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Characterization of Conditioned Nuclear Waste
for its Safe Disposal in Europe

Waste Acceptance Criteria: Outputs from the CHANCE Project

Crina Bucur

Institute for Nuclear Research Pitesti, Romania - RATEN ICN

crina.bucur@nuclear.ro

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  - chemical characteristics
  - mechanical characteristics
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- Opinions of the CHANCE EUG on WAC Harmonisation

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CHANCE project

- Funded by Euratom research and training programme 2014-2018 under **Grant Agreement N°755371**
- Within the NFRP 7-2016-2017 topic "Research and innovation on the overall management of radioactive waste other than geological disposal"
- Duration of 4 years: 1 June, 2017 - 31 May, 2021
- Total budget: 4,25 M€
- EC contribution: 3,98 M€
- Consortium: 12 partners from 8 European countries
- Coordinator: ANDRA

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CHANCE objectives

- to establish at the European level **a comprehensive understanding of current conditioned radioactive waste characterization and quality control schemes** across the variety of different national radioactive waste management programmes;
  - *based on input from end-users such as WMO, regulators, waste producers and repository operators*

- to further **develop, test and validate non-destructive techniques** that will improve the characterization of conditioned radioactive waste:
  - **Calorimetry** as an innovative non-destructive technique to **reduce uncertainties on the inventory of radionuclides**;
  - **Muon Tomography** as a non-destructive technique to ***control the content of large volume nuclear waste***;
  - **Cavity Ring-Down Spectroscopy** (CRDS) as an innovative technique to characterize ***outgassing of radioactive waste***.

CHANCE Questionnaire

18 questions aimed to help identifying:

- **key parameters** that need characterization;
- **technologies/methods** commonly used for characterization of conditioned RW;
- **waste acceptance criteria applied for different storage and disposal facilities**;
- **the possibilities of WAC harmonization in Europe**;
- **specific problematic issues** for the characterization of conditioned radioactive waste;
- **R&D needs** and the **on-going R&D programmes** on the characterization of conditioned RW;
- **potential applications of the characterization methods developed under** CHANCE;
- **socio-technical and ethical issues** associated with the waste characterization process.

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Answers received

Nr.crt	Country	Organisation	Type
1	BE	ONDRAF/ NIRAS	WMO
2	ES	ENRESA	WMO
3	FR	ANDRA	WMO
4	IT	Nucleco S.p.A.	WMO
5	PL	Radioactive Waste Management Plant	WMO
6	RO	ANDR	WMO
7	SE	SKB	WMO
8	UK	RWM	WMO
9	BE	SCK-CEN	RE
10	DE	JULICH	RE
11	FR	CEA	RE
12	PL	INCT	RE
13	RO	RATEN ICN	RE

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RW managed by the CHANCE EUG members

Depending on the nuclear programme of each country, in countries with

- **no nuclear energy production and no RR** (currently and/or in the past) the RW are generated from research, medicine, industry – usually **VLLW, LLW** and **sealed spent sources** have to be managed
- **RR and/or NPPs**: all spectrum of RW from VLLW to HLW and SNF have to be managed

Different RW classification schemes are applied across EU countries:

- some adopted a waste classification scheme in agreement with **IAEA GSG-1** (2009)
- others adopted the **IAEA 111-G-1.1** recommendations (1994)

Waste Acceptance Criteria

The answers received from the CHANCE EUG members are related to the following categories of WAC:

- **Site specific WAC** and applied for operational
  - **interim repositories**:
    - CEDRA facility, Cadarache, France
    - interim storage facilities in Dessel and Mol, Belgium
  - **final repositories**:
    - Centre de l'Aube in France
    - El Cabril in Spain
    - Drigg LLW Repository in the UK
    - SFR facility in Forsmark, Sweden
    - Rozan national waste repository in Poland
    - Baita Bihor national repository in Romania
    - Konrad repository in Germany – even it is a planned facility, the **WAC are already fixed and in force**

Waste Acceptance Criteria

- **Preliminary WAC** developed for the **planned disposal facilities**:
  - **Near-surface (for LILW-SL)**:
    - cAt-project in Belgium
    - near surface disposal project Romania
    - National Repository project in Italy
  - **Geological**:
    - Cigeo project in France
    - KBS3 project in Sweden

*Regardless of whether the WAC are preliminary or final and applicable, **parameters for which limitations** are imposed through WAC are grouped into:*

- **radiological**
- **chemical**
- **mechanical**
- **other parameters**

Radiological parameters *- near surface repositories -*

The following limits are generally applicable:

- **limits of radionuclide specific** activity per package - for **safety relevant RNs**
  - **The list of relevant RNs depends on facility type/concept and host site** and generally consists of **short- and long-lived**, **beta-gamma and alpha/neutron** emitting RNs
- **total activity**: for the whole disposal facility or per disposal zone
- **dose rate** at surface and certain distance and **integrated dose**
- **surface contamination** (for β-γ and α emitters).
- in some cases, limits for **total activity of β-γ emitters** and **total activity of α emitters**.

