Milestone 88: Current use of Waste Acceptance Criteria (WAC) in European Union Member-States and some Associated Countries

Work Package 9 (ROUTES)

Task 4 (Sub-task 4.1)

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Executive Summary

"Waste management routes in Europe from cradle to grave" (ROUTES) is one of twelve work packages (WPs) being conducted as part of the European Joint Programme on Radioactive Waste Management (EURAD). The objectives of ROUTES are to:

- Provide an opportunity to share experience and knowledge on waste management routes between interested organisations (from different countries, with programmes at different stages of development, and with different amounts and types of radioactive waste to manage).
- Identify safety-relevant issues and their R&D needs associated with the waste management routes (from cradle to grave), including the management routes of legacy and historical waste, considering interdependencies between the routes.
- Describe and compare the different approaches to characterisation, treatment and conditioning and to long-term waste management routes, and identify opportunities for collaboration between European Union (EU) Member-States.

This report has been produced under ROUTES Task 4, which concerns the identification of waste acceptance criteria (WAC) used in EU Member-States for different waste management alternatives in order to inform development of WAC in countries without WAC / facilities. It provides an overview of the use of WAC in Member-States and some Associated Countries, focusing on the use of WAC as a management tool across the waste lifecycle (i.e. for both pre-disposal and disposal steps). It also discusses commonalities and differences between national approaches to develop and apply WAC. The report will inform subsequent activities under ROUTES Task 4 and, in due course, will feed into the final Task 4 deliverable (ROUTES Deliverable D9.9).

The analysis presented here is based primarily on national responses to the ROUTES questionnaire, which was developed in order to seek inputs to all ROUTES tasks through a single consolidated information gathering exercise. Section 2 of the questionnaire concerned WAC and asked the following questions.

- **Question 5**: Do Waste Acceptance Criteria (WAC) exist in your country for any or all stages of the waste lifecycle?
- **Question 6**: How were these WAC originally developed and what (if any) provisions are in place to update them?
- **Question 7**: If generic WAC are in place, how are these implemented?
- **Question 8**: Please describe how the WAC in your country take the following into account (for each stage of the waste lifecycle and with regard to different waste types, if relevant):
  - Radiological characteristics of the waste
  - Physical, chemical and biological characteristics of the waste
  - The waste package and its constituent components
  - Underpinning information requirements and process quality management
  - Waste management documentation
  - Secondary wastes
- **Question 9**: For each of the WAC described above, please explain how compliance with these is determined.
- **Question 10**: What is the standard response when a non-compliance with one or more WAC is detected by the waste management authority, the waste producer, the site operator (for operational facilities) or the regulator?

Detailed national responses to the ROUTES questionnaire were received from twenty-one countries. These provide a considerable body of information to analyse, and much experience to share and learn from. This report provides a synthesis of responses for each of the questions above. The full national responses to the ROUTES questionnaire have been compiled separately and are not reproduced here. A brief discussion of WAC in other European countries that did not respond to the ROUTES questionnaire is also provided, based on published information. Notable observations by country and

associated points of context are recorded throughout, as well as observations that are more generally applicable. The discussion is sub-divided to cover different stages in the waste lifecycle (i.e. retrieval / pre-treatment; treatment; conditioning and packaging; interim storage; transport, which may take place at multiple stages; and disposal) separately where relevant.

Since different countries employ different approaches to waste classification, the national responses have been compared in this report through application of the IAEA's system of radioactive waste classification, which defines radioactive waste classes based primarily on the combination of activity content and half-life of the radionuclides. According to this system, all low or medium active waste that contains predominantly short-lived radionuclides is considered to be low-level waste (LLW), whilst low or medium active wastes that are predominantly composed of long-lived radionuclides are considered to be intermediate-level waste (ILW). Similarly, high level waste (HLW) is interpreted to encompass vitrified HLW (for countries that have stocks) and spent nuclear fuel (where this is considered a waste).

Nature and scope of WAC

With regard to pre-treatment, treatment and conditioning, and storage, most countries have finalised WAC that are in use for one or more facilities and are applicable to various waste classifications, reflecting the widespread nature of such radioactive waste management practices and the value of WAC as a management tool. In countries where there are no WAC applicable for these waste lifecycle stages, there are various reasons why this is the case, e.g.:

- Waste management activities are still at an early stage and/or certain waste classifications have only recently been introduced in national legislation.
- WAC are not required for the lifecycle stage in question because no pre-treatment / treatment / conditioning / storage is carried out for certain waste classifications.
- Acceptance criteria are generally not defined for facilities that accept all waste / material regardless of its characteristics, since the term '*acceptance*' criteria implies the potential to also *reject* consignments to a facility, as well as to require that non-compliances are remediated. This is particularly the case where only one facility exists in a country for handling certain classes of material / waste (e.g. for centralised storage of spent nuclear fuel).
- WAC are not always reported for management activities conducted outside of the country responding to the ROUTES questionnaire.
- Treatment, conditioning, packaging and storage requirements may be incorporated into WAC covering multiple lifecycle stages, but primarily focused on storage and/or disposal.

It is noted that the term 'WAC' is typically used in relation to the receipt of waste at storage and disposal facilities. However, corresponding conditions / requirements / procedures / policies / decrees / criteria / regulations / specifications (the terminology in use varies from country to country) also apply for other (pre-disposal) stages in the waste lifecycle, and are relevant to consider under ROUTES Task 4. This is particularly the case where there is no transfer of ownership / liability (e.g. where waste producers are responsible for storing their own waste). It is also often the case during the management of spent nuclear fuel, since in many countries, this material is not classed as a waste.

For transport between nuclear licensed sites / users, countries operated in accordance with IAEA transport regulations, European Council Directives and international agreements concerning the carriage of dangerous goods as WAC for transport. These are often reflected in national legislation, sometimes, with extensions or additions to reflect the national context. Elsewhere, elements are applied directly, without such promulgation. Transport between facilities on the same site is often not subject to formalised WAC, although there may still be export / receipt requirements at the original and destination facilities respectively.

There is much more variation in the status of WAC for disposal, including considerable variation for different waste classifications within individual countries, largely depending on the status of existing and planned disposal routes for different waste classes. For very low-level waste (VLLW) and LLW, most countries have preliminary or final WAC (for planned or operational repositories, respectively), although some countries are at an early stage of developing waste management / disposal arrangements and do not yet have plans on which to base disposal WAC. In contrast, for ILW and HLW, most countries do not have any disposal WAC because planning for geological disposal is still at an early stage. With the exception of Hungary and Czechia, those countries that do have WAC for ILW and HLW disposal do not have finalised WAC, but instead have either:

- Preliminary WAC that will be developed and updated as planning and implementation of the associated disposal facility progresses.
- Generic WAC that are not specific to a particular disposal facility or site, but are defined as a precursor to facility-specific WAC, in order to enable waste conditioning and packaging to progress in the meantime.

This reflects the relatively long lead times for siting, developing, implementing and licensing disposal facilities, particularly geological repositories for ILW and HLW. Preliminary and generic WAC are of limited relevance in the commissioning of treatment, conditioning and storage facilities because the timescales for bringing such facilities online are generally much shorter than for disposal facilities and the details of their site and planned scope of operation are almost always known in advance. In contrast, when final disposal WAC are not available, preliminary or generic WAC are important for guiding the pre-disposal management of waste so that it can be conditioned and stored safely until a suitable disposal route is available.

Development and application of generic WAC

The focus of generic WAC on disposal reflects uncertainty about the characteristics of disposal systems that are yet to be developed, and associated uncertainty about the safety functions to be placed on the waste package and its constituents. Even so, the development and application of generic WAC is only conducted in a limited number of European countries and within these countries, the interpretation of what 'generic WAC' constitute varies widely.

Only the UK has developed and applied an extensive system of generic 'WAC' that is integral to its national approach to radioactive waste management (these apply to waste destined for geological disposal). Ukraine has used a similar approach for the initial development of WAC for a geological disposal facility as a basis for future planning, but employs site-specific WAC for other disposal facilities.

Elsewhere, generic WAC are not necessarily a precursor to site- or facility-specific WAC to be developed at a later date. I In some cases they reflect an overarching set of requirements, beneath which site- or facility-specific WAC are specified (France), and in other cases they reflect a set of requirements that are to be applied by any sites generating radioactive waste, and followed by any organisations involved in such activities, as is the case for requirements governing the discharge of radioactive waste in Cyprus.

Generic WAC / disposability criteria have also been defined by the IAEA and through collaborative international programmes, e.g. THERAMIN. These have been produced as a starting point for the development of tailored WAC that are specific to a particular national context and facility.

The use of generic WAC for disposal might have benefit in other countries that are at relatively early stages of planning for radioactive waste disposal. Indeed, the Slovakian response notes that generic WAC are not used at the moment but may be helpful as an inspiration when developing specific WAC for a deep geological repository. It could be interesting to explore whether this view is more widely held as part of future Task 4 discussions. For example, a planned gap analysis could involve group discussion of whether (and how) generic WAC could provide a tool to facilitate waste management (conditioning, packaging, storage and evaluation of disposability) for wastes where no disposal route is currently available.

Development and update of WAC

In countries with long-standing nuclear programmes, historic acceptance limits or specifications were typically formalised as WAC to comply with some general rules / norms imposed by the regulator. In contrast, for facilities that are planned / in development, or became operational in the last few years, the

WAC were developed during the licensing process of the particular facility (either for treatment & conditioning or for storage/disposal), based on the safety assessment. Often, WAC form part of the safety case or Safety Assessment Report.

Usually, WAC are developed by the waste management organisation or facility operator (which is sometimes the same entity) in consultation with other parties and agreed / approved by the regulator, but in some cases, WAC have been established by the regulator itself. Elsewhere, the regulator appears not to have had direct involvement in the development of WAC (or related requirements).

Most countries have provisions for periodic review and update of WAC, but the frequency varies and is not always explicitly set out. Often, WAC are updated, if necessary, as part of periodic or step-wise relicensing activities for a facility (conditioning/packaging, storage or disposal facilities) and the indicated frequency is related to the periodicity of licence revision / renewal.

Preliminary WAC (for disposal facilities that are planned / in development) are continuously reviewed, and updated from time to time, typically at each major milestone of the development programme. Changes to the legal and regulatory framework were, in most cases, the main factor driving historical WAC updates. WAC were also updated in response to the introduction of new waste types, waste containers or waste forms and to consider the experience accumulated from past operations.

Comparison of detailed requirements set out in WAC

Observed commonalities are that WAC (for LLW) devote a lot of attention to radiological characteristics (nuclide activities) and properties (dose rate, surface contamination), but less to physical, chemical, biochemical and biological characteristics or properties. Nevertheless, the WAC of most countries address physical hazards (explosion, fire, …), putrescible materials, waste form stability, voidage, free liquids and prescribe the use of a certain type of container (or containers). Organic and reactive wastes that have the potential to produce gas, complexants and/or free liquids as they degrade generally require treatment to convert them to a more passively safe form prior to conditioning and packaging, particularly where WAC preclude their acceptance for storage and/or disposal.

For geological disposal, long-term safety mainly relies on the host rock as a barrier. Nevertheless, WAC for HLW and ILW still set out specific requirements and/or values for the integrity of the waste package, container and waste form under disposal conditions, reflecting the assignment of long-term safety functions to these barriers as well. The applicable WAC are currently preliminary (France) or generic (UK) and are therefore expected to be developed further before geological disposal is implemented.

The heat output, which is a specific characteristic of HLW, is controlled through the design of the waste package and the repository rather than through WAC.

Checking compliance with WAC and managing non-compliances

The methods used to verify compliance with WAC are quite different among EU countries: from simple radiometric measurements (such as dose rate measurements) to more involved methods such as chemical analysis and chromatography for detection of gas generation and identification of the gas. Both non-destructive methods, such as physical inspection, radiometric measurements, or gamma spectrometry, and destructive methods, such as radiochemical analysis, are used to check waste package compliance with WAC either for storage or for disposal.

Dose rate measurement is the most widely used radiometric method for checking compliance of waste packages with WAC. In some countries, specific nuclide vector / scaling factors or the 'dose to Becquerel' methodology complement dose rate measurements to derive radionuclide activities. It is noted that these methods require good knowledge of the origin and/or history of the waste, which can be problematic for legacy wastes.

Measurement of the masses for specific materials or chemical / toxic species in the waste, characterisation of challenging wastes, such as legacy wastes or heterogeneous wastes, and measurement of difficult to measure radionuclides are indicated as the biggest difficulties for checking waste package compliance with WAC.

The detailed roles of different parties during application of WAC and compliance verification vary from country to country, with distinct nuances in the responsibilities applicable in each country. In some countries, a single organisation fulfils several roles. Often, several organisations (or representatives of different divisions within a single organisation) are responsible for specific compliance activities. Such cross-over can help to ensure that any non-compliances are identified.

The national safety authority (regulator) is generally responsible for approving the framework within which waste management activities are carried out. However, this does not always explicitly include a role in the development and/or application of WAC, nor in the selection or qualification of approaches to determine compliance.

Non-compliances can be detected by a range of different stakeholders including the waste management organisation, waste producers, facility operator or the regulator. The status of a non-compliance, once identified, is often tracked until it is resolved to all parties' satisfaction. In particularly serious cases, the regulatory body may withdraw the license and thus stop operation of a nuclear installation.

In most cases, the waste is not accepted if a non-compliance with one or more WAC is detected. The waste package can generally be sent back to the waste producer for remediation actions to eliminate the non-compliance if no means of remediation can be taken on the site where the non-compliance was detected. However, there are situations in some countries in which the waste package can be accepted without remediation if the producer performs an impact analysis and demonstrates that the consequences regarding long-term safety are acceptable.

If the detected non-compliance cannot be remediated, the waste package can be stored at the producer facility and eventually repackaged / overpacked. Alternatively, in some countries (e.g. Belgium) the waste can be accepted if it meets WAC for a different waste management route. In France, if a non-compliance is detected at the disposal site, the waste producer's agreement to consign waste to that site can be temporarily suspended.

