Defining WAC for Interim Storage Dedicated to Tritium Decay - 15164

C. Decanis[a], D. Canas[c], F. Derasse[a], D. Dall'ava[c], J. Pamela[b]
[a] : *CEA, DEN, Centre de Cadarache, F-13108 Saint-Paul-lez-Durance, France*
[b] : *CEA, Agence ITER-France, F-13108 Saint-Paul-lez-Durance, France*
[c] : *CEA, DEN/DADN, Centre de Saclay, F-91191 Gif-sur-Yvette cedex, France*

ABSTRACT

Considering the high mobility of tritium through the package in which it is contained, the new 50-year storage concepts proposed by the CEA currently provide a solution adapted to the management of waste with high tritium concentrations, associated with adapted disposal sites. The 50-year intermediate storage corresponds to 4 tritium radioactive periods i.e. a tritium reduction by a factor 16.

The waste acceptance criteria (WAC) for this interim storage concept will take into account the safety of the facility, the reference scheme for the management of tritiated waste in France, and the criteria applicable at Andra[1] disposal centers. This will lead to define a set of waste specifications that describe the generic criteria such as acceptable waste forms, general principles and specific issues, e.g. conditioning, radioactive content, tritium content, waste tracking system, and quality control.

This paper details how the work by the CEA has led to a storage facility project that not only takes into account the specificity of tritium, but also the producers' needs and Andra's disposal requirements.

INTRODUCTION

As described in reference [1], fusion facilities like ITER will produce radioactive waste during operation and decommissioning. This waste results from the activation of materials by 14 MeV neutrons and from contamination by tritium, which is used as fuel in the fusion reaction. Most of the waste will be tritiated, which requires a specific management strategy taking into account the physical and chemical properties of tritium, its capability to diffuse through metals and its half-life of 12.3 years (5.6% of the tritium decays annually). In the nuclear field as well as in other industrial sectors, interim storage can be a necessary buffer function in the process management. A program for the creation of interim storage facilities for tritiated waste was defined in France, within the framework of the National Radioactive Materials and Waste Management Plan [PNGMDR, Réf. 2]. After the tritium decay, the waste packages will be shipped to the surface disposal facilities.

Waste acceptance criteria have to be established to specify the radiological, mechanical, physical and chemical characteristics of waste packages that are to be stored: for example, their radionuclide content or activity limits, the properties of the waste form and packaging. This paper presents the studies carried out on one of these interim storage facilities in order to establish the Waste Acceptance Criteria (WAC) taking into account all of the requirements.

TRITITED WASTE MANAGEMENT IN FRANCE

General Principles

Waste management can be optimized as a whole system - from production to disposal – and comprises the following steps:

- Waste production (waste volume, material used in processes, possibilities of sorting/recycling/treatment)

- Packaging design in relation with storage, transportation and disposal

- Storage duration and waste package flow in relation to transportation and disposal.

This requires a great deal of interfacing between radwaste management players within a structured framework to find the optimum solutions in term of cost efficiency.

Producers are involved and responsible at each stage of the waste management process. They must ensure a high level of quality to prevent the occurrence of any problem.

Legal Framework of Radwaste Management

Waste management is governed by law which complies with the international requirements: each government shall provide for an appropriate national legal and regulatory framework within which radioactive waste management activities can be planned and safely carried out.

In France, the PNGMDR is a key tool in ensuring the long-term implementation of the principles laid down in the Program Act of June 28, 2006 concerning the sustainable management of radioactive materials and waste to protect individual health, security and the environment.

It aims primarily at producing a regular overview of radioactive substance management policy, to evaluate new requirements and to determine the objectives to be met in the future, particularly with regards to studies and research. Its validity was confirmed on a European level when the directive establishing a community framework for the responsible and safe management of spent fuel substances was adopted on July 19, 2011.

