling or transportation accidents.

With many installations reaching the end of their operational life, and a complete phase out of nuclear energy foreseen in some EU-Member States, nuclear decommissioning is an important issue coming to the fore. The JRC research activities in this area encompass decommissioning of conventional and non-conventional nuclear installations, and even of degraded facilities following an accident. Today, decommissioning of conventional nuclear power plants and facilities is achieved industrially. Here, process improvements and cost savings are the envisaged dimensions benefitting EU citizens. In contrast, decommissioning of non-conventional facilities, including damaged sites, and facility remediation are alive with unknowns and uncertainties: dedicated R&D is thus essential to achieve industrial maturity. JRC's R&D efforts in this area aim at developing synergies with its own operational decommissioning, which encompasses a broad array of tasks and challenges. In particular, the operational decommissioning programme carried out at the JRC-Ispra site provides a suitable testing ground for new and promising analytical techniques and characterization methods originating from various nuclear R&D programmes of JRC. In all cases, improved assay methods will lead to free release of larger quantities of materials, while the development and qualification of portable and efficient analytical methods will enable timely and inexpensive measurements, leading to improved efficiency of the process. The ultimate goal will include achieving solutions that can be leveraged and applied elsewhere.

The activities carried out by JRC in the domain of nuclear waste management and decommissioning are not limited to knowledge generation aspects. For instance, JRC is interested in investigating socio-political aspects associated with the public perception of nuclear waste management issues, including factors shaping them in the current European

context. JRC is directly involved in developing a proposal to implement Joint R&D Programming among the Member States; the role of JRC includes both to be a Research Actor of a joint R&D work-programme and to contribute developing governance and implementing structures. Furthermore, JRC is entrusted with the lead in establishing the corresponding Knowledge Management platform, to preserve and make it accessible for future generations of experts and stakeholders. During the last few years, several PhD students have carried out experimental activities at JRC in fulfilment of their doctoral project on research topics related (fully or partially) to nuclear waste management and decommissioning. Typically, on a given year 2-3 students have been working full time at JRC with several more students visiting our facilities for shorter stays.

Selected output for science and policy

Policy reports:

1. Management of spent nuclear fuel and its waste, a Joint Research Centre and European Academies' Science Advisory Council (EASAC) Report, EASAC policy report no. 23 - JRC Reference Report, July **2014**, ISBN 978-92-79-33885-4

2. T. Charpentier, L. Martel, A. H. Mir, J. Somers, C. Jégou, S. Peuget, Self-healing capacity of nuclear glass observed by NMR spectroscopy, Sci. Reports, 6:25499 (**2016**).

Peer reviewed papers:

3. E. González-Robles, D. Serrano-Purroy, R. Sureda, I. Casas J. de Pablo, Dissolution experiments of commercial PWR (52 MWd/KgU) and BWR (53 MWd/KgU) spent nuclear fuel cladded segments in bicarbonate water under oxidising conditions. Experimental determination of matrix and instant release fraction, J. Nucl. Mater. 465, 63-70 (**2015**).

4. González-Robles, E., Metz, V., Wegen, D. H., Herm, M., Papaioannou, D., Bohnert, E., Gretter, R., Müller, N., Nasyrow, R., de Weerd, W., Wiss, T., Kienzler, B., Determination of fission gas release of spent nuclear fuel in puncturing test and in leaching experiments under anoxic conditions. J. Nucl. Mater. 479, 67-75 (**2016**).

5. S. Peuget, T. Fares, E.A. Maugeri, R. Caraballo, T. Charpentier, L. Martel, J. Somers, A. Janssen, T. Wiss, F. Rozenblum, M. Magnin, X. Deschanels, C. Jégou, Effect of $^{10}B(n, a)^{7}Li$ irradiation on the structure of a sodium borosilicate glass, NIMB, 327, 22-28 (**2014**).

6. K. Popa, M. Cologna, L. Martel, D. Staicu, A. Cambriani, M. Ernstberger, P. E. Raison, J. Somers, $CaTh(PO_4)_2$ cheralite as a candidate ceramic nuclear waste form: Spark plasma sintering and physicochemical characterisation, J. Eur. Ceram. Soc. 36, 4115–4121 (**2016**).

7. K. Popa, P. E. Raison, L. Martel, P. M. Martin, D. Prieur, P. L. Solari, D. Bouëxière, R. J. M. Konings, J. Somers, Structural investigations of PuIII phosphate by X-ray diffraction, MAS-NMR and XANES Spectroscopy, J. Solid State Chem. 230, 169–174 (**2015**).

8. M. Krachler, R. Alvarez Sarandes Lavandera, Capabilities of high resolution ICP-OES for plutonium isotopic analysis. Microchemical Journal 125, 196-202 (**2016**).

9. P. Carbol, D. Wegen, T. Wiss, P. Fors, Spent nuclear fuel as waste material. Materials Science and Materials Engineering, Elsevier; (**2016)**.

10. T. Wiss, J.-P. Hiernaut, D. Roudil, J.-Y. Colle, E. Maugeri, Z. Talip, A. Janssen, V. Rondinella, R.J.M. Konings, Hj. Matzke, W.J. Weber, "Evolution of spent nuclear fuel in dry storage conditions for millennia and beyond", J. Nucl. Mater. 451 198-206 (**2014**).

11. T. Fanghänel, V.V. Rondinella, J.-P. Glatz, T. Wiss, D.H. Wegen, T. Gouder, P. Carbol, D. Serrano-Purroy, D. Papaioannou, "Reducing uncertainties affecting the assessment of the long-term corrosion behaviour of spent nuclear fuel", Inorg. Chem. 52, 3491-3509 (**2013**).

12. P. Cakir, R. Eloirdi, F. Huber, R. J. M. Konings, T. Gouder: Surface reduction of Neptunium dioxide and Uranium mixed oxides with Plutonium and Thorium by photocatalytic reaction with ice, J. Phys. Chem. C 119 (**2015**) 1330−1337.

13. P. Cakir, R. Eloirdi, F. Huber, R. J. M. Konings, T. Gouder: XPS and UPS study on the electronic structure of ThO_x ($x \leq 2$) thin films, J. Phys. Chem. C 118 (**2014**) 24497−24503.

14. S. Cohen, M.H.Mintz, S. Zalkind, A. Seibert, T. Gouder, N. Shamir: Water chemisorption on a sputter deposited uranium dioxide film – Effect of defects, Solid State Ionics 263, 39–45 (**2014**).

Hosting Directorate

Directorate: Nuclear Safety and Security (DIR G)