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AND	Accord Européen relative au transport international des marchandises dangereuses par voies de navigation intérieures (European agreement concerning the international carriage of dangerous goods by inland waterways)
ADR	Accord Européen relative au transport international des marchandises dangereuses par route (European agreement concerning the international carriage of dangerous goods by road) From 1 January 2021 will be renamed to: "Agreement concerning the International Carriage of Dangerous Goods by Road"
CHANCE	Characterization of conditioned nuclear waste for its safe disposal in Europe
CIRES	Centre Industriel de Regroupement, d'Entreposage et de Stockage (Industrial facility for grouping, sorting and disposal) (France)
CSA	Centre de Stockage de l'Aube (Aube waste repository) (France)
CSD-V	Conteneur standard de déchets vitrifiés (Standard container for vitrified high level waste)
CTN/IST	Campus Tecnológico e Nuclear / Instituto Superior Técnico (Portugal)
CW	Conditioned waste (Belgium)
DGR	Deep geological repository (see also GDF)
EU	European Union
EURAD	European Joint Programme on Radioactive Waste Management
EW	Exempt waste
GDF	Geological disposal facility (see also DGR)
HAW	Higher activity waste (UK)
HLW	High level waste
IAEA	International Atomic Energy Agency
ILW	Intermediate level waste
IMDG	International maritime dangerous goods code
LIMS	Large inventory Member-States
LLW	Low level waste
NCSRD	National centre for scientific research "Demokritos" (Greece)
NCW	Non-conditioned waste (Belgium)
NEA	Nuclear Energy Agency
NORM	Naturally occurring radioactive material
NPP	Nuclear power plant
NWP	National waste programme
RE	Research entity
RID	Règlement concernant le transport international ferroviaire des marchandises dangereuses (Regulations concerning the international carriage of dangerous goods by rail)
ROUTES	Waste management routes in Europe from cradle to grave
SA	Safety assessment
SC	Safety case
SNF	Spent nuclear fuel
SIMS	Small inventory Member-States

SRS	Sealed radioactive source
THERAMIN	Thermal treatment for radioactive waste minimization and hazard reduction
TSO	Technical support organisation
UNF	Used nuclear fuel
VLLW	Very low level waste
VSLW	Very short lived waste
WAC	Waste acceptance criteria
WMO	Waste management organisation
WP	Work package
WPSGD	Waste package specification and guidance documentation (UK)

1. Introduction

1.1 Background to ROUTES

"Waste management routes in Europe from cradle to grave" (ROUTES) is one of twelve work packages (WPs) being conducted as part of the European Joint Programme on Radioactive Waste Management (EURAD), a five-year initiative, which aims to coordinate activities on agreed priorities of common interest between European Waste Management Organisations (WMOs), Technical Support Organisations (TSOs) and Research Entities (REs). EURAD commenced in June 2019 and draws participants from over 20 European countries, with an overall budget of nearly €60M [1].

The objectives of the ROUTES work package are to:

- Provide an opportunity to share experience and knowledge on waste management routes between interested organisations (from different countries, with programmes at different stages of development, and with different amounts and types of radioactive waste to manage).
- Identify safety-relevant issues and their R&D needs associated with the waste management routes (from cradle to grave), including the management routes of legacy and historical waste, considering interdependencies between the routes.
- Describe and compare the different approaches to characterisation, treatment and conditioning and to long-term waste management routes, and identify opportunities for collaboration between European Union (EU) Member-States.

Over the course of its work programme, ROUTES will consider experience from completed and on-going EU projects, such as THERAMIN (Thermal treatment for radioactive waste minimization and hazard reduction) [2], CHANCE (Characterization of conditioned nuclear waste for its safe disposal in Europe) [3] and other international initiatives (e.g. IAEA/NEA projects).

Activities within the ROUTES work programme are organised under seven tasks:

Task 1: Coordination, state of the art and training materials.

Task 2: Identification of challenging wastes to be collaboratively tackled within EURAD.

Task 3: Description and comparison of radwaste characterisation approaches.

Task 4: Identification of waste acceptance criteria (WAC) used in EU Member-States for different disposal alternatives in order to inform development of WAC in countries without WAC / disposal facilities.

Task 5: Radioactive waste management solutions for small amounts of wastes (focusing on disposal strategies for small-inventory Member-States).

Task 6: Description of the state of the art of shared solutions in European countries for characterisation, treatment, storage and disposal and planned sharing of facilities between Member-States, as well as identification of gaps and R&D requirements.

Task 7: Interactions with Civil Society.

1.2 Task 4 objectives and breakdown

Well-established WAC or related systems for both pre-disposal and disposal steps help to define a waste management strategy and are an important requirement for a management route to be effective. Task 4 of ROUTES aims to identify WAC used in EU Member-States for different waste management alternatives in order to inform development of WAC in countries without WAC / facilities.

More specifically, Task 4 has the following objectives:

- To provide an overview of the current application in Member-States of WAC at different stages in the waste lifecycle[1] and to describe mechanisms to implement them.
- To offer a structured approach to support decision-taking of "no regret" waste management measures.
- To identify R&D needs and opportunities for collaboration between EU Member-States.

These objectives will be delivered via three sub-tasks:

- **Sub-task 4.1:** *Current use of waste acceptance criteria* – this sub-task will provide an up to date overview per country on the use of WAC in Member-States, focusing on the use of WAC as a management tool across the waste lifecycle. Sub-task 4.1 ran for 15 months from June 2019.
- **Sub-task 4.2:** *Sharing of experience on waste management with and without WAC being available* – this sub-task will provide a gap analysis of different approaches to waste management whilst maintaining compatibility with a range of options for radioactive waste disposal. This will offer a structured approach to support "no regret" waste management decisions. Sub-task 4.2 started in November 2019 and runs until October 2021.
- **Sub-task 4.3:** *R&D needs and opportunities for collaboration* – this sub-task will identify and prioritise common R&D needs related to the management of challenging wastes and identify opportunities for collaboration between Member-States. The sub-task will also integrate the overall results of Task 4 and document these in a deliverable report (ROUTES Deliverable D9.9). Sub-task 4.3 begins in November 2021, once other Task 4 activities are complete.

1.3 Objectives of this report

This report records the work completed under ROUTES Sub-task 4.1. In due course, it will feed into the final Task 4 deliverable (due for completion by September 2022).

The objectives of this report are:

- To provide an overview of the current use of WAC both for pre-disposal and disposal steps across the waste lifecycle for each country.
- To discuss commonalities and differences between national approaches to develop and apply WAC.

1.4 Approach to produce this report and report scope

1.4.1 ROUTES questionnaire

An early activity in Year 1 of the ROUTES work programme was to seek information inputs across all ROUTES tasks by way of a consolidated questionnaire [4]. The questionnaire was structured into six sections, covering: 1) general information; 2) development and use of waste acceptance criteria; 3) inventory of challenging waste and associated management routes; 4) characterisation; 5) management strategy and R&D programmes; and 6) shared solutions for waste management. Twenty-five questions were asked.

The ROUTES questionnaire was issued to all EURAD participants, and partners from the same country were asked to work together (and, where relevant, with other organisations in their respective countries) to produce a single national response. Twenty-one national responses to the ROUTES questionnaire

[1] The waste lifecycle (sometimes referred to as the waste cycle or waste management lifecycle) encompasses retrieval and pre-treatment of raw waste (e.g. sorting, drying,…); waste treatment (e.g. thermal treatment); waste conditioning and packaging, interim storage, transport (which may take place at multiple stages) and disposal.

were received, covering radioactive waste management activities in the following countries: Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), Czechia (CZ), Denmark (DK), France (FR), Germany (DE), Greece (GR), Hungary (HU), Lithuania (LT), The Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), Ukraine (UA) and the United Kingdom (UK). The national responses to the ROUTES questionnaire, together with clarifications provided during various ROUTES workshops and in response to follow-up queries, form the main source of input to Sub-task 4.1 and, hence, to this report.

Questions relevant to Sub-task 4.1 and considered in this report are taken from Section 2 of the ROUTES questionnaire and are as follows:

- **Question 5**: Do Waste Acceptance Criteria (WAC) exist in your country for any or all stages of the waste lifecycle?
- **Question 6**: How were these WAC originally developed and what (if any) provisions are in place to update them?
- **Question 7**: If generic WAC are in place, how are these implemented?
- **Question 8**: Please describe how the WAC in your country take the following into account (for each stage of the waste lifecycle and with regard to different waste types, if relevant):
  - Radiological characteristics of the waste
  - Physical, chemical and biological characteristics of the waste
  - The waste package and its constituent components
  - Underpinning information requirements and process quality management
  - Waste management documentation
  - Secondary wastes
- **Question 9**: For each of the WAC described above, please explain how compliance with these is determined.
- **Question 10**: What is the standard response when a non-compliance with one or more WAC is detected by the waste management authority, the waste producer, the site operator (for operational facilities) or the regulator?

The full text associated with these questions in the questionnaire (including subsidiary questions and guidance on responding) is reproduced at the start of each subsequent section of this report. Other questions are relevant to Sub-task 4.2 and will be considered later in the ROUTES work programme.

In the interest of brevity, and to avoid repetition across ROUTES deliverables, the full national responses to the ROUTES questionnaire have been compiled in a separate report [5] and are not reproduced here.

1.4.2 Other sources of input

Not all EU Member-States are participating in EURAD. Consequently, national responses to the ROUTES questionnaire have not been received for the following Member-States: Croatia (HR), Estonia (EE), Ireland (IE), Italy (IT), Latvia (LV), Luxembourg (LU) and Malta (MT). Some of these countries have established nuclear power programmes, whilst others use radioactive material primarily for medical, industrial and research purposes. Various other European countries that are not EU Member-States have established radioactive waste management programmes from which there is experience to share, including Norway (NO) and Switzerland (CH).

Information on WAC in these countries is presented, where available, in Section 8, drawing on public domain materials, including:

- National reports submitted under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management in support of the Convention on Nuclear Safety and made available by the IAEA.
- Published reports from other EU projects, such as THERAMIN [6] and CHANCE [7].

- National reports [8] and national radioactive waste and spent fuel management programmes [9] submitted to the EU in accordance with Directive 2011/70/Euratom (noting that these generally make only limited references to WAC).
- The NEA's national summaries of radioactive waste management programmes in member countries (noting that these are often rather out of date).

However, the available information is rather limited, so these countries are not included in the more detailed analysis elsewhere in this report.

1.4.3 Scope of analysis

This report provides a synthesis of responses for each of the questions above. It draws primarily on national responses to the ROUTES questionnaire, plus clarifications provided during the series of ROUTES workshops held in Athens in March 2020 [10] and in response to follow-up queries. Where necessary, national responses have been augmented with information drawn from other sources, as identified in Section 1.4.2 and in references cited throughout.

The report summarises components of the national responses where relevant to the provision of an overview on the current use of WAC for each country and a discussion of commonalities and differences between national approaches, but does not repeat the full responses themselves. The intention is to allow a comparison of approaches in different countries. With this in mind, the report is structured by question and then (where relevant) subdivided so that different stages in the waste lifecycle are considered separately. Extensive use is made of tables to facilitate comparison.

Not all of the questions and sub-questions set out in the ROUTES questionnaire were answered in every national response. Generally, this was because the questions were not relevant in the national context, or because the answers to the question were unknown at the time of responding. In some cases, it was unclear why no response was provided. This report summarises information that was widely provided across different national responses.

For brevity, except where explicitly stated, the term 'WAC' is used in this report as an umbrella term to refer collectively to the various regulations, procedures, policies and other requirements that govern waste management across all lifecycle stages (as identified in national responses to the ROUTES questionnaire).

1.4.4 Approach to compare national responses

Different countries have adopted and apply different approaches to radioactive waste classification that are based, to varying degrees, on factors such as the activity content of the waste; whether such activity is predominantly long-lived or short-lived; levels of heat output (arising predominantly from radiogenic decay) and/or the planned management route for the waste. National approaches to waste classification (and categorisation) are discussed in more detail in ROUTES Deliverable D9.4 [11] and have also been the subject of previous reviews [12].

One of the main objectives of ROUTES is to compare radioactive waste management strategies and approaches. However, the different waste classification approaches adopted in different countries make it difficult to consider the development and application of WAC in different countries in a consistent manner. Throughout this report, national responses have therefore been compared through application of the IAEA's system of radioactive waste classification, as set out in its General Safety Guide No. GSG-1 [13] and summarised in Figure 1. This defines radioactive waste classes based primarily on the combination of activity content and half-life of the radionuclides. The IAEA's approach enables certain suitable waste management / disposal routes to be associated with each waste class. The IAEA's definitions are provided in Box 1, together with clarifications on how they were applied when producing this report.