Content of fissile materials is limited in order to guarantee **under-critic conditions** in all scenarios that could occur during the facility life time.

Radiological parameters - geologic repositories -

Generally the preliminary WAC **do not impose a limit for specific activity** nor for the **total activity of RNs**.

- **for KBS3 project (SE)**:
  - the **RN content** in each canister has to be **determined and documented**
  - SNF has to be in **oxide form** and has low dissolution rate in the repository conditions
- **for Cigeo project (FR)**:
  - **activity of radionuclide by radionuclide** has to be known

Content of fissile materials is limited to guarantee **under-critic conditions** in all scenarios that could occur during the facility life time.

Limitations regarding the **heating power** are imposed to preserve geologic barrier functions and exclude the risk of fire.

- For example, for Konrad facility (for disposal of RW with negligible thermal activity), the heat generated by the waste is limited as **heat per RW container** and as **container averaged heat constant**

Chemical parameters

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In all situations particular attention is paid to the **chemical reactivity** to ensure the **stability of the waste matrices** and of the **engineered barriers.**

There are limitations on the:

- complexing and chelating agents;
- accelerators of leaching processes (chlorides, fluorides, nitrates, sulphates, carbonates);
- organic substances (EDTA, NTA, DTPA, TTHA, oxalates, citrates, acetates, TBP, ethylene diamine …);
- pyrophoric, flammable, explosive, corrosive or oxidizing, strongly reactive metallic materials.

Waste in liquid form or waste containing liquid are not allowed

Biologically active waste (infectious or putrescible) are generally **forbidden**.

Inventory of **toxic species** is **strictly controlled**

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Mechanical parameters

Through the *mechanical parameters* included in the WAC it is intending to ensure that there will **not be a collapse leading to the break of a safety barrier**.

- limits on **compression resistance** of the waste forms and waste packages
- **void** limitation
- **drop resistance** (also required by transport regulations)
- **swelling**
- handling/stacking parameters:
  - package **weight** and **size**
  - **centre of mass**

The **RW have to be solidified** (no free liquids are allowed)

The waste matrices **have to confine in a significant way the radionuclides** (limits on **diffusivity** and **leachability**).

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Other parameters

- **hydrogen** production
- **homogeneity** of the waste
- types of **conditioning matrices**
- specification for the **disposal container**
  - requirements related to **physical dimensions and weight** are specified as the transport, handling and emplacement equipments are designed with respect to the weight and dimensions of the canister
  - **identification and labelling**
    - for example, for KBS 3 concept it is specified that the copper shell shall be:
      - ✓ designed so it is possible to lift the canister by the lid
      - ✓ provided with an ID-code and a marking that shall be unique and readable after sealing, machining and deposition of the canister
      - ✓ the ID-numbers of the SNF assemblies shall be related to the ID code of the canister they are encapsulated in

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Opinions on WAC harmonisation (1/2)

- The large majority of respondents (11 out of 13) were of the opinion that, for **safety relevant parameters,** harmonisation is **neither possible**, **nor desirable**.
- The arguments supporting this opinion were that:
  - WAC reflect "*strategic choices*"
  - WAC are "*derived from the safety assessment of a particular disposal facility*", and therefore are "*linked to the design of the facility, local constraints and also on the type of waste to be disposed*"
  - One participant expressed concern that, in several cases, harmonization could lead to "***unjustified accumulation of constraints***"
- On the other hand, majority of the respondents (10 out of 13) expressed the view that, in terms of the **underlying rationale for WAC** development, the **basic assumptions for safety studies**, or the **potential parameters** to be evaluated through WAC, harmonization **may be appropriate and achievable.**

Opinions on WAC harmonisation (1/2)

Examples of **parameters that could be harmonized**:

- general conditions of acceptance
- physical & chemical properties
- acceptable waste for the main categories of disposal facility
- reactive metals and materials
- packaging and transport requirements
- approved disposal containers
- non-containerized waste
- package/container weight
- disposal container labelling
- records and transport regulations

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THANK YOU FOR YOUR ATTENTION!

For more information: crina.bucur@nuclear.ro ; Denise.Richard@andra.fr

The synthesis of answers received to the CHANCE questionnaire is available on

www.chance-h2020.eu