The PNGMDR also organizes the implementation of research and studies on the management of materials and waste according to three aspects [2]:

- Reducing the quantity and harmfulness of the waste, in particular by reprocessing spent fuels and processing and packaging radioactive waste

- Using interim storage as a preliminary step, in particular with a view to carrying out fuel and waste reprocessing, or to dispose of the waste;

- Using deep geological disposal after interim storage as a permanent solution for ultimate waste that cannot be disposed of on the surface or at a shallow depth for nuclear safety or radiation reasons.

Interim Storage for Tritiated Waste Management

Because of their properties, certain radioactive waste categories require special management routes. This is, for example, the case with waste containing tritium (tritiated waste). The key points of the strategy established within the framework of the PNGMDR program for tritiated waste management are:

- Setting up a temporary storage site to allow for tritium decay if necessary for about 50 years, based on feedback from existing storage facilities, until the waste can be accepted for disposal

- Selecting a temporary storage site that is located as close as possible to the producer

- Designing the future disposal sites considering the tritiated radwaste characteristics after an interim storage period

- Making sure the producer takes into account waste sorting, consistency of the conditioning, characterization and treatment

- Paying special attention to the most out-gassing waste, considering detritiation techniques or high integrity containers.

The creation of new storage facilities by the CEA offers a satisfactory solution in terms of short- to medium-term safety, pending its future transfer to disposal facilities.

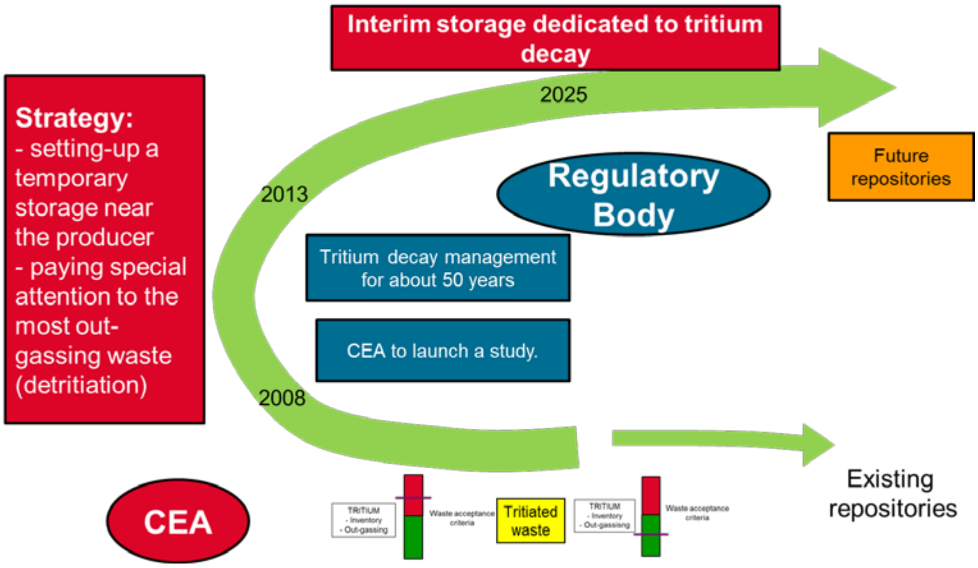

Fig.1: French strategy for tritiated waste management

Interim storage requires:

- Pending availability of the disposal facility
- Activity and/or heat decay which provides a solution in an industrial optimized chain.

INPUT DATA FOR THE INTERIM STORAGE FACILITY DESIGN

The design requires:

- Producers' data and the solutions for radwaste transportation
- Interim storage facility functions
- Safety options of the facility and its design
- Specifications of the waste disposal outlets.

Based on this data, the process to create the Waste Acceptance Criteria (WAC) of the interim storage can be launched (see section below). In the following paragraphs, we will focus on tritiated waste to be disposed of directly after interim storage. It has to be noted that some of the waste to be stored will need appropriate conditioning before disposal.

Producers' Data

The data required from the producers is:

- Data on the primary radwaste:
    - o Radwaste inventory during the whole interim storage period, with an estimation of the uncertainties with respect to the waste quantity
    - o Physical and chemical characteristics of the radwaste
    - o Radiological spectrum used with tritium content and associated uncertainties
    - o Packaging envisaged for the radwaste and durability during the entire interim storage period.
- Production and shipping records
- Required documentation and records including the waste history

- Identification of the waste packages
- Identification of the means of transportation.

This list is consistent with the international recommendations [3].

Interim Storage Functions and Main Components

<u>The technical interim storage functions are expected to be:</u>

- Collection of the packages provided by the producers
- Loading / unloading of the transport casks and packages
- Radiological control of the packages when received (contamination, dose rate, etc.)
- Packages control and characterization (tritium activity, outgassing measurements, etc.)
- Buffer storage of the packages
- Intermediate storage
- Packaging retrieval when needed
- Facility operation and maintenance
- Monitoring of the packages
- Environment monitoring (releases),
- Shipment of the packages to the disposals,
- Treatment (study as an option),
- Repackaging.

<u>As a consequence, the main facility equipment is expected to be:</u>

- Concrete buildings including truck bay, measurement/characterization rooms, storage rooms, maintenance/repair cell, control room, ancillary buildings, etc.
- Ventilation devices
- Power supply components,
- Power supply emergency unit
- Handling equipment: cranes, forklifts, etc.
- Monitoring of discharges/releases
- Radioprotection monitoring components.

Safety Options and Impact on the Design

The safety case has to be prepared by the operator early in the development as a basis for the regulatory decision-making process and approval with the following objectives:

- Protect the packages from external and internal hazards in order to maintain package integrity
- Protection of the workers, the public and environment against the hazards associated with radioactive waste in normal and accident conditions.

The storage facility design mainly depends on the type of radioactive waste, its characteristics and associated hazards, the constraints linked to the handling equipment, the radioactive inventory and the expected period of storage.

Depending on the source term, the facility will be licensed under the French “Licensed Nuclear Facility” ministerial order (called in France Installation Nucléaire de Base – INB).

To comply with this regulation, design is driven by the safety options chosen to demonstrate that the environmental impact is acceptable and the exposure of workers and the public in normal and accident conditions is also acceptable taking into account: earthquake hazard, extreme weather conditions, external flooding, internal fire, and load drop, etc.

The safety options in terms of confinement are based on static barriers (the radwaste package itself and the building) and on a dynamic confinement ensured by a specific air renewal system to deal with tritium out-gassing resulting from the large volumes of radwaste.

The earthquake hazard recommends the building to be constructed on rock.

Due to the high amount of tritium in the radwaste, the packages are expected to be stored temporarily for about 50 years; therefore, the lifetime expected for the interim storage facility (including the loading and unloading periods) is about 70 years, requiring specific measures to taking into account aging, the monitoring process and the maintenance strategy.

As a licensed nuclear facility, it will be subject to 10-yearly inspections conducted by the regulator, usually leading to refurbishment or upgrading.

Specifications of the Disposal Facilities

The packages after storage shall comply with the acceptance criteria of the disposals. In France, there are 2 surface disposals available: the Cires dedicated to the VLLW and the CSA for SL-LILW. Andra is the French national agency for radioactive waste management and it is in charge of disposal.

<u>Very Low Level Waste (called “déchets TFA” in French):</u>

From a radiological viewpoint, the acceptance of a waste batch depends on the IRAS (French radiological acceptance index for repositories), which takes into account the specific activity and the radiotoxicity class of the radionuclide:

$$IRAS = \sum \frac{A_{mi}}{10^{class_i}}$$

where A_{mi} is the specific activity of the radionuclide i expressed in Bq/g (waste + packaging).

To be considered as VLLW, the IRAS of a batch must be lower than or equal to 1 and the IRAS of each package in the batch must be lower than or equal to 10.

As an example, the radiotoxicity class of tritium is 3. This means that for purely tritiated waste, an IRAS of 1 is obtained with a tritium activity in the waste equal to 1000 Bq/g. The lower the toxicity class of a radionuclide, the smaller the amount accepted in the waste package.

The Cires disposal facility dedicated to VLLW was commissioned in 2003 by Andra and has a storage capacity of 650,000 m^3.

<u>Short-lived Low and Intermediate Level Waste (called “Déchets FMA-VC” in French):</u>

In its waste acceptance specifications, Andra has defined maximal activity levels for a list of 143 nuclides (half-life generally lower than 31 years). Out-gassing of gaseous radionuclides is also an important criterion.

For safety reasons, Andra has set rather stringent acceptance criteria in terms of tritium contents and out-gassing for its present disposal facilities. The waste acceptance criteria in terms of tritium for SL-LILW are as follows (current specifications):

- Specific activity acceptance limit $< 2.10^5$ Bq/g
- Total activity < 1 GBq for a 200L drum compactable and 50 GBq for the other packages

- Out-gassing acceptance limit < 0.2 MBq/metric ton/day.

Located in the Aube Department, the CSA disposal facility for SL-LILW was commissioned in 1992 by Andra and offers a waste storage capacity of 1,000,000 m^3. It took over from the CSM facility (Manche Department) which is currently being monitored as part of its post-closure phase.

Based on the safety options, Andra's disposal specifications and taking into account the requirements defined in the reference strategy for tritiated waste management, the WAC of a dedicated interim storage have been established.

ESTABLISHMENTOF THE WAC OF AN INTERIM STORAGE FOR TRITIATED WASTE

Methodology

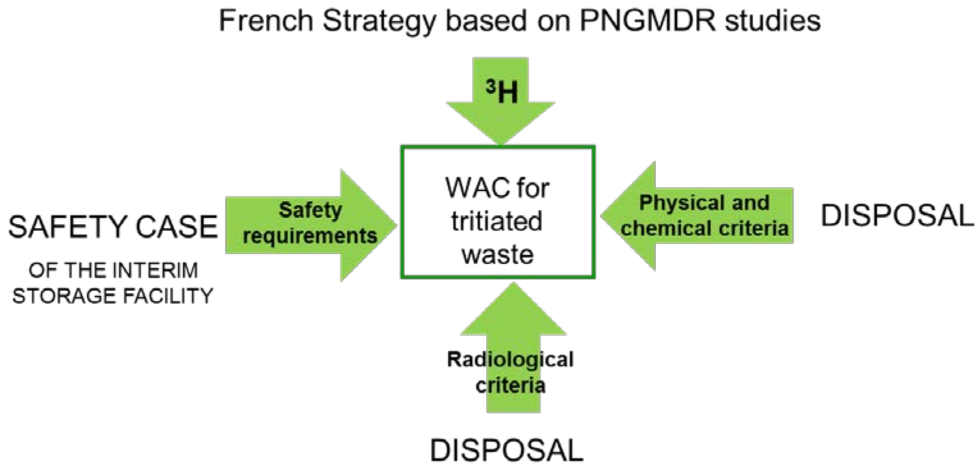

Fig.2 Methodology to define WAC for tritiated waste interim storage

The results of applying this methodology are detailed in the next sections.

General WAC for an Interim Storage

The waste producer must sign an agreement with Andra for its packages and only pre-accepted waste packages that comply with the disposal requirements will be stored.

The process for accepting waste packages in disposals is under construction with Andra and expected to be as follows:

- The producer must declare the characteristics of these packages to Andra to check the possibility of their transfer to the final disposal site on the basis of:

  - The radiological and physicochemical criteria defined in the acceptance specifications of the disposal facilities at the time the waste packages are produced
  - Tritium activity and off-gassing rate at the time the waste packages are produced.

- Only those packages declared by Andra to comply with these criteria can be directly shipped to Andra

- Those complying with the first criterion and expected to comply with the second after a cooling period up to 50 years will be deemed pre-accepted by Andra and shipped to the interim storage facility.

As an example, the waste producer must comply with the following main provisions to ensure its waste packages will be pre-accepted by Andra and therefore accepted by the interim storage facility:

- Most accurate knowledge possible of the type of waste and its non-hazardous nature. In particular, waste exhibiting flammability, reactivity or pyrophoricity should be specifically treated or packaged

- Assessment of the waste activity levels and related decay dynamic calculations covering a period of 50 years (βγ total, α, tritium, 14C)

- Assessment of tritium packages off-gassing rates and related decay dynamic calculations covering a period of 50 years

- Conditioning adapted to the type of waste and to the transport

- Issuing of a tracking sheet and a waste package ID card which implies the producer's responsibility

- Compliance with irradiation levels and external labile contamination thresholds,

- Compliance with mechanical resistance properties that are compatible with the waste handling, stacking and recovery operations.

Quality system:

The producer must provide a file ahead the storage of the packages. The important points from the quality point of view are the following:

- Radwaste management organization consistency

- Radwaste traceability

- Processing of non-conformities and possible refusal of the faulty packages

- Devices and equipment for measurement, inspection and periodic tests

- Checks performed by the producer (formalisation, traceability)

- Consideration of monitoring performed by the interim storage operator and the disposal facility.

Specific WAC for an Interim Storage for VLLW and SL-LILW Tritiated Waste

Tritiated Very Low Level Waste (VLLW):

The acceptance criteria are mainly the following ones:
- the authorized physical natures are defined in the Andra's specifications,
- boxes or other containers for the conditioning adapted to a 50-year interim storage are required,
- the IRAS repository radiological acceptance index shall be less than 1 for waste batches or less than 10 for waste packages, calculated on the basis of the tritium activity after a 50-year cooling period and the activity levels of other radionuclides on the waste production date.

Short-Lived Tritiated Low- and Intermediate-Level Waste (SL-LILW):

The acceptance criteria are mainly:
- Authorized physical natures are defined in the Andra's specifications
- Packages have to be classified IP2 according to the ADR Order of 5 December 1996 on the carriage of hazardous goods by road
- Radwaste radiological activities comply with maximum acceptance limits after a 50-year cooling period for tritium and at the waste production date for other radionuclides.

WAC Revision

The current WAC may need to be revised in the following cases in the event of:
- Lessons learned from the analysis of an unexpected event
- Regulatory changes related to the overall tritiated waste management scheme (production, storage, treatment, disposal, transport)

- Regulatory body (ASN) demand asking for a modification of the authorised range,
- Change in the producer’s needs if the impact is accepted by Andra and the interim storage operator,
- Extension or reduction of the disposal WAC, in particular in the allowed physical and chemical forms and the RN amounts after review and approval by the interim storage operator.

CONCLUSION AND NEXT STEPS

Conclusion

Interim storage is a buffer function in the process management and definition of the waste acceptance criteria is a key milestone in the facility development cycle.
The interim storage concept has shown its robustness, its technical maturity and is well-tried and tested. It also offers an answer to all types of tritiated radwaste as compared with other solutions.
The validation of the waste acceptance criteria by the producer and the waste disposal manager is ongoing.

Next Steps

In parallel to the facility detailed design, several potential improvements will be examined:
- Define mechanisms securing the acceptance of the waste packages after the interim storage phase
- Prepare a dynamic interim storage management strategy as part of the provisional solution:
    - Adaptability to the possible modifications in the producer’s process, in the interim storage safety analysis or in the disposal facility
    - Flexibility of the facility and of its future upgrades. For example, a staggered construction process is foreseen
    - Taking into account the operational feedback of other facilities of the same type
    - Launch an active technology watch on a national and international level to find alternatives solutions to interim storage such as new radwaste treatments designed to reduce tritium contents.

ACKNOWLEDGMENTS

This work is being performed within the Working Group on tritiated Waste Management, in close collaboration with representatives and experts of Andra and DGEC. The authors want to acknowledge Mr Dutzer from Andra for his useful comments.

REFERENCES

[1] J. Pamela, JM. Bottereau, D. Canas, C. Decanis, K. Liger, F. Gaune. ITER tritiated waste management by the Host state and first lessons learned for fusion development, ISFNT, Barcelona, 2013.
[2] Summary of the French National Plan for the management of radioactive materials and waste (2013-2015).
[3] IAEA Safety Standards. The management system for the processing, handling and storage of radioactive waste.