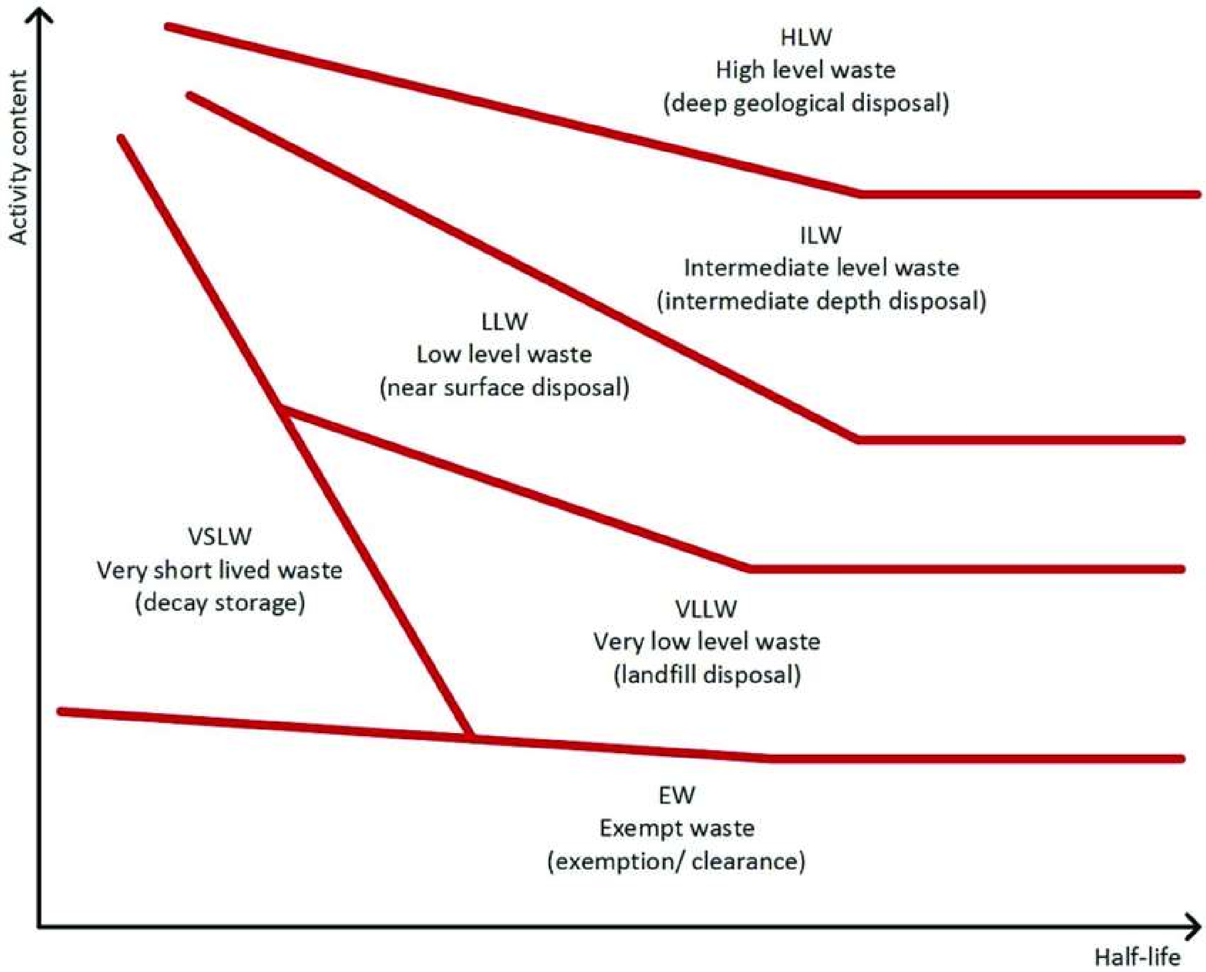

Figure 1 – Conceptual illustration of the IAEA's waste classification system (adapted from [13])

Box 1 – IAEA radioactive waste classifications, from [13]. Explanations of how these classifications have been applied in this report are provided in blue text.

- **Very low level waste (VLLW):** Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in near surface landfill type facilities with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer lived radionuclides in VLLW are generally very limited.
- **Low level waste (LLW):** Waste that is above clearance levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities. This class covers a very broad range of waste. LLW may include short lived radionuclides at higher levels of activity concentration, and also long lived radionuclides, but only at relatively low levels of activity concentration.
  In this report, wastes that are predominantly short-lived are assumed to fall into this class, even if they are identified as short-lived ILW in national responses.
- **Intermediate level waste (ILW):** Waste that, because of its content, particularly of long lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. However, ILW needs no provision, or only limited provision, for heat dissipation during its storage and disposal. ILW may contain long lived radionuclides, in particular, alpha emitting radionuclides that will not decay to a level of activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon. Therefore, waste in this class requires disposal at greater depths, of the order of tens of metres to a few hundred metres.
  Wastes that are predominantly long-lived are assumed to fall into this class, even if they are identified as long-lived LLW in national responses.
- **High level waste (HLW):** Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long lived radionuclides that need to be considered in the design of a disposal facility for such waste. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognized option for disposal of HLW.

  Includes vitrified HLW (noting that only countries that have reprocessed spent fuel will have stocks) and spent fuel (where this is considered a waste).

The following IAEA waste classifications are not considered in this report (since they are out of scope for consideration of long-term radioactive waste management):

- **Exempt waste (EW):** Waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes.

  Very short lived waste (VSLW): Waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for research and medical purposes[2].

[2] VSLW is referred to in some countries as 'transient' or 'transitional' radioactive waste.

1.5 Report structure

The rest of this report has the following structure:

- Section 2 summarises responses to Question 5 of the ROUTES questionnaire, concerning the status and nature of WAC in different countries.
- Section 3 discusses approaches to develop and update WAC, based on the response to Question 6.
- Section 4 describes the use in some countries of generic WAC, that is, WAC that are not linked to a specific site or facility. This reflects national responses to Question 7.
- Section 5 summarises the detailed requirements set out in national WAC (or related systems), based on responses to Question 8.
- Section 6 summarises approaches to determine compliance with WAC, based on responses to Question 9.
- Section 7 describes approaches to respond when a non-compliance with one or more WAC is detected, as recorded in responses to Question 10.
- Section 8 presents information on WAC in various European countries that did not provide national responses to the ROUTES questionnaire.
- Section 9 presents the report conclusions.

2. Analysis of responses to Question 5 of ROUTES questionnaire

2.1 Approach to review national responses

Question 5 from the ROUTES questionnaire is as follows. Guidance text is provided *in blue*.

Q5: Do Waste Acceptance Criteria (WAC) exist in your country for any or all stages of the waste cycle?

If different WAC apply to different stages of the waste lifecycle then please describe them separately in your response. You may wish to copy this table to provide separate responses or use sub-headings to organise your response.

You may also wish to refer to responses made by participants from your country to Q3 of the CHANCE End-User-Group questionnaire ("What are the waste acceptance criteria (WAC) for the storage / disposal facilities identified above… (operational and foreseen to be commenced in the future)?")[3].

- *Please provide an overview of the existing WAC that apply at every stage of the waste cycle by putting a "X" in the appropriate box(es) of the table below. Merge boxes or revise waste classifications as appropriate for your country. For every "X", please answer the questions below.*

	Retrieval and pre-treatment of raw waste (e.g. sorting, drying,…)	*Waste treatment (e.g. thermal treatment)*	*Waste conditioning and packaging*	*Interim storage*	*Transport*	*Disposal*
Very low-level waste (VLLW)						
Low-level waste (LLW)						
Intermediate-level waste (ILW)						
Spent / used nuclear fuel (SNF / UNF)						
High-level waste (HLW)						

- *Have these WAC been developed for specific facilities (either planned or existing) or are they generic at this time, i.e. applicable to all facilities performing a certain function, including those envisaged for future development?*

- *Are these WAC adopted and in use (for waste acceptance at certain facilities) or are they in some way preliminary?*

[3] The CHANCE End-User-Group questionnaire is available here: https://3okrv814vuhc2ncex71gwd1e-wpengine.netdna-ssl.com/wp-content/uploads/2019/08/D2.1-CHANCE-End-User-Group-Questionnaire.pdf
A synthesis of the responses to this questionnaire is available here: https://3okrv814vuhc2ncex71gwd1e-wpengine.netdna-ssl.com/wp-content/uploads/2019/08/D2.2-CHANCE-Synthesis-EUG-questionnaire-answers.pdf

- *Do these WAC apply to specific treatment, conditioning and/or packaging approaches?*
- *Please provide a reference (and ideally a web address) to any documentation describing the identified WAC that can be made available to ROUTES (in English). Ideally, this would be a reference from your national programme, but it would also be helpful to identify other sources of relevant information such as IAEA reports.*
- *What is the status of this documentation (e.g. publicly available; draft under development; unpublished but available for use in ROUTES;…)?*

As noted earlier, the full national responses to the ROUTES questionnaire are recorded elsewhere [5]. Not all of the bulleted sub-questions under Question 5 were explicitly answered in every national response; this analysis is based on inspection and comparison of the responses received.

Table 1 summarises responses for all countries and identifies the WAC available by country, for each stage in the waste lifecycle. Relevant IAEA waste classifications are identified in this table for each lifecycle stage (noting that in some cases, this results in different entries compared to the waste classifications provided in the national responses – this is highlighted where relevant).

Notable observations by country and associated points of context are recorded after the table. Further information on national waste inventories, waste classification approaches and management arrangements is available in ROUTES Deliverable D9.4, produced under Task 2 [11]. Observations relating to WAC that are more widely applicable are discussed in Section 2.3.

It is noted that the transport of radioactive materials is governed by the IAEA's transport regulations [14], European Council Directives [15,16] and agreements developed under the auspices of the United Nations concerning the carriage of dangerous goods (there are separate documents for carriage by road (the 'ADR'), rail (the 'RID'), sea (the 'IMDG') and inland waterways (the 'ADN')) [17,18,19,20]. These are typically reflected in the national legislation of countries handling radioactive wastes or else, elements such as the ADR are applied directly, without such promulgation. Table 1 assumes the application of such regulations as WAC for transport across all included countries and only identifies additional country-specific transport requirements that have been mentioned in national responses to the ROUTES questionnaire.

Table 2, Table 3 and Table 4 summarise the status of identified WAC for specific lifecycle stages including retrieval / pre-treatment; treatment and conditioning (which have been grouped together because of similarities in the scope of responses for these stages from many countries); interim storage and disposal. For each lifecycle stage, the types of WAC available in each country for each IAEA waste classification have been assigned to the following categories:

- Not applicable (N/A) – wastes falling into this classification do not exist in this country, so do not require management.
- None – wastes exist but WAC are not currently available. This is typically the case if no plans for a facility to receive or process a particular classification of waste currently exist.
- Generic – WAC that are in use but are not linked to a specific site or facility.
- Preliminary – WAC that are in development / draft. This term is generally used to indicate early versions of WAC for a specific site or facility.
- Final – WAC that are in use and site- or facility-specific. These may still be subject to periodic review / revision, as discussed in Section 3.

These tables include entries where WAC have been identified to exist (for the applicable waste classification and lifecycle stage) in the national responses; otherwise an assignment of ‘None’ is used (or ‘N/A’ if a waste classification is not used in a particular country).

2.2 Summary of responses

2.2.1 Summary of WAC by country

Country / Waste Cycle Stage	Austria	Belgium	Bulgaria	Cyprus	Czechia	Denmark	France	Germany	Greece	Hungary	Lithuania	The Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Ukraine	United Kingdom
Retrieval and pre-treatment of raw waste (*e.g. sorting, drying,…*)	**YES** (LLW & ILW)	**YES** (LLW; ILW – NCW)	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**YES** (HLW)	**NO**	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (LLW)*	**YES** (LLW & ILW)	**YES** (VLLW & LLW; ILW)	**YES** (VLLW, LLW & ILW)	**NO**	**YES** (VLLW, LLW & ILW)	**YES** (VLLW & LLW)*	**YES** (LLW & ILW)	**NO**
Waste treatment (*e.g. thermal treatment*)			**YES** (LLW, ILW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW)	**NO**	**YES** (LLW & ILW)	**YES** (VLLW, LLW)	**YES** (VLLW; LLW & ILW)		**NO**	**YES** (VLLW & LLW)	**YES** (LLW & ILW)	**NO**	**YES** (VLLW, LLW & ILW)	**YES** (VLLW & LLW)*	**YES** (LLW & ILW)	**YES** (LLW & ILW)
Waste conditioning and packaging		**YES** (LLW; ILW; HLW – CW)	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW, HLW)	**NO**	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**YES** (VLLW; LLW, ILW, HLW)		**YES** (LLW & ILW)	**YES** (VLLW & LLW)	**YES** (VLLW & LLW)	**NO**	**YES** (VLLW, LLW, ILW & HLW)	**YES** (VLLW & LLW)*	**YES** (LLW & ILW)	**YES** (VLLW & LLW)
Interim storage	**YES** (LLW & ILW)		**YES** (VLLW, LLW, ILW)	**YES** (VLLW & LLW)	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW & HLW†)	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW, HLW)	**YES** (VLLW, LLW & ILW)	**YES** (LLW & ILW)	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW, HLW)		**YES** (LLW & ILW)	**YES** (VLLW & LLW; ILW; HLW)	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW & HLW)	**YES** (LLW & ILW)	**YES** (VLLW & LLW)*	**YES** (LLW & ILW)	**YES** (ILW & HLW)
Transport (*'WAC' in addition to IAEA transport regulations, EC Directives & international requirements on the carriage of dangerous goods, which are widely applicable*)	**NO**	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW, HLW) Based on IAEA Standards	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, ILW, HLW)	**YES** (VLLW; LLW, HLW)		**YES** (LLW & ILW)	**NO**	**YES** (VLLW, LLW, HLW)	**NO**	**YES** (LLW & ILW)	**NO**	**NO**	**YES** (VLLW & LLW)
Disposal	**NO**	**YES** (LLW)	**YES** (VLLW, LLW, ILW, HLW)	**YES** (VLLW, LLW)	**YES** (VLLW, LLW, ILW, HLW)	**NO**	**YES** (VLLW, LLW, ILW, HLW)	**YES** (LLW, ILW)	**NO**	**YES** (LLW & ILW)	**YES** (VLLW, LLW)	**YES** (VLLW)	**YES** (LLW)*	**NO**	**YES** (VLLW, LLW)	**YES** (VLLW & LLW)	**YES** (LLW)	**YES** (VLLW, LLW)*	**YES** (VLLW & LLW)*	**YES** (LLW)*	**YES** (VLLW & LLLW)

* Application of IAEA waste classifications in this report results in these entries being different in this table compared to the corresponding entries provided in the national response to the ROUTES questionnaire.
† SNF from research reactors is classed as ILW in Denmark.

Table 1 – Overview of WAC availability by country, for each stage in the waste lifecycle. Rows have been merged where applicable, as reflected in national responses to ROUTES questionnaire – this approach has sometimes been used to indicate where one set of WAC applies across multiple lifecycle stages.

Context notes and observations on WAC by country

Austria

- The VLLW classification is not used.
- There is no HLW (including SNF) requiring long-term management – SNF from the ASTRA and TRIGA research reactors is repatriated to the USA.
- Nuclear Engineering Seibersdorf (NES) operates both waste management facilities and interim storage facilities and has the role of WMO in Austria.
- The WAC for raw radioactive waste apply to specific waste categories (e.g. solid non-combustible, solid combustible, liquids, sources, …) which define the waste management processes applied.
- The WAC for interim storage (at NES) specify the packaging approaches for the interim storage facility as well as defining standard waste matrices (e.g. 200 litre drums with high-pressure compacted pellets, homogenously cemented 200 litre drums, and 200 litre drums with a container/capsule of sealed sources cemented inside).

Belgium

- The VLLW classification is not used.
- The WAC for disposal of Category A waste (LLW) will shortly be revised to take account of requirements for the planned surface disposal facility in Dessel, and are therefore treated as 'preliminary' rather than 'generic' in this analysis.
- The WAC for disposal of LLW currently only consider conditioning via cementation.
- WAC for non-conditioned waste (NCW) and conditioned waste (CW) are adopted and in use for pre-disposal activities, but a thorough revision is currently being prepared, in line with planned disposal activities at the Dessel surface repository.
- WAC for conditioning, packaging and storage of HLW are only applicable to the production of vitrified HLW (CSD-V) canisters, and are no longer in use (reprocessing of SNF from Belgian NPPs is suspended). There are no corresponding WAC for SNF.

Bulgaria

- SNF is not classified as radioactive waste in Bulgaria.
- Waste is currently held in existing temporary storage facilities operated by Kozloduy NPP at the plant site, and in the facilities of the State Enterprise for Radioactive Waste (SERAW) [21,22].
- Two further facilities are planned:
    - The National Disposal Facility for short-lived low and medium active waste (i.e. LLW, according to IAEA waste classifications), which is under construction.
    - A facility for interim long-term storage of HLW and long-lived low and medium active waste (i.e. ILW, according to IAEA waste classifications).
- WAC are in use for all types of radioactive waste and are specific to the facilities in operation. WAC are available for all waste classifications emplaced or to be emplaced in the above-mentioned facilities. Disposal WAC for VLLW and LLW (to the National Disposal Facility) can be regarded as preliminary.
- Geological disposal is envisaged as the end point for disposal of ILW and HLW; interim long-term storage will be employed until a geological disposal facility is available. Preliminary WAC for the planned facility are included in the relevant design and safety case.

Cyprus

- Cyprus follows the guidelines of the IAEA [13] regarding the definition and classification of radioactive waste.

- In Cyprus, 'disposal' is in the form of authorised discharges to the environment[4]. Radioactive waste (primarily composed of short-lived radionuclides from medical uses) is discharged once it meets exemption levels provided for by law, so does not require long-term management.
- Consequently, there are no formal WAC in place at present, although there are generic requirements covering storage and discharge of radioactive waste.
- National policy regarding the safe management of radioactive waste foresees the establishment of WAC, if necessary.

Czechia

- Facilities in Czechia carry out activities through all stages of waste management and WAC are used for each process.
- ILW, LLW and the small amounts of VLLW that exist in Czechia are currently managed via the same routes and disposed of in the same installations (long-lived and short-lived wastes are not managed separately). The same WAC are applied to all of these waste classes.
- Three repositories are currently in operation:
    - Richard repository (a near-surface repository in an old mine) - for the storage and disposal of institutional waste.
    - Bratrství repository (an old mine) - for the disposal of waste containing naturally occurring radionuclides only[5].
    - Dukovany repository (an engineered surface facility) - for the disposal of radioactive waste generated by NPPs (excluding SNF).
- ILW (i.e. waste containing long-lived radionuclides) is currently disposed of in the Richard and Bratrství repositories (alongside LLW and VLLW).
- A deep geological repository (DGR) is also envisaged (the roadmap for its development assumes that the DGR will commence operations in 2065). Associated planning is at a relatively early stage and WAC for the DGR have not yet been developed.
- Once available, it is expected that all types of radioactive waste will be disposed of in the DGR except for LLW / VLLW arising from operation and decommissioning of NPPs.
- It is not intended to retrieve already disposed of ILW for disposal in the DGR once this becomes available. The repositories that are currently in operation will be closed by this time.

Denmark

- The VLLW classification is not used.
- The highest activity waste in the Danish inventory is in the form of spent fuel from research reactors (no reprocessing is carried out). This is classed as ILW in Denmark.
- National policy is for storage until 2073 followed by disposal of all radioactive waste to a geological disposal facility (GDF).
- There are four interim storage facilities operating in Denmark, all located in the Risø area. Routing of wastes to these facilities distinguishes between waste from operations at Dansk Dekommissionering (Dekom) and external users, and decommissioning waste (which may be larger items).

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[4] It is noted that authorised discharges are not normally considered to be disposal; moreover, nuclear licensed sites worldwide have authorised discharge limits but these are not generally regarded as WAC and are therefore not included in other national responses to the ROUTES questionnaire.

[5] Czech law recognises several types of waste containing only naturally occurring radionuclides:
- Waste arising from uranium / thorium ore mining and processing. This is not classed as radioactive waste. The state mining company is responsible for this material, which is deposited in sludge lagoons.
- Waste arising from non-radioactive uses of materials containing naturally occurring radionuclides (e.g. titanium white production; transportation of raw oil / gas; water pipelines; waste water treatment; etc). This is classed as NORM, rather than radioactive waste. Nevertheless SURAO (the Czech WMO) is responsible for the development of a special disposal facility for this waste.
- Radioactive waste arising from medical or industrial uses but containing only naturally occurring radionuclides (e.g. Ra-needles; materials contaminated by uranium). Such waste is disposable in the Bratrství repository.

- WAC for these facilities differ in terms of container types accepted; radionuclide inventory (with respect to the fissile material content); and dose rates one metre from the surface of the waste package. Some of the storage facilities use selective emplacement of waste packages to manage units with a higher associated dose rate (by surrounding these packages with other waste units to provide shielding).
- The WAC do not describe the waste in terms of its origin, material content or classification.
- External users are responsible for arrangements to transport wastes they have produced to Dekom.
- Waste transfer from the decommissioning sites at Risø to storage facilities in the same area takes place over short distances and is carried out according to agreements with the Danish authorities. Transfers are mainly carried out using trucks, although a large remote-controlled vehicle (moving at walking speed) has been used to transfer a few large containers of decommissioning waste (up to 77 tonnes).
- The volume of radioactive waste requiring storage and disposal must be minimised, e.g. by incineration, melting and reuse, or when possible by clearance. Combustible waste is sent to the Studsvik incineration facility in Sweden [23].

France

- France has opted for a closed nuclear fuel cycle. Uranium oxide spent fuel is currently reprocessed; other spent fuels (i.e. mixed oxide fuel and spent fuel from research reactors) are planned for reprocessing, at present. Reprocessed uranium is planned for feeding back into the fuel cycle. A new centralised facility for wet storage of SNF is also planned.
- No publicly available WAC exist for raw waste retrieval and pre-treatment activities. However, all facilities producing radioactive waste have rules in place for sorting the waste to facilitate downstream management, based on its activity content and physical and chemical characteristics (e.g. combustible/non-combustible; compactable/non-compactable).
- WAC for conditioning and storage facilities are in use; they are defined on a case-by-case basis for each facility and each waste package in order to meet safety and technical requirements.
- Requirements relating to the transport of radioactive waste (including the promulgation of international obligations) are set out in the law on Transparency and Security in the Nuclear Field (the so-called “TSN Act”) [24]; these flow down into underlying decrees, orders, regulatory decisions and guidelines.
- Both generic and site-specific WAC are applicable to operating disposal facilities (the CSA for disposal of LLW and the CIRES for disposal of VLLW):
    - Generic Basic Safety Rules are laid down by the French regulator (ASN) at national level (to be followed at all facilities for LLW).
    - Site-specific requirements are included in the national license for the CSA site and in WAC specified by the WMO (Andra) and approved by ASN; these are applied to waste packages on a case-by-case basis.
    - VLLW disposal facilities are not considered to be “Basic Nuclear Installations” (BNI) and are therefore not subject to national licensing; a local decree applies instead, along with site-specific WAC developed by Andra and approved by ASN.
- Detailed preliminary WAC have been developed for the disposal of long-lived ILW and HLW at the Cigéo geological repository; these are set out in a guide for deep geological disposal.
- Many of the WAC for ILW and HLW are approved by the regulator in the framework of producing and applying the national waste programme (NWP).
- It is planned to dispose of long-lived low activity wastes (e.g. graphite and radium wastes) in a dedicated near-surface (“sub-surface”) disposal facility. WAC have not yet been developed for this proposed management route because it is still at an early stage of planning.

Germany

- In Germany, disposal in deep geological formations is intended for all types of radioactive waste. Accordingly, there is no need to differentiate between wastes containing radionuclides with comparatively short half-lives and those with comparatively long half-lives. Radioactive wastes are therefore subdivided based on whether or not they generate significant quantities of heat.
- The VLLW classification is effectively irrelevant – disposal to landfill is not carried out or planned.
- Final disposal of wastes with negligible heat generation (i.e. LLW and ILW) is planned in Schacht Konrad, a former iron ore mine at Salzgitter (Lower Saxony). The Konrad disposal facility is expected to become operational in 2027.
- WAC for LLW and ILW are reported for routing to disposal at Schacht Konrad (the Asse and Morsleben repositories are no longer receiving new waste for disposal).
- A separate site for disposal of heat-generating radioactive waste (i.e. SNF and reprocessing wastes) is planned; operation of this facility is envisaged from around 2050. Associated disposal WAC are not yet available.
- In the meantime, heat-generating wastes are placed in dry storage in transport and storage casks.
- For wastes with negligible heat generation the temperature increase in the host rocks adjacent to the waste emplacement chambers (resulting from the decay heat of radionuclides contained in the waste) must not exceed 3°C on average.
- Planning for retrievals from Asse (as mandated in law since 2013) [25] is currently based on the WAC for Schacht Konrad since these represent the state of the art for conditioning and packaging of radioactive waste in Germany. It is likely that retrieved waste will require reconditioning and repackaging in order to meet WAC for storage and disposal elsewhere.

Greece

- There is no HLW in Greece. All SNF from the Greek research reactor has been returned to the USA.
- Virtually all wastes are in their raw form and not yet conditioned for disposal. An exception is ~50 drums of cemented sludge from the past operation of an evaporator for liquid waste. The majority of these drums are exempt waste, with the remainder (~10%) being VLLW.
- For storage, waste packages must satisfy WAC setting out dose rate limits as well as criteria for transport. Some wastes are sent to centralised storage at the NCSR “Demokritos”, but at present, most wastes are stored at the producer sites. More waste may be transferred to centralised storage over time.
- VLLW, LLW and ILW are stored separately at the NCSR “Demokritos” storage facility.
- Criteria for storage at the NCSR “Demokritos” facility are defined for operational safety purposes and include limits on:
    - Dose rates at the package surface (and at 0.7 m).
    - Surface contamination on waste packages.
    - The waste package mass (weight), to enable handling using a forklift truck.
- Waste packages are placed in the storage facility to optimise worker safety (e.g. by placing the waste packages with the lowest dose rates at the edges of an array of waste packages) [10].
- Disposal in near-surface facilities, surface trenches and/or boreholes is envisaged but no plans have been developed as yet.

Hungary

- The disposal routes for LLW and ILW are determined by the origin of the waste (either from institutional use or from NPPs) and do not vary depending on whether the waste contains predominantly short-lived / long-lived radionuclides, except that long-lived institutional waste is interim stored at the Radioactive Waste Treatment and Disposal Facility (RWTDF), pending final disposal in a deep geological repository.

- Short-lived institutional waste is disposed of at the RWTDF (surface disposal).
- A multi-level system of WAC for storage and disposal of institutional waste is defined:
  - Publicly available WAC for accepting waste from producers.
  - WAC for short-term storage.
  - WAC for long-term storage.
  - WAC for disposal.
- All LLW and ILW from NPP operation and decommissioning is disposed of at the National Radioactive Waste Repository (NRWR) at Bátaapáti, where disposal takes place 200-250 metres below the surface in the granite bedrock [26]. WAC for the NRWR are publicly available and defined for each waste type separately.
- The VLLW classification was recently introduced in Hungary. Activity limits have been set out in legislation but are not yet applied and, at present, VLLW is not currently segregated from LLW. A dedicated VLLW repository is foreseen but associated plans are at an early stage and preliminary WAC are not yet available.
- A deep geological repository is planned for HLW (including SNF and waste with a high heat output). No reprocessing is carried out. SNF is not considered to be a waste in Hungary and, as such, there are no associated WAC, although there are requirements on handling and storage.

Lithuania

- HLW is in the form of spent fuel (no reprocessing is carried out). According to the Lithuanian Law on Nuclear Energy, spent fuel is classed as radioactive waste [27].
- A landfill facility for VLLW disposal is under construction and is expected to begin operations in ~2020.
- A near-surface repository for LLW disposal is planned for construction between 2021-2024/5.
- Work is also ongoing to determine whether to transform an existing storage facility for bituminised waste into a repository and dispose of the emplaced waste in situ (or else, to recover and repackage the waste for disposal elsewhere).
- WAC for disposal of VLLW and LLW in the new facilities have been derived based on the Technical Design (TD) and Preliminary Safety Analysis Report (PSAR) developed for the planned disposal facilities, and agreed with the national regulator (VATESI). Once construction of these facilities is complete, the Final Safety Analysis Report (FSAR) will be prepared and associated WAC will be finalised.
- The existing disposal WAC for both VLLW and LLW are already in use. For LLW these are based on the PSAR; for VLLW they are based on the Updated Safety Analysis Report (USAR), an intermediate stage between the PSAR and FSAR. ~10,000 m^3 VLLW has been characterised and packaged based on these WAC.
- Various updates to the VLLW WAC are currently under review by VATESI, e.g. to account for additional radionuclides and to reflect stricter requirements on free release. Further updates are planned between now and 2022 (for VLLW) and 2023 (for LLW), e.g. to cover the disposal of disused SRSs, as well as hazardous and certain other wastes with particular characteristics. Changes reflected in these updates will not affect waste packages that have already been produced for disposal against the current WAC.
- A deep geological repository is planned for the disposal of ILW and HLW. Associated planning is at an early stage (e.g. preparation of site selection criteria; development of the public information programme; planning for site investigations,).
- WAC exist for the interim storage of spent fuel and ILW, but not yet for disposal (since there is no geological repository and associated planning is still at an early stage) [10].

The Netherlands

- The VLLW classification is not used in The Netherlands. It is used in the Dutch questionnaire response to set out WAC relating to NORM waste that is less than a factor of ten times above the clearance (exemption) level, which is suitable for landfill disposal. NORM wastes with higher levels of radioactivity are transferred to COVRA for storage pending geological disposal (as for other radioactive wastes) [28].

- Deep geological disposal is planned for all other types of radioactive waste in The Netherlands except exempted waste and VSLW.
- The requirements placed on waste to be accepted for storage by COVRA are intended to enable direct transfer of waste packages to the DGR, once available, without further processing (such that all stored waste is ready for final disposal).
- Dutch HLW includes vitrified HLW (from reprocessing of SNF from the Borssele and Dodewaard NPPs), SNF from research reactors and waste from molybdenum production. SNF from Dodewaard was reprocessed in the UK; SNF from Borssele is reprocessed in France.
- WAC have been developed for specific treatment / processing steps. Facilities also have their own WAC.
- The term 'generic WAC' is used in the Dutch response to refer to WAC that are facility specific but not specific to acceptance of particular waste types. In particular, COVRA defines generic WAC for each of its storage facilities (e.g. dose rate limits).
- Some resin waste streams are stored for short periods (~5 years) in packages that don't meet the dose rate WAC for the relevant storage facility. This allows time for COVRA to identify and deploy suitable conditioning solutions. In the meantime, "smart packaging and stacking" is employed to ensure safe storage. For example, some waste packages might have an extra concrete shielding package placed around them for a period of time [10], thereby enabling dose rate criteria to be met.

Poland

- The VLLW classification is not used in Poland.
- LLW and ILW is processed and stored by the Radioactive Waste Management Plant (ZUOP) at Świerk before transfer to the National Radioactive Waste Repository (KSOP) in Różan. Short-lived waste is disposed of in near-surface facilities; long-lived waste (mainly alpha-bearing waste) as well as some nuclear materials (e.g. depleted uranium) is stored in surface buildings, pending availability of a deep geological repository.
- Material stored at the KSOP is likely to be repackaged and transferred to another site for ongoing storage, pending disposal, before the KSOP closes.
- The only WAC in Poland are for disposal of waste at the KSOP – these also encompass packaging and preparation of the waste for disposal.
- A new near-surface repository is envisaged, to receive LLW and some ILW (e.g. from future NPPs / research reactor decommissioning) once the KSOP at Różan is closed. New WAC will be developed for this facility.
- Two research reactors have operated in Poland: EWA (shut down in 1995) and MARIA (still in operation). Most of the SNF from these research reactors has been returned to Russia; SNF from the last few years of operating the MARIA reactor (produced since the last shipment to Russia in 2016) is currently cooling in wet storage facilities at Świerk, and will be returned to the manufacturer in due course [29].
- Other ILW and HLW stocks include mainly SRSs and waste from decommissioning the EWA research reactor. HLW sources are stored at ZUOP; ILW is stored at both ZUOP and at the KSOP, as described above. There are no WAC for storage; basic safety standards are met. Each SRS is stored in a specific way, depending on its size, activity and other characteristics.
- Geological disposal is foreseen as a disposal option for HLW and some ILW. If progressed, a DGR will be constructed after 2050. Until this time, any SNF arising from NPPs would be stored at the NPP sites.

Portugal

- The VLLW classification is assigned to radioactive waste that may be cleared by the regulatory authority for release as exempt waste in future. In the meantime, such waste is managed as if it were LLW.
- There is no HLW in Portugal; SNF from shutdown of the Portuguese Research Reactor was transferred to the USA.
- Only raw waste is currently stored in Portugal, at the Pavilhão de Resíduos Radioativos (PRR) on the campus of the university hosting the Portuguese Research Reactor (CTN/IST). Consequently, there are no applicable WAC for treatment or conditioning; only procedures to ensure safe storage, which affect packaging (see below).
- There is a national programme for radioactive waste management but it does not include WAC as yet.
- At the PRR waste management facility, there are procedures for the management of wastes that consider the national waste classification, radionuclide inventory, physical characteristics (solid, liquid, compressible, etc.), dose rate limits and surface contamination. However, no 'WAC' exist as yet for the interim storage facility.

Romania

- VLLW exists in Romania, but its management is not currently segregated from that of LLW.
- Disposal at the Baita Bihor near-surface repository (of short-lived institutional waste) takes place in galleries at a depth of ~50 m below ground level (the elevation of the former uranium mine is 840 m above sea level).
- A near-surface disposal facility is planned for LLW generated from the Cernavoda NPP and for short-lived institutional waste following closure of the Baita Bihor repository (in ~2040).
- Operational LLW generated at the Cernavoda NPP is treated by incineration or melting at a European operator (e.g. Studsvik, Belgoprocess).
- Long-lived waste requires geological disposal, foreseen in 2055. In the meantime, all ILW is stored. ILW generated at the Cernavoda NPP is stored in dedicated facilities on the Cernavoda site. Institutional ILW is stored in 13 stainless-steel tubes ('pits') set into the basement of the hot cells within the Post Irradiation Examination Facility of RATEN ICN Pitesti. This facility is also used to store high activity, short-lived SRSs collected from all around the country.
- No requirements for the treatment or conditioning of long-lived waste to be consigned to a future geological disposal facility have been defined as yet, so there are no associated WAC.
- The HLW category refers to spent fuel that is considered to be radioactive waste (CANDU SNF from the Cernavoda NPP and TRIGA SNF). All SNF from the VVR-S research reactor that is being decommissioned has been returned to Russia.
- SNF from the TRIGA research reactor (in operation on the RATEN ICN Pitesti site) is stored in the reactor storage pool. TRIGA was converted to burn LEU instead of HEU fuel under the IAEA's technical cooperation programme and with the support of the US Department of Energy (DoE). All of the TRIGA HEU fuel has been repatriated to the USA under agreement with the DoE. It is also intended to return the spent LEU fuel resulting from continued operation of the TRIGA reactor to the country of origin, provided a new agreement is signed; otherwise this SNF will be consigned to geological disposal, together with the CANDU SNF.
- SNF from NPPs is stored in dedicated on-site facilities (in ponds for the first six years and then in dry storage). Acceptance criteria are applied both for CANDU spent fuel cooling pools and for the CANDU dry storage facility (DICA). Only intact SNF assemblies are transferred to dry storage. Damaged SNF assemblies are stored in a carousel-type container for an initial decay (for 4 to 8 weeks) and after that they are encapsulated in stainless steels capsules and transferred for storage in a separate cooling pond dedicated to the damaged encapsulated spent fuel.

- For the dry storage facility, the CANDU SNF has to meet the following criteria to be accepted:
  - The SNF has to be mechanically intact.
  - The SNF has to be cooled for six years in the cooling ponds adjacent to each reactor.
  - SNF assemblies are first loaded underwater in special stainless-steel containers (storage baskets) which are dried and sealed by welding.
  - The maximum residual thermal power of a SNF assembly is 9.75 W.
  - The maximum thermal power released in the storage module has to be:
    - 390.5 W per storage basket (each storage basket contains 60 spent fuel assemblies).
    - 3905 W per storage cylinder (each cylinder contains 10 storage baskets).
    - 78.11 kW per storage module (each storage module accommodates 20 storage cylinders.
- There are no specific WAC for transport in Romania; however, there are specific norms for transport of radioactive materials set out in national legislation.

Slovakia

- All procedures that might have an influence on nuclear safety or radiation protection are applied in WAC including specific pre-treatment (e.g. sorting), treatment, conditioning and/or packaging, storage and transport approaches. Operating nuclear facilities are required to have specific WAC, which are approved by the Nuclear regulatory authority (NRA SR).
- JAVYS (the Slovakian WMO) operates radioactive waste treatment centres in Bohunice (the JAVYS Treatment Centre) and Mochovce (FS KRAO). The latter is intended for processing and treatment of liquid waste generated from NPPs situated in Mochovce.
- Some of these treatment facilities accept and treat foreign wastes (as well as radioactive waste generated in Slovakia). Once treated, foreign wastes are returned to the country of origin for onward storage / disposal.
- All waste to be treated at a facility must meet the (same) WAC for that facility, regardless of its origin or the future destination of the conditioned waste. However, disposal WAC will differ depending on the destination country and facility.
- SNF is not reprocessed; it is stored in a central interim storage facility on the Bohunice site.
- JAVYS also operates various other storage facilities at Bohunice, as well as a dedicated store for institutional waste that was recently constructed on the Mochovce site.
- One surface disposal facility is currently in operation (the National radioactive waste repository in Mochovce). This accepts VLLW and LLW (predominantly comprising short-lived radionuclides) for disposal in separate areas. The products from upstream treatment activities must comply with WAC for disposal at Mochovce (if this is the intended disposal route).
- A deep geological repository is planned for the disposal of ILW (predominantly comprising long-lived radionuclides) and SNF; long-term storage is implemented in the meantime. WAC for this disposal route are not yet available.
- The Slovakian questionnaire response notes that only very small volumes of ILW will be consigned to a deep geological repository (e.g. reactor internals and activated / heavily contaminated components, along with other radioactive wastes containing significant amounts of alpha radionuclides). Decommissioning waste will be routed to Mochovce.

Slovenia

- WAC development for storage and disposal is a legal requirement defined in the Slovenian rules on radioactive waste and spent fuel management (JV 7, Off. Gaz.49/2006). WAC are therefore in use for all such nuclear facilities in operation. Article 19 of JV 7 ("criteria for acceptance in storage or disposal") requires that limits are specified for various parameters (detailed in Section 5.2).

- Requirements related to waste treatment, conditioning and packaging are captured within the WAC for these facilities, on the basis that all radioactive waste will be placed in such facilities in due course. Separate WAC for pre-storage activities are therefore not a legal requirement.
- The VLLW classification is assigned to radioactive waste that may be cleared by the regulatory authority for nuclear and radiation safety for release as exempt waste in future. Subsequently, this waste is managed via existing routes, either for exempt waste or for LLW, at the direction of the regulator.
- A separate disposal route for VLLW is therefore not planned and there are no dedicated VLLW storage facilities at nuclear sites (only small stores at hospitals and other non-nuclear facilities, which do not require WAC). Any future VLLW storage or disposal facilities would require accompanying WAC.
- Two storage facilities for both LLW and ILW are in operation: the Solid Radioactive Storage Facility (SRSF) at Krško NPP and the Central Interim Storage (CIS) Facility at Brinje (for radioactive waste from small producers). There are also SNF storage facilities at the TRIGA reactor and Krško NPP. All SNF is placed directly in storage without treatment, conditioning and packaging.
- Near-surface disposal of LLW and a small amount of ILW is planned at the Vrbina near-surface disposal facility. Construction is expected to start in 2020.
- In addition, two disposal sites (Jazbec and Borst) are used for the disposal of radioactive waste containing only naturally occurring radionuclides that are produced in the exploitation and reprocessing of nuclear mineral raw materials or in other industrial processes.
- Deep geological disposal is planned for some ILW (particularly long-lived wastes arising from NPP decommissioning) and HLW.

Spain

- SNF discharged from NPPs is considered to be waste according to Spanish regulations. It is not reprocessed.
- LLW, VLLW and some ILW are disposed of at the El Cabril near-surface disposal facility. Treatment, conditioning and storage (of LLW and ILW) and 'inertization' and a small amount of transitional storage (of VLLW) are also carried out at El Cabril [30]. The WAC for disposal at El Cabril permit only relatively low activity concentrations from long-lived alpha emitters.
- A surface centralised storage facility (the CTS) is planned to provide temporary storage of all HLW (mainly SNF) from Spanish NPPs for the next 60-100 years. Construction of the CTS was originally planned to begin in 2019 but permitting is currently being blocked.
- HLW and ILW with higher concentrations of long-lived alpha emitters are currently stored in facilities on waste producer sites and will be stored at the CTS in due course.
- The conceptual design of the CTS envisages the storage of:
    - Vitrified HLW canisters arising from reprocessing of SNF from the Vandellós I NPP.
    - SNF conditioned in sealed canisters.
    - Storage of ILW in an annex building on the surface, including:
        - ILW generated during Vandellós I fuel reprocessing operations, whose radiological characteristics prevent its storage at El Cabril.
        - Technological waste from the dismantling of Spanish NPPs (encapsulated in metal containers), such as reactor vessel components, BWR fuel channels and fittings or parts of fittings not insertable into the fuel.
        - Disused, encapsulated SRSs and other packages not suitable for storage and/or disposal at El Cabril.
- WAC for ILW and HLW to be stored at the CTS are not yet finalised (and are currently unpublished); they will need to cover all wastes that cannot be disposed of at El Cabril. At present, acceptance criteria have been established to take account of construction engineering, geotechnical and geological characteristics, under the supervision of the Spanish Regulatory Entity (CSN).

- Deep geological disposal is the preferred end point for management of HLW and SNF in Spain (along with special wastes and ILW that are not suitable for disposal at El Cabril). Provisional plans for the development of a deep geological repository are set out in Spain's General Radioactive Waste Plan (GRWP).

Sweden

- VLLW is cleared for disposal at municipal landfills or else disposed of in shallow land burials at Studsvik and at the Forsmark, Oskarshamn and Ringhals NPPs. The permits for landfill include requirements that are equivalent to WAC which have to be met in order to deposit waste.
- LLW is disposed of at the SFR shallow geological repository (~100 m below ground). Construction of an extension to SFR is planned to start in 2023. WAC are adopted and in use for the existing areas of SFR (these specify conditioning and packaging approaches). Preliminary WAC have been developed for the SFR extension.
- Long-lived waste (i.e. ILW, according to IAEA waste classifications) is planned to be disposed of at the SFL geological repository (construction is planned to start in 2037). Preliminary WAC will be developed in the coming years.
- In the meantime, ILW is stored at the NPP sites and also at SKB's Central Interim Storage Facility, "Clab". The ILW in each of these facilities comprises institutional waste from early research reactors and NPP operational waste, including control rods, core components and neutron measuring probes. WAC covering waste handling activities are in place for these facilities. The requirements for transportation of ILW to interim storage are compiled in a separate handbook.
- Plans for interim storage of some ILW in the SFR extension were withdrawn by SKB in 2017 [31].
- No reprocessing of Swedish SNF is carried out. SNF is planned to be disposed of in a deep geological repository at a depth of 500 m; it is stored at Clab in the meantime. Repository construction is planned to start in 2022.
- SKB participates in the work of licensing new fuel types and ensures that each fuel type can be handled within the Swedish transport system, existing interim storage facilities and the final repository before it can be used. The associated requirements are well known and documented but are not compiled in a specific document that would correspond to WAC for SNF.

Ukraine

- A new radioactive waste classification system aligned with that of the IAEA is currently being implemented and will come into force in 2021.
- At present (until 2021) only LLW, ILW and HLW classifications are applied in Ukraine, with the boundaries between these classes distinguished by specific activity criteria (or dose rates, if the waste inventory is known). Other criteria for attributing wastes to specific classes are not currently defined. However, Guidelines on Radioactive Waste Classification in Ukraine (aligned to the new classification system) are currently under development.
- The VLLW classification is not currently used, but will apply from 2021. It might be expected that a significant portion of waste currently classed as LLW will be classed as VLLW going forwards.
- Planned management routes for VLLW after 2021 envisage safe disposal in surface facilities, with barriers to ensure containment and isolation of the radioactive waste for at least 100 years.
- Two disposal facilities for LLW are currently in operation in Ukraine: the engineered near-surface disposal facility (ENSDF) at the Vector complex in the Chornobyl exclusion zone and the Buryakivka disposal facility for waste arising from the Chornobyl nuclear accident. The permissible content of long-lived activity is limited at both facilities through application of WAC.
- Various legacy storage / disposal facilities also exist at Radon enterprises and in the Chornobyl exclusion zone, for which a decision on whether to retrieve waste for disposal elsewhere will be

made based on the results of safety assessment. Two more near-surface disposal facilities are also under construction at the Vector complex.
- A roadmap for development of a deep geological repository for ILW and HLW disposal is under development – the Chornobyl exclusion zone is considered as the preferred location based on regional screening.
- SNF is not considered to be a waste in Ukraine. It is currently stored on site at NPPs. The Zaporizzhya NPP has its own long-term storage facility in operation. A centralised long-term storage facility for SNF from three other NPPs is under construction and a long-term storage facility for SNF from the Chernobyl NPP is under commissioning. Some historic SNF is being sent back to Russia [10].
- Long-term interim storage is applied for disused sealed radioactive sources only.
- Facility-specific WAC are required for all existing and designed facilities (both pre-disposal and disposal). They are developed initially during the design of the facility and form part of the safety case. These 'design-basis WAC' are preliminary; they are subsequently finalised in preparation for facility operation. In addition, technical specifications for waste packages are developed taking into account WAC for the subsequent lifecycle stages of radioactive waste management.

United Kingdom

- The UK waste classification approach does not distinguish between short-lived and long-lived wastes – wastes are classified according to the type and quantity of radioactivity they contain and how much heat is produced.
- Two facilities are in operation for the disposal of LLW: the Low Level Waste Repository (LLWR) in Cumbria and the Low Level Waste Facilities (LLWF) at Dounreay; the latter only accepts wastes generated at Dounreay and the Vulcan Nuclear Reactor Test Establishment; the LLWF WAC are therefore not publicly available.
- Three landfill sites are permitted to receive VLLW (Clifton Marsh, the East Northants Resource Management Facility and Lillyhall).
- A GDF is planned for the disposal of HLW, ILW and some LLW that is unsuitable for disposal to the LLWR (collectively referred to as Higher Activity Waste, or HAW).
- WAC are in place for the disposal of VLLW and LLW. Packaged VLLW and LLW is generally not stored for extended periods prior to disposal.
- There are currently no WAC developed for the disposal of HAW. However, Radioactive Waste Management Ltd (RWM) produces packaging specifications as a means of providing a baseline against which the suitability of plans to package waste for geological disposal can be assessed. These are generic in nature (i.e. they make no assumptions regarding the geographical location of the GDF, the geological environment in which it will be constructed or the specific geological disposal concept which could be adopted) and may also be regarded as preliminary WAC for the GDF [32].
- Proposals for conditioning and packaging HAW are assessed against these generic waste package specifications in several iterations, and require endorsement by RWM before operations can proceed.
- For HAW, which is stored pending availability of a GDF, WAC or more commonly "Conditions for Acceptance" (CfA) are defined for individual storage facilities by the operators (e.g. Sellafield Ltd for the Encapsulated Product Stores and Dounreay Site Restoration Ltd for the Interim Drum Store). A full list of UK stores is available in the NDA's industry guidance on interim storage of HAW [33]. Acceptance of packaged waste into storage facilities is often controlled primarily by acceptance into the preceding treatment and conditioning plant (evaluated against the relevant CfA).
- It is noted that the significant time gap between packaging of HAW for interim storage and its eventual disposal in the GDF places additional requirements on record keeping (collection, qualification and longevity) to underpin future assessment against disposal WAC.

2.2.2 Status of national WAC by lifecycle stage

Lifecycle Stage: Retrieval / Pre-treatment, Treatment, Conditioning & Packaging

	Type of Waste Acceptance Criteria				
	N/A	**None**	**Generic**	**Preliminary (e.g. draft)**	**Final (in use)**
Very low-level waste (VLLW)	Austria, Belgium, Cyprus, Denmark, Germany, Poland, Ukraine (until 2021)	Greece, Hungary, Slovenia			Bulgaria, Czechia, France, Lithuania, The Netherlands, Portugal (packaging only, as for LLW), Romania, Slovakia (no treatment applied), Spain, UK (conditioning & packaging only), Sweden
Low-level waste (LLW)	Cyprus	Denmark, Greece, Slovenia (requirements captured in storage WAC)			Austria, Belgium, Bulgaria, Czechia, France, Germany, Hungary, Lithuania, The Netherlands, Poland, Portugal (packaging only), Romania, Slovakia, Spain, Sweden, Ukraine, UK (treatment, conditioning & packaging)
Intermediate-level waste (ILW)	Cyprus	Denmark, Greece, Poland, Slovenia (requirements captured in storage WAC), Romania (treatment & conditioning), Sweden			Austria, Belgium, Bulgaria, Czechia, France, Germany, Hungary, Lithuania (retrieval, conditioning & packaging only), The Netherlands, Portugal (packaging only), Romania (retrieval – sorting only), Slovakia (retrieval / pre-treatment & treatment only), Spain, Ukraine, UK
High-level waste (HLW)	Austria, Cyprus, Greece, Portugal	Denmark, Germany (treatment), Hungary, The Netherlands, Poland, Romania, Slovakia, Slovenia, Sweden (compliance requirements exist for every handling step but these are not formally “WAC”), UK (packaging for disposal)			Belgium (CSD-V; activities now terminated), Bulgaria, Czechia, France, Germany (conditioning & packaging), Lithuania (retrieval, conditioning & packaging only), Spain (conditioning & packaging only), Ukraine (treatment, conditioning & packaging), UK (treatment and conditioning)

Table 2 – Types of WAC by country for pre-storage stages in the waste lifecycle (i.e. retrieval and pre-treatment; treatment; conditioning and packaging). Refer to Section 2.1 for an explanation of the types of WAC assigned here.

Lifecycle Stage: Storage

	Type of Waste Acceptance Criteria				
	N/A	**None**	**Generic**	**Preliminary (e.g. draft)**	**Final (in use)**
Very low-level waste (VLLW)	Austria, Belgium, Denmark, Germany, Poland, Ukraine (until 2021)	Hungary, The Netherlands, Slovenia, Spain, UK	Cyprus		Bulgaria, Czechia, France, Greece, Lithuania, Portugal (as for LLW), Romania, Slovakia, Sweden
Low-level waste (LLW)		UK	Cyprus		Austria, Belgium, Bulgaria, Czechia, Denmark, France, Greece, Germany, Hungary, Lithuania, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Ukraine
Intermediate-level waste (ILW)	Cyprus	Poland		Spain (storage at CTS)	Austria, Belgium, Bulgaria, Czechia, Denmark, France, Greece, Germany, Hungary, Lithuania, The Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain (storage at El Cabril and producer facilities), Sweden, Ukraine, UK
High-level waste (HLW)	Austria, Cyprus, Greece, Portugal	Bulgaria, Hungary, Poland, Sweden (compliance requirements exist for every handling step but these are not formally “WAC”)		Spain (storage at CTS)	Belgium (CSD-V), Czechia, Denmark (as for ILW), France, Germany, Lithuania (SNF), The Netherlands, Romania, Slovakia (SNF), Slovenia, Ukraine, UK

Table 3 – Types of WAC by country applicable to storage. Refer to Section 2.1 for an explanation of the types of WAC assigned here.

Lifecycle Stage: Disposal

	Type of Waste Acceptance Criteria				
	N/A	**None**	**Generic**	**Preliminary (e.g. draft)**	**Final (in use)**
Very low-level waste (VLLW)	Austria, Belgium, Denmark, Germany, Poland, Portugal, Ukraine (until 2021)	Greece, Hungary, Slovenia	Cyprus (discharge)	Bulgaria, Romania (as for LLW below)	Czechia, France, Lithuania, The Netherlands, Romania (as for LLW below), Slovakia, Spain, Sweden, UK
Low-level waste (LLW)		Austria, Denmark, Greece, The Netherlands, Portugal	Cyprus (discharge), France	Belgium, Bulgaria, Germany, Slovenia, Romania (waste to be disposed of in the future near-surface disposal facility), Sweden (for SFR extension)	Czechia, France, Hungary, Lithuania, Poland, Romania (institutional waste @ the Baita Bihor repository), Slovakia, Spain, Sweden (for existing SFR), Ukraine, UK
Intermediate-level waste (ILW)	Cyprus	Austria, Belgium, Czechia (for DGR), Denmark, France (graphite and radium wastes planned for near-surface disposal), Greece, Hungary (long-lived institutional waste), Lithuania, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia (for DGR), Spain, Sweden	UK (WPSGD for HAW), Ukraine (for proposed geological disposal concepts)	Bulgaria, France, Germany, Slovenia (waste to be disposed of in Vrbina)	Czechia (for waste disposed of at Richard and Bratrství), Hungary (operational and decommissioning NPP waste)
High-level waste (HLW)	Austria, Cyprus, Greece, Portugal	Belgium, Czechia, Denmark, Germany, Hungary, Lithuania, The Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden (compliance requirements exist for every handling step but these are not formally "WAC").	UK (WPSGD for HAW), Ukraine (for proposed geological disposal concepts)	Bulgaria, France	

Table 4 – Types of WAC by country applicable to disposal. Refer to Section 2.1 for an explanation of the types of WAC assigned here.

2.3 Analysis and conclusions

The national responses to the ROUTES questionnaire are detailed and extensive, covering waste management activities in 22 European countries. They provide a considerable body of information to analyse, and much experience to share and learn from. This section presents observations relating to WAC for specific lifecycle stages, based on the information recorded in Table 2, Table 3, and Table 4, followed by some general observations and conclusions relating to the nature of WAC in Member-States and Associated Countries.

2.3.1 Observations relating to pre-treatment, treatment and conditioning

Table 2 indicates that most countries have finalised WAC that are in use for one or more waste treatment, conditioning and/or packaging facilities, reflecting the widespread nature of such radioactive waste management practices.

The responses for eleven countries suggest that no WAC apply to this waste lifecycle stage, for at least some waste classifications. There are several reasons why this is (or may be) the case:

- Waste management activities are still at an early stage in some of these countries and currently, only raw waste is stored, e.g. Greece, Portugal (which only has procedures affecting packaging).
- Some waste classifications have only recently been introduced in national legislation and associated waste management plans are still in development, e.g. VLLW in Hungary.
- Unless it is reprocessed, SNF is generally stored without treatment or conditioning, either in ponds or in dry stores in shielded containers that are often not intended as the final container for disposal. Moreover, in many countries, SNF is not considered to be a waste and/or detailed plans for its long-term management have not yet been formulated. Consequently, WAC are often not relevant, at present, for SNF during this lifecycle stage, e.g. in Germany, Romania, Slovenia, UK.
- The term '*acceptance* criteria' implies the potential to *reject* consignments to a facility if they do not meet certain requirements, as well as to require that non-compliances are remediated. Consequently, 'WAC' are generally not defined for facilities that accept all raw waste / material, regardless of its characteristics. This is particularly the case for facilities that handle and consolidate SNF. Such facilities typically incorporate provisions for managing out-of-spec / damaged SNF assemblies within their design and operating strategies but they do not reject any such assemblies because no alternative management route is available. Often only one such facility exists in a country and it is the only facility available for managing SNF in the medium to long term (pending availability of a DGR).
- Countries that transport components of their radioactive waste inventory to facilities in other countries for treatment typically do not define treatment WAC for these wastes. For example:
    - Combustible waste from Denmark is sent to the Studsvik incineration facility in Sweden (WAC are available [23], but this is not a Danish facility).
    - SNF from Dutch NPPs is reprocessed in France (and, historically, in the UK) so no treatment WAC for HLW are defined in The Netherlands. Acceptance criteria are (were) set out by the facilities in the countries performing reprocessing. This is true for all SNF sent for reprocessing by facilities in other countries.
- Treatment, conditioning or packaging requirements are sometimes incorporated into WAC covering multiple lifecycle stages, but primarily focused on storage and/or disposal, e.g. Poland, Slovenia.
- The lack of WAC, or responses describing WAC, for some countries reflects the fact that requirements for treatment, conditioning and packaging are not always referred to as 'WAC' (e.g. France, in the case of rules governing waste retrieval and pre-treatment activities, Lithuania, where requirements for treatment are set out in the treatment facility designs (description of processes) and not in WAC, and Sweden, where compliance requirements exist

for every SNF handling step, but are not compiled in a specific document or formally referred to as 'WAC'). This point is discussed further in Section 2.3.4.

No countries identified generic or preliminary WAC for this waste lifecycle stage. This point is discussed further in Section 2.3.4.

2.3.2 Observations relating to storage

As in Table 2, Table 3 indicates that most countries have finalised WAC that are in use to help manage the storage of radioactive waste with a range of waste classifications. This is to be expected based on widespread radioactive waste management practices.

The responses for eight countries (Bulgaria, Hungary, The Netherlands, Poland, Slovenia, Spain, Sweden and the UK) indicate that, at present, there are no WAC for the storage of some classifications of radioactive waste. The absence of WAC for storage is perhaps more unexpected than for the pre-treatment, treatment and conditioning lifecycle stages discussed in Section 2.3.1. Modern radioactive waste stores are designed to provide safe handling and storage of specific waste types / waste packages, so there is a clear basis from their specification and design for WAC setting out what the store can / cannot accept from a logistical and a safety perspective.

Some countries give reasons why storage WAC do not apply for certain waste classes. For example:

- In Slovenia, there are currently no storage facilities for VLLW (since it is managed as either exempt waste or LLW, as directed by the regulator).
- The VLLW classification is used in the Dutch questionnaire response to set out WAC relating to NORM waste that is less than a factor of ten times above the clearance (exemption) level, and is suitable for landfill disposal. This waste is routed directly to disposal, without storage.
- The VLLW classification was only recently introduced in Hungary and its management is not currently segregated from LLW.
- In Spain, most VLLW is consigned straight to disposal on receipt at El Cabril; WAC for interim storage of VLLW are therefore not required.
- Similarly, in the UK, packaged VLLW and LLW is generally not stored for extended periods prior to disposal.
- In Hungary SNF is not classed as a waste, and associated storage requirements are therefore not referred to as WAC. SNF is stored at the Spent Fuel Interim Storage Facility (SFISF) near the Paks NPP on the territory of PURAM, the Public Limited Company for Radioactive Waste Management. The main requirements are that (i) the SNF has to be cooled in ponds at the NPP for at least three years and (ii) the transport container received at the storage facility must be gastight (e.g. assemblies must be placed in a hermetic overpack).

The reasons for other countries not having storage WAC are not currently clear, but are likely to be similar to those discussed above, and in Section 2.3.1, i.e.:

- Storage requirements may be incorporated in WAC covering multiple lifecycle stages, but primarily focused on disposal.
- Requirements for storage are not always referred to as 'WAC'. This is particularly the case where waste owners are responsible for storage of their own waste, such that there is no transfer of ownership / liability.

Only Cyprus has generic storage requirements. For Cyprus, the legal obligations for storage of radioactive waste prior to discharge to the environment are generic in the sense that they must be applied by all sites handling such waste, but are also final (i.e. in use). Prior to receiving questionnaire responses, it was assumed that generic 'WAC' would be a precursor to site- or facility-specific WAC, but this is not the case here.

Note that the term 'generic WAC' is used in the Dutch response to refer to WAC (for LLW and ILW) that are facility specific but not specific to acceptance of particular waste types. In particular, COVRA defines generic WAC for each of its storage facilities (e.g. dose rate limits). These do not fall within the definitions for generic WAC used in the table above, so are listed in Table 3 as WAC that are final (in use). Generic WAC are discussed further in Section 4.

Only Spain has preliminary (draft) storage WAC (for storage of ILW and HLW at the CTS, which is currently experiencing a hiatus in permitting). The timescales for implementing a storage facility are typically much shorter than those for a disposal facility. Consequently, unlike for disposal, the ‘preliminary’ category is not particularly relevant – WAC are typically only preliminary for a short time during development and commissioning.

2.3.3 Observations relating to disposal

Table 4 shows that there is much more variation in the status of WAC for disposal in countries responding to the ROUTES questionnaire than for any of the pre-disposal stages already discussed. All types of disposal WAC exist for all waste classifications in at least one country, except for final WAC for HLW (since no disposal facility / repository is currently in operation for HLW). For ILW, the only countries having final disposal WAC that are in use are Czechia (for Richard and Bratrství) and Hungary (for Bátaapáti).

For VLLW and LLW, most countries have preliminary or final WAC (for planned or operational repositories, respectively), but some countries are at an early stage of developing waste management / disposal arrangements and do not yet have plans on which to base disposal WAC (e.g. Austria, Denmark, Greece, The Netherlands and Portugal, plus Hungary for VLLW only). In Slovenia, VLLW is currently managed as either exempt waste or LLW, as directed by the regulator so there are no dedicated disposal facilities (and therefore no associated WAC).

In contrast, for ILW and HLW, most countries do not have any disposal WAC because planning for geological disposal is still at an early stage. With the exception of Hungary and Czechia, those countries that *do* have WAC for ILW and HLW disposal do not have finalised WAC, but instead have either:

- Preliminary WAC that will be developed and updated as planning and implementation of the associated disposal facility progresses.
- Generic WAC that are not specific to a particular disposal facility or site, but are defined as a precursor to facility-specific WAC, in order to enable waste conditioning and packaging to progress in the meantime.

The large number of countries with preliminary or generic disposal WAC reflects the relatively long lead times for siting, developing, implementing and licensing disposal facilities, particularly geological repositories for ILW and HLW. Preliminary and generic WAC therefore persist for longer periods and help to facilitate timely waste management even when disposal routes are not available, as well as contributing to documentation that underpins approval of the facility by the relevant safety authority and other stakeholder groups. Further discussion of generic WAC is presented in Section 4.

Plans for the disposal of SNF in Sweden are mature, and construction of the underground repository is planned to begin in 2022. Here, compliance requirements exist for every SNF handling step but, unusually, these are not compiled in a specific document or formally referred to as WAC. SKB participates in the work of licensing new fuel types and ensures that each type can be handled at all lifecycle stages, including in the final repository.

2.3.4 General observations

The term ‘WAC’ is typically used in relation to the receipt of waste at storage and disposal facilities. However, corresponding conditions / requirements / procedures / policies / decrees / criteria / regulations / specifications (the terminology in use varies from country to country) also apply for other (pre-disposal) stages in the waste lifecycle, and are relevant to consider under ROUTES Task 4.

The differing scope of national responses to Section 2 of the ROUTES questionnaire (covering WAC) reflects different interpretations of the questions asked and different approaches to present information. The national responses are not always comprehensive. For example:

- Some responses focus primarily (or solely) on requirements for storage and/or disposal, e.g. Lithuania (for the reasons discussed in Section 2.3.1) and Slovenia (in line with legal requirements).
- Some responses only include information for "WAC" and not wider requirements / procedures / policies / decrees / criteria / regulations / specifications that serve broadly the same purpose (e.g. Sweden). Requirements designated as "WAC" are most often associated with storage or disposal, so this observation often goes hand in hand with a focus on these lifecycle stages.
- Other responses give WAC for selected facilities but not necessarily all national facilities. For example, WAC for disposal at the German Asse and Morsleben facilities are not described because disposal no longer takes place at these facilities). This observation is particularly true for large inventory Member-States (LIMS) with a large number of nuclear licensed sites / facilities, since it would be a very significant undertaking for these countries to provide a fully comprehensive national response to the ROUTES questionnaire. The responses provided are nevertheless sufficient to understand how WAC are developed and applied in each country.
- In some cases, requirements for upstream lifecycle stages are captured in storage / disposal WAC, rather than separately, e.g. Denmark, Germany, Poland, Slovenia, Sweden and the UK (especially for HAW).
- The term 'WAC' is generally interpreted to imply that there must be some kind of conditional acceptance of waste packages / consignments at the point of receipt (and therefore the potential for rejection of some packages / consignments and/or the ability to require that non-compliances are remediated before waste can be accepted). Pre-disposal requirements that specify how a transfer between lifecycle stages is conducted, but do not lead to the rejection of any waste consignments, are therefore not typically regarded as WAC.

Transport to treatment / storage facilities has been captured in two different ways in the national responses: some responses capture all transport WAC under the transport column of the table provided in Question 5, whereas others capture transport to a pre-disposal facility under the associated lifecycle step. For transport between nuclear licensed sites / users, most countries simply apply IAEA transport regulations and international agreements concerning the carriage of dangerous goods as WAC for transport, without specifying additional requirements. Elsewhere, transport WAC are heavily based on these international regulations / requirements, with extensions to reflect the national context. Transport between facilities on the same site is often not subject to formalised WAC, although there may still be export / receipt requirements at the original and destination facilities respectively.

Generic WAC may be precursors to site-specific WAC (e.g. in Ukraine and the UK), but can also be final (i.e. in use) requirements for an operation to be performed at multiple sites (or by multiple organisations / licensees), as is the case for generic requirements for storage and 'disposal' (discharge) of radioactive waste in Cyprus. As noted earlier, further discussion of generic WAC is presented in Section 4.

Timescales for commissioning a treatment / conditioning or storage facility are much shorter than those for a disposal facility. Consequently, unlike for disposal, the 'preliminary' WAC category is not really relevant for these waste lifecycle stages (WAC are only preliminary for a short time during planning and commissioning). Similarly, the use of 'generic' WAC as a precursor to final (facility-specific) WAC is not needed for pre-disposal facilities, since the timescales for their implementation are relatively short and details of their site and planned scope of operation are almost always known in advance. The exception to this observation is for generic WAC that apply across multiple waste management sites, or need to be followed by multiple organisations, as discussed above.

3. Analysis of responses to Question 6 of ROUTES questionnaire

3.1 Approach to review national responses

Question 6 from the ROUTES questionnaire is as follows. Guidance text is provided *in blue*.

Q6: How were these WAC originally developed and what (if any) provisions are in place to update them? *When considering past or planned WAC updates you may wish to refer to responses made by participants from your country to Q5 of the CHANCE End-User-Group questionnaire ("How do you deal with the fact that WAC as well as the final disposal concepts are in constant evolution…?").*
• *Please explain how (and when) the identified WAC were established, detailing the involvement of waste management organisations, waste producers, site or facility operators, regulators and any other parties as appropriate [no more than ½ page].* • *Were there any particular factors prompting their development at that time?* • *Are the WAC subject to periodic review / update and if so, how and when?* • *What factors have driven previous updates of the WAC?* • *Which stakeholders have influenced their development?*

Note that the first bullet above asks for information on who is responsible for developing the WAC. The last bullet asks how other groups, organisations and/or individuals have the opportunity to provide input to WAC development (e.g. through consultation or review of drafts).

Most of the answers received for Question 6 refer to the disposal (and sometimes also the conditioning / packaging and storage) of short-lived low and medium active waste that is already disposed of or intended to be disposed of in near-surface facilities, i.e. LLW according to IAEA waste classifications, as discussed in Section 1.4.4. Some responses (e.g. Denmark and The Netherlands) cover a wider suite of waste classes, in line with national plans for disposal of most, or all, wastes to a single (geological) disposal facility. For the particular case of Germany, this overview refers to WAC for the disposal of wastes with negligible heat generation (i.e. LLW and ILW) at Schacht Konrad, whilst for Hungary, the response covers the development of WAC for the disposal of NPP operational and decommissioning LLW and ILW at the NRWR at Bátaapáti. Only France and the UK gave answers related to the development process of WAC for geological disposal of HLW (as well as other waste classes). Apart from these exceptions, the following overview addresses the development of WAC for waste classes that are suitable for disposal in near-surface repositories.

Table 5 summarises responses related to how and when the WAC were established and the organisation responsible for developing the WAC.

Table 6 summarises the stakeholders involved in WAC development in all countries responding to the ROUTES questionnaire, except for Cyprus and Portugal that do not have WAC established as yet. This table also indicates whether periodic review and/or update of the WAC are foreseen and, if so, the frequency of review and update specified.

Table 7 summarises the factors that have driven previous updates of WAC.

Notable observations and points of context are recorded by country, where relevant, after each table, followed by remarks that are commonly applicable. For more details, the full national responses to the ROUTES questionnaire can be consulted; as discussed earlier, these have been compiled in a consolidated report [5].

3.2 Summary of responses

3.2.1 How and when WAC were established and the organisation responsible for developing WAC in each country

Country	How	When	Organisation responsible for WAC development
AT	*Raw waste*: WAC were established together with a pricelist for treatment and conditioning services *Storage facilities*: WAC were written to integrate the requirements for a formal take-over of the waste packages into the IMS (QM) system.		WMO
BE	WAC were developed in accordance with the General Rules for the establishment of acceptance criteria (General Rules exist since 1999).	~ 2000 for CW ~ 2010 for NCW	WMO
BG	WAC are part of the Safety Analysis Report for the storage / disposal facilities.		WMO
CZ	The limits and conditions were approved by the state authority for each repository. WAC are derived from the Safety Analysis Report, specifically the part of the documentation underpinning radioactive waste management licenses.		WMO
DK	The WAC are published in the Terms for Operation and Decommissioning.		Regulator
FR	*CIRES (VLLW)*: by 2003 local decree. *CSA (LLW)*: WAC were developed in the framework of the license process for construction of the CSA site; at first as a generic "Basic Safety Rule" (BSRI.2) and later on as a second Basic Safety Rule (BSRIII.2.e), including experience feedback from the first disposal site (Centre de la Manche). *Cigéo (ILW and HLW)*: Preliminary WAC for geological disposal have been developed, adapted and specified over the years based on the results of the R&D work carried out in the framework of the Law 2006-739.	*CIRES*: 2003 (revised in 2016, 2018, 2019) *CSA*: 1986 (revised in 1995) *Cigéo*: 2006	Regulator (safety guides) WMO (site-specific WAC)
DE	WAC were developed based on the SA for the flooding scenario.		WMO
GR	WAC for storage at the NCSR "Demokritos" interim storage facility were developed by the facility operator and established in the framework of licensing by the regulatory authority.	2013	Facility operator
HU	The WAC are derived from the SA results. The safety of transport, treatment, storage, and disposal, including the post-closure period are taken into account.		WMO
LT	WAC were developed as part of the Preliminary Safety Analysis Reports for both VLLW and LLW disposal facilities.	VLLW disposal: 2012 LLW disposal: 2017	Regulator
NL	Generic WAC have existed since the beginning of the storage buildings.	LLW and ILW storage facility: 1992 HLW storage facility: 2003	WMO

Country	How	When	Organisation responsible for WAC development
PL	WAC for the Różan repository (in operation since 1961) are of general form and were developed in an iterative manner with support from scientific institutions.		WMO
RO	For conditioning facilities, the WAC were developed to allow obtaining of conditioned waste packages that accomplish the WAC for final disposal in National Repository Baita Bihor. For disposal of institutional waste, the existing technical specifications were formalised as WAC and derived based on SA. The preliminary WAC for LLW disposal in the future near-surface disposal facility were developed in the framework of the PHARE project, based on SA.	*institutional waste*: 2007 *future near-surface repository*: 2006	*Institutional waste*: Facility operators *Future near-surface repository*: WMO
SK	WAC are based on legislative provisions, decisions of regulatory body, SA results and lessons learned by waste management organisations.		Repository designer (WMO), with input from TSOs, the Nuclear Regulatory Authority, the State Health Authority and Licence holders
SI	Before 2006, WAC were established in the framework of the Safety Analysis Reports for nuclear facilities. After 2006, procedures on how and when WAC should be established were defined in national rules on radioactive waste and spent fuel management (JV 7). In WAC development, special attention is given to the interrelation of different radioactive waste management steps.	Official requirement from 2006 on all nuclear radioactive waste (storage and disposal) facilities	Facility operator
ES	The safety assessment established the WAC according to the environmental aspects and quality needs of the repository.	1988, with application for the construction permit and authorisation for commissioning of the El Cabril expansion	Repository operator, which in Spain is the WMO (ENRESA)
SE	During WAC development the existing waste type descriptions were considered.	2012	WMO
UA	WAC for each specific radioactive waste management stage are based on acceptance criteria set for other stages and/or facilities within the integrated radioactive management process.		Facility operator
UK	WAC are part of the authorisation requirements for the near-surface disposal of radioactive waste. WAC and the associated control arrangements are an essential part of ensuring compliance with the Environmental Safety Case (ESC). the current WAC take account of the 2011 ESC and implementation of the 2015 permit for further disposals of radioactive waste at the LLWR.	2011	Repository operator (i.e. LLW Repository Ltd)

Table 5 – WAC development process and the responsible organisation.

Observations / remarks per country

Austria

- Treatment and interim storage facilities are both operated by NES (the WMO).
- No WAC for a final repository - the final waste package is unknown.
- WAC for interim storage allow a maximum of flexibility while still making sure the stability of the waste matrix (e.g. WAC doesn't call for a cementation of the high-pressure compacted pellets).
- WAC go through an approval process with the regulator.

Belgium

- WAC have the form of an ONDRAF/NIRAS note.
- WAC are approved by the CEO of ONDRAF/NIRAS after formal advice by the Review Committee of Acceptance Criteria (RCA).
- The Belgian nuclear safety agency (AFCN/FANC) does not have direct control over WAC, which are legally the sole competence of ONDRAF/NIRAS. However, the AFCN/FANC can exercise an influence on the WAC in two ways:
  - Belgian legislation requires WAC to be set up in accordance with General Rules, proposed by ONDRAF/NIRAS and approved by the competent authority. With respect to the latter requirement, it is the AFCN/FANC who will act on behalf of the competent authority. Thus, the AFCN/FANC can approve or reject the General Rules proposed by ONDRAF/NIRAS. The AFCN/FANC also has the right to verify whether the WAC are truly set up in accordance with the approved General Rules[6].
  - The AFCN/FANC has to approve the safety reports and licenses of nuclear installations. As such, the AFCN/FANC can impose criteria on the receipt of radioactive waste in any waste management installation. The latter criteria are referred to as "conformity criteria"[7]. Clearly, the WAC set up by ONDRAF/NIRAS have to comply with these conformity criteria. WAC may not conflict with any safety regulation of license. As such, through the conformity criteria, the AFCN/FANC can control the boundary limits that the WAC have to respect.
- A permanent technical committee (CTP/VTC) is established by Law to represent the waste producers in matters regarding the WAC.
- WAC are adopted by the CTP/VTC and take effect after being referenced in the waste transfer contracts of the concerned waste producers.
- Since 2000, specific WAC have been established whenever a producer announced the generation of a specific type of conditioned waste (CW).
- WAC may not discriminate between waste producers.
- Work is ongoing to revise the WAC for waste having the Dessel surface repository as a final destination - to improve the structure and the comprehensibility of the criteria and to take account of the conformity criteria in the safety report.
- Future legislation is expected to enhance the legal status of the General Rules.

Bulgaria

- Response is referred to the WAC for waste storage/disposal facilities.
- During the procedure for the approval of the selected site for storage/disposal facility, preliminary SA report, including WAC are developed.

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[6] Although there is a common understanding that the AFCN/FANC has these roles, it is not yet reflected in formal legislation.

[7] In Belgium, conformity criteria are distinct from WAC. Conformity criteria form part of the safety report of a specific installation (e.g. storage building, repository) and are the instrument for the safety authority to judge whether the waste will not compromise the safety of the installation. In contrast, WAC are located in specific notes developed by the WMO (ONDRAF/NIRAS) and are the instrument for the WMO to judge the safety and practical feasibility of its further management of the waste. This encompasses more than just meeting the conformity criteria.

- During the procedure for the approval of the design of the storage/disposal facility, intermediate SA report, including WAC is developed.
- WAC are agreed by the regulator.

Cyprus

- There are no formal WAC in Cyprus; WAC development has not been considered necessary to date.
- The Radiation Protection Section of the Department of Labour Inspection is the responsible authority, which inspects and advises facilities that handle radioactive substances and ionising radiation.

Czechia

- Czech Atomic Law (no. 263/2016 Coll) has general provisions (requirements) for WAC derivation that apply to all types of storage and disposal facility.
- WAC are developed for each facility taking account of these provisions, but adapted to the specifics of the storage / disposal facility. The WAC are derived from safety analysis against the main requirement not to exceed the dose limit for the representative person.
- At present, the following storage and disposal WAC exist:
    - Richard repository (in operation since 1964):
        - For LLW and ILW disposal.
        - For LLW and ILW storage.
    - Bratrství repository (in operation since 1974):
        - For LLW and ILW disposal.
    - Dukovany repository (in operation since 1995):
        - For LLW (and VLLW) disposal.
    - Surface facilities at waste producer installations:
        - For storage of all waste classes (including SNF interim storage).
- Waste producers have WAC that are dependent on the technologies employed and the ways in which they manipulate radioactive material, i.e. for waste sorting, conditioning and storage.

France

- The first French disposal site (Centre de la Manche) started operation in 1969 on the La Hague site. After some years of operation, it was necessary to establish a regulatory framework for the waste management operations at Centre de la Manche and the two Basic Safety Rules (BSRI.2 & BSRIII.2.e) were published in 1982 and 1986 respectively.
- After closure of the Centre de la Manche in 1994 the feedback from this first disposal site was integrated into BSRIII.2.e and applied to the CSA (in operation since 1992).
- After 1999, following establishment of the French zoning strategy, including absence of a clearance level, it was decided to construct the CIRES repository for VLLW – this became operational in 2003 by local decree.
- In 1991, in response to the Bataille Act (the French law on radioactive waste management), a 15-year research programme was launched on three areas of research: partitioning and transmutation, conditioning and long-term storage, and deep geological disposal of HLW.
- Based on the results obtained from the 15 years of research, their review by various bodies, and the 2005-2006 public debate, France's Parliament ratified the choice of reversible deep geological disposal for long-term management of HLW and ILW-LL and set deadlines for its implementation (Law 2006-739).

Germany

- For the flooding scenario considered in the SA of the Konrad repository, the hazard associated with the radionuclides and other chemical compounds in groundwater have to be below the level defined by permission based on the Federal Water Act (Wasserhaushaltsgesetz).

Greece

- WAC for storage at the NCSR "Demokritos" interim storage facility were developed by the facility operator and established in the framework of licensing by the regulatory authority.
- At present, the main task of the NCSRD facility operators is the refurbishment and "reconstruction" of the storage facility. New waste containers are also foreseen.
- The safety case and safety assessments are being developed for the new facility in conjunction with these updates.

Hungary

- Given the heterogeneity of institutional waste it cannot be expected that each waste producer can perform adequate treatment. Consequently, the WMO (PURAM) is responsible for applying appropriate WAC, and has developed a multi-level system of WAC (as described in Section 2.2.1) based on the intended short- and long-term management plans for the waste.

Lithuania

- WAC refer to VLLW disposal in landfill facilities and LLW disposal in engineered near-surface disposal facilities.
- WAC for storage of ILW are also established, as are requirements equivalent to WAC for the storage of SNF.
- A Technical Design and Preliminary Safety Analysis Report are required to obtain a licence for repository construction from the national regulator (VATESI). For the new VLLW and LLW disposal facilities, licences for construction and operation have already been provided.

The Netherlands

- COVRA is responsible for the predisposal management of all types of radioactive waste, as well as the siting and design of the planned deep geological facility. The response to Question 6 covers all waste classes.

Poland

- Monitoring data of the Różan repository are available for inspection as local community is interested in safety of this facility.
- New WAC have to be developed for the new disposal facility proposed to be commenced in future.

Portugal

- There is a national programme for radioactive waste management but it does not include a system of WAC as yet.
- As noted in Section 2.2.1, at the PRR waste management facility, some (internal) procedures are implemented for the management of wastes, considering the national waste classification, radionuclide inventory, physical characteristics (solid, liquid, compressible, etc.), dose rate limits and surface contamination. However, no 'WAC' have been established, detailing the involvement of WMOs, waste producers, site or facility operators, regulators or any other parties.

Romania

- WAC for treatment & conditioning facilities for institutional waste were developed as request of licencing the facilities.
- WAC for Baita Bihor repository (for institutional waste only) were developed based on SA and updated in 2012, after the repository refurbishment.
- Preliminary WAC for the future near-surface disposal facility (mainly for waste generated by the Cernavoda NPP) were developed for the licensing of this facility (currently at the siting stage).

Slovakia

- In developing WAC, the worst possible scenario is anticipated.
- All procedures that might have an influence on nuclear safety or radiation protection are applied in WAC, including specific treatment, conditioning and/or packaging approaches.
- WAC must be developed and approved prior to commissioning of any nuclear facility.
- A chapter on WAC forms part of the Safety Assessment Report for each facility.
- The level of nuclear safety, including WAC, of all operational nuclear installations is subject to periodic review in accordance with national legislation (NRA Decree No. 33/2012).

Slovenia

- According to the Atomic Act all storage and disposal facilities for LLW, ILW and HLW are designated as nuclear facilities.
- WAC have to be approved for different stages of the licensing process for storage / disposal facilities: construction, trial operation and operation.

Spain

- The WAC discussed in the Spanish response concern activities at the El Cabril repository.

Sweden

- The WAC discussed in the Swedish response concern the disposal of LLW at SFR.
- The WAC document is part of the Safety Assessment Report for SFR.

Ukraine

- According to national regulations, the design basis for any facility must include design-basis WAC for the given facility and design-basis WAC for the facility to which waste / waste packages are to be transferred for further management.
- The design basis shall be justified in the Safety Assessment Report and it is part of the SC.

United Kingdom

- WAC addressed in this synthesis refer to the LLWR in Cumbria, for LLW disposal.
- These WAC apply to specific treatment routes and to conditioning and packaging of all waste being consigned for disposal at the LLWR.
- As noted in Section 2.2.1, the LLWF at Dounreay only accepts wastes generated at Dounreay and the Vulcan Nuclear Reactor Test Establishment and associated WAC are not publicly available. However, it is noted in the UK questionnaire response that the LLWF are authorised by the Scottish Environment Protection Agency (SEPA) to operate under an Environmental Authorisations (Scotland) Regulations 2018 Permit, which sets limits and conditions on the waste to be disposed of.

3.2.2 Stakeholders involved in WAC development & provisions for periodic review / update

Country	Stakeholders involved in WAC development						Periodic review	Periodic update	Frequency of periodic review / update
	WMO	Facility operator	Waste producer	Regulator	TSO / RE	Other			
AT	√			√			√	√	Raw waste: yearly review and update storage: update as part of the IMS (QM) system
BE	√	√	√	√			-	-	-
BG	√	√	√	√	√		√	√	Periodically - as the licensing process progresses
CZ	√	√	√	√				√	Every five years as part of updating the SA
DK				√			-	-	-
FR	√	√	√	√	√	√	√	√	CIRES specific WAC: no periodic review, but revision possible at any time CSA specific WAC: revision with ten years periodic safety review
DE	√							√	Updated if necessary, considering the state-of-the-art in science and technology
GR		√						√	Update before any new configuration of the waste packages in the storage facility
HU	√			√			√		Every five years
LT				√				√	Every ten years
NL	√	√					-	√	Annually, if necessary, for processing facilities
PL	√	√		√	√		√	-	WAC are reviewed in a continuous manner
RO	√	√	√	√			√	√	*Baita Bihor repository and waste conditioning facilities*: revision, if necessary, every five years with licence renewal *Future near-surface repository*: both review and revision as licensing process progresses
SK	√	√		√	√	√	√	√	*Periodic review*: reassess every ten years: in case of any change at the nuclear facility
SI	√	√	√				√	√	Periodic, as part of the licence renewal Previous updates of WAC were driven by regulatory requirements
ES	√	√		√			√	√	With periodic safety analysis of the repositories

Country	Stakeholders involved in WAC development						Periodic review	Periodic update	Frequency of periodic review / update
	WMO	Facility operator	Waste producer	Regulator	TSO / RE	Other			
SE	√	√	-	√	-	-	-	-	Updated if necessary
UA	√	√	√	√	√		√	√	In case of issuing the license for operation of radioactive waste management facility or as part of the SC
UK		√		√		√	√		On an ongoing basis as required by waste acceptance issues and technical work that helps to refine the position of LLW Repository Ltd. Also, every ten years alongside review of the Environmental Safety Case

√ responsibility indicated in the country's response

- clear indication on no involvement of a stakeholder, or no regular review / update

Table 6 – Stakeholders involved in WAC development and indication of the frequency of periodic review / update of the WAC.

In some countries, TSOs and REs were indicated as organisations involved in WAC development. In the context of EURAD, a TSO is the support organisation for the national regulator (e.g. IRSN in France, or CIEMAT in Spain), whilst a RE means a research organisation (e.g. SCK.CEN in Belgium or RATEN in Romania).

With regard to other stakeholders influencing WAC development: public inquiry is mentioned in the French answer, the State Health Authority in the Slovakian answer and Local Stakeholder Groups in the UK answer.

In Belgium, no system of regular evaluation of the WAC exists but, to take account of experience and the acquisition of new knowledge, a system of regular evaluation by ONDRAF/NIRAS is expected to be foreseen in the future legislation. Currently, in Belgium work is ongoing to revise the WAC aiming to improve the structure and the comprehensibility of the criteria and to take account of the conformity criteria in the safety report of the Dessel surface repository.

In France, there are no periodic reviews specified in either the CIRES local licence (issued by the local regulator), in the CIRES specific WAC or for the generic WAC for LLW. Regarding the revision, it is possible at any time for CIRES and CSA specific WAC; furthermore, for CSA specific WAC revision with ten years periodic safety review is foreseen.

In Slovenia, previous updates of WAC have been driven by regulatory requirements specifying that any change of defined parameters, any introduction of new treatment and conditioning methods, or any other significant change is subject to special assessment as defined in the National Rules on operