

Metadata in Geological Disposal of Radioactive Waste: The RepMet Initiative

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Abstract

The OECD Nuclear Energy Agency (NEA) launched the Radioactive Waste Repository Metadata Management initiative (RepMet) in 2014 under the auspices of the Integration Group for the Safety Case (IGSC) technical advisory body. RepMet's goal is to recommend sets of metadata that can be used by national radioactive waste repository programmes to manage their data, information and records thereof, in a way that is both harmonised internationally and suitable for long-term management and utilisation, e.g. in safety cases. Furthermore, the initiative that involves over ten different countries' programmes worked on the formulation of a consistent set of guiding principles for capturing and generating metadata, recommending a shortlist of selected relevant standards and guidelines on international good practices.

National radioactive waste repository programmes require large amounts of data across multiple disciplines (e.g. geoscience, radioactive waste management, engineering) that increase as these programmes proceed in number, type and quality, for multiple reasons and goals (e.g. site characterisation, licensing, safety case elaboration). Considering these boundary constraints, the core idea of long-term data management is that "data are being collected and managed for others to use them". Next generations of data-users have to be able to understand and access the information that the preserved data represent. Individual scientists and research teams, as well as managers and communications specialists, need to be aware of this and document their work accordingly.

RepMet is facilitating their task by bringing about a better understanding of a key aspect of the modern data management within the field of radioactive waste disposal, namely the identification and management of metadata. The initiative has analysed the metadata implementation both from the high-level point of view (i.e. methodologies, approaches, organisation policies) and from a more technical one (i.e. recommendation and application of selected metadata standards, data modelling techniques and implementation of controlled dictionaries).

The RepMet initiative fills a unique and important niche in the broader programmes on data, information and knowledge management that are conducted nationally and internationally by operators, regulators and other relevant actors in the radioactive waste management field. This paper provides an overview of the initiative and the status of the initiative as of the time of writing.

1. RepMet Introduction

The Radioactive Waste Repository Metadata Management (RepMet) initiative was launched

in 2014 by the Integration Group for the Safety Case (IGSC) of the Radioactive Waste Management

Committee (RWMC) at the OECD Nuclear Energy Agency.

RepMet analysed and investigated the application of metadata, a fundamental tool of the modern data and information management, within national programmes for radioactive waste repositories.

Radioactive Waste Management Organisations (RWMOs) have to manage very large amounts of data that they produce and receive to support their operational, pre-closure safety cases or other requirements. A special characteristic of radioactive waste repositories is the significant time, typically more than one hundred years, between facility construction and closure. Therefore, data handled by RWMOs require special treatment to be considered reliable and consequently usable for such a long period.

Within this challenging framework, the main goal of RepMet was to identify sets of metadata which enable RWMOs to manage their repository data, information and records in a way that is both suitable for long-term management and utilisation, and harmonised internationally (e.g. to support the data interoperability). Furthermore, the initiative worked on the formulation of a consistent set of guiding principles for capturing and generating metadata, as well as a shortlist of selected relevant standards and a collection of international good practises.

Several worldwide RWMOs and research laboratories from NEA countries were involved in the RepMet initiative: Andra (France), Enresa (Spain), JAEA (Japan), Nagra (Switzerland), NDA (United Kingdom), NWMO (Canada), ONDRAF/NIRAS (Belgium), Posiva (Finland), PURAM (Hungary), Sandia National Laboratories (United States), SKB (Sweden) and SÚRAO (Czech Republic). The RepMet group met twice yearly; working groups, composed of RepMet members and contractors, furthered the initiative in the intervening periods.

2. Metadata

National programmes for radioactive waste repositories are collecting large amounts of data that must be managed throughout the entire period of institutionalised oversight spanning a considerable amount of time. The data, metadata and related records also increase in number, type, and quality as programmes proceed through the successive stages of repository development: pre-siting, siting, site characterisation, construction, operations, pre-closure and finally closure. Regulatory and societal approvals are included in this sequence. Current programmes are also documenting past repository programmes, so that current and future generations can understand actions carried out in the past, by retrospectively adding metadata to help organise and arrange programme records.

The available data, information and records are accessed and updated according to management systems, with the underlying repository allowing users to locate what they require through searches of full text or the associated metadata.

Metadata allows context to be stored with data and provide additional information so that it can be located, used and reused. It can also be a useful tool to help waste management organisations to demonstrate that their programmes are appropriately driven. Such context-setting information may include data on quality checking or approval; provenance or ownership.

When considering metadata for a domain (as for RepMet), metadata are typically associated with a set of predefined digital or physical objects, for example an ID for a waste package or signing date of a quality log. It is important to remember, however, that metadata also cover how these elements are to be constructed and related to one another (for example how a waste package relates to a packaging campaign), the type and range of values they may take (for example, a package weight must be greater than 0 kg), etc.

3. RepMet Scope

The scope of the RepMet initiative includes the following:

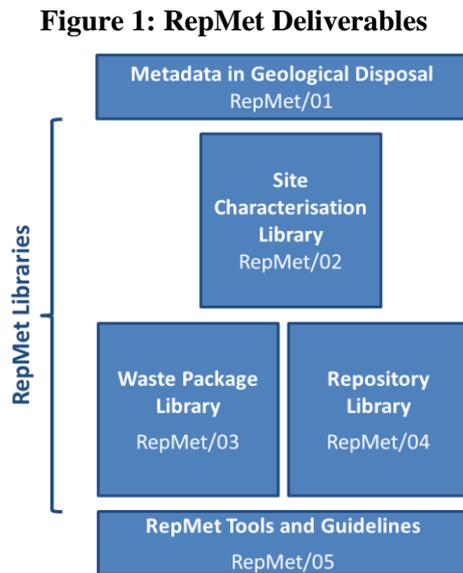
- Identification of methods and procedures for the gathering and management of data and metadata.
- Justification of the sufficiency of the set of metadata describing the identified data to support use and re-use.
- Relationship to safety assessment. The metadata required for information captured “in the field” will differ from that required for analysed and derived data that are often used within safety assessment models. (Safety assessment models are to be discussed in detail in future work.)
- Identification of methods and principles to guarantee the persistence in time of the above procedures.
- Guidelines for metadata management.
- Controlled dictionaries and policy as a means of ensuring consistency and reliability of data and cataloguing.
- Use of metadata to support data auditability, verification methods and, if needed, modification.
- Provision of a basis for the exchange and sharing of data between organisations, stakeholders and member nations, which may be separated across generations.

- Identification of methods and procedures for the data and metadata gathering and management.

RepMet does not intend to promote any commercial products or services for managing metadata.

4. RepMet Deliverables

Figure 1 illustrates the structure of the RepMet initiative deliverables that were produced during the initiative from its launch in 2014 to 2017.



The first document of the deliverables deals with the application of metadata in the field of radioactive waste geological disposal from a general, high-level point of view:

- RepMet/01 – “Metadata in Geological Disposal” provides an overview and summary of RepMet goals, deliverables, various aspects of metadata implementation and issues for consideration.

The following three deliverable documents, the so-called “Libraries”, adopted a more technical point of view. They discuss the key aspects of data and related metadata for selected topics of different scientific and technical disciplines involved in the realisation of a radioactive waste repository. The Libraries include conceptual data models (CDMs), descriptions of data entities, attributes, associated metadata and other relevant information:

- RepMet/02 – “Site Characterisation Library” deals with data and related metadata that are considered during the selection of the characterisation of a site investigated and surveyed for suitability for radioactive waste disposal purposes leading up to site selection.
- RepMet/03 – “Waste Package Library” deals with data and related metadata about packaged waste and spent nuclear fuel that, after proper treatment

and conditioning processes, are ready for final disposal at the repository.

- RepMet/04 – “Repository Library” deals with data and related metadata which relate to the engineered structures and waste acceptance requirements of the radioactive waste repositories.

The above Libraries can be used independently of each other, however utilising all of the libraries and the approach outlined in these documents provides the additional benefit of having a uniform approach to data and metadata management.

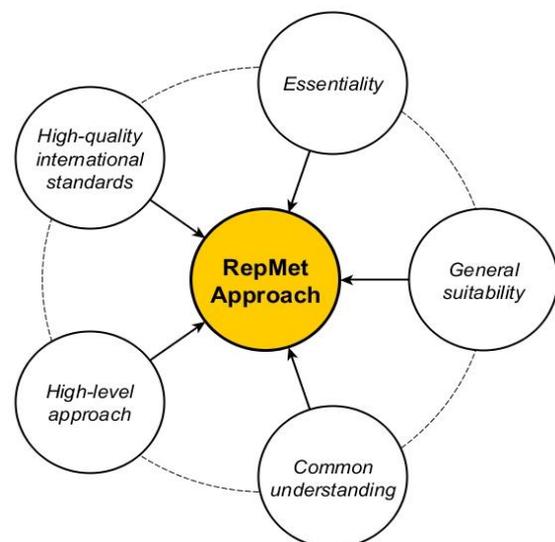
This document includes common techniques and tools that RepMet has adopted for the development of multiple libraries and which are deemed useful for relevant RWMO activities and initiatives:

- RepMet/05 – RepMet Tools & Guidelines supports the libraries providing several useful tools, methods, guidelines, and approaches that were either used in developing the Libraries or are useful for the RWMO when adopting and implementing the Libraries.

RepMet will close its activities in 2017. The above deliverable documents will be made available publicly in electronic form on the RepMet webpage¹ on the NEA website in the next months.

5. RepMet Approach

Figure 2: RepMet Approach



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- **High-level approach** – RepMet did not consider the choice of the IT systems for data

1. www.oecd-nea.org/rwm/igsc/repmet.

management and the related technology. It lies outside the initiative scope.

- **Essentiality** – The content of the libraries (e.g. the information about the final waste package for the safety case) is not exhaustive or universal. The group defined the minimal and essential information about the single selected topics.
- **General suitability** – All the RWMOs, independently of the RWM programme maturity, could apply the results of RepMet’s work in a manner considered suitable with their specific circumstances and needs. In this perspective, countries currently starting their own RWM national programmes might look at the current content as the core information that is recommended to collect at least in the first stages. On the other hand, more experienced RWMOs can extend the information according to their requirements and specifications.
- **Common understanding** – Controlled dictionaries for library contents such as entities, data, metadata, properties, etc., are at the root of the initiative, to promote and facilitate dialogue among the different organisations.
- Use of **international** well-consolidated and high-quality **standards**.

The last of the above listed principles of the RepMet approach for the library development requires additional explanation. As a matter of fact, the number of international and local standards relating to metadata management is overwhelming and as a result does not necessarily help the goal of standardisation. Different organisations also favour, or are prescribed to use, different standards.

As a principle, RepMet has attempted to select existing standards, rather than define its own to avoid escalating this number further. Selecting the best standard from the numerous standard candidates that often overlap or are subsets of each other is a complex endeavour. Different standards may focus on different themes.

The principles followed by RepMet when selecting relevant standards were the following:

- The essential minimum is recommended.
- Only standards that would work for all RWMOs are recommended.
- Less complex standards are given preference if suitable.
- Standards proven to work and widely used by the profession already are favoured.

6. RepMet Libraries

The development of the three RepMet Libraries across the main disciplines involved in the safety case

analysis for a radioactive waste repository (i.e. radioactive waste management, engineering and geoscience) was the core activity of the RepMet initiative. Table 1 shows the topics that the group selected for each library from the three disciplines.

The structure of the three RepMet libraries is uniform and composed of:

- *Conceptual data models* (CDMs) describing real or abstract objects related to the topic (e.g. the “waste”, the “wasteform”, the “spent nuclear fuel” or the “disposal module” in the “Waste Package Library”).
- *List of properties* (alternative called *attributes*) describing characteristics of the library objects (e.g. the “mass”, the “content of anions” or the “total alpha activity” of a waste) in the form of *controlled dictionaries*.

The information related to each property in the libraries plays a role in the development of a robust safety case for a radioactive waste repository. The sources of these pieces of information emanate from the same RWMOs involved in the initiative, since the RepMet group conducted analysis and an internal survey on data that the same RWMOs are currently collecting on the library topics. In this sense, RepMet used CDMs and controlled dictionaries to shape and organise the safety case information in a way supporting the common understanding between different organisations.

The safety case information must be maintained and preserved throughout the repository lifecycle. To achieve this demanding result, it would not be sufficient to just maintain the data related to a property: e.g. the numeric value (i.e. data) of the activity of a transuranic radionuclide (i.e. property) in a spent nuclear fuel assembly might be poor in meaning if the data-user does not know how it was obtained. It is important to have additional data, alias metadata according to their classic definition (i.e. “data about data”), to describe and maintain the information associated with the data. RepMet selected and adopted some metadata standards (i.e. OGC Observation & Measurement (O&M) metadata standard – ISO19156, and the Minnesota Recordkeeping Metadata Standard) to describe the properties in the RepMet Libraries. These standards provide some abstract (meta)data models that identify and arrange metadata to describe the information about a single property in a way that future users can trust.

Table 1: Topics and Disciplines of the RepMet Libraries

| Discipline | Libraries | Topics |
|------------------------------|------------------------------|--|
| Radioactive Waste Management | <i>Waste Package</i> | Packaged waste and spent nuclear fuel ready for final disposal |
| Engineering | <i>Repository</i> | Repository requirements and structure at closure |
| Geoscience | <i>Site Characterisation</i> | Geological and geophysical characterisation of the repository site |

7. Closing Remarks

Metadata enables RWMOs to manage their data in a well-organised manner, meeting statutory requirements and ensuring that data quality is not eroded, confidence in the stored data is kept, and that the data remain suitable for support of their future decisions and operations efforts, and meets the requirements of their designated communities in the present and in the future.

RepMet has formulated a consistent set of guiding principles for metadata management in the context of geological repositories. The results of this work are useful to operators, regulators and other relevant actors. The Libraries and associated documents have been prepared with the purpose to provide generic models, processes and descriptions that can be tailored to the needs of virtually any RWMO. These can be regarded as a common basis for the development of metadata.

RepMet recognises that each RWMO's activities are in many respects unique, and that each radioactive waste site has characteristics that are exclusive to that particular site. However, there are also many common and general aspects of radioactive waste management and final disposal.

Each RWMO needs to adapt the provided models, processes and descriptions in order to meet the requirements of local regulations, the RWMO's individual needs, and the characteristics and the applied technology of the individual radioactive waste management operations.

While RepMet has completed key deliverables in its initial phase, the group recognises the following outstanding work areas:

- Development of a complete metadata structure/database for a safety assessment tailor-made for the needs of the nuclear waste industry. Extension of the developed metadata structure developed by RepMet to encompass also the data related to the safety case and its

“models” (abstract, geometric, stochastic, deterministic).

- Creation of new RepMet Libraries including different topics for waste management pre-closure, e.g. “waste treatment and conditioning”, “plant operations”, “interim storage of the waste package”.
- Extension of the current RepMet Libraries (e.g. maturing, increasing the level of detail).
- Application of the O&M standard that RepMet has adopted to support safety assessment process chains and for the development of the safety case (e.g. new and dedicated RDF/SKOS controlled dictionaries and models).
- Definition of RDF/SKOS controlled dictionaries for the IGSC FEP Task Group.
- Definition of conceptual requirements for the creation of a central metadata database to allow data from multiple databases (e.g. commercial off the shelf [COTS] offerings) to be extracted and combined from a single query. These requirements should consider the possible conflicts of interest when handling metadata.
- Formulation of data dictionaries for RWMO modelling.

8. Disclosure

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The opinions expressed and arguments employed herein are those of the author(s) and do not necessarily reflect the official views of the OECD, the NEA or of the governments of their member countries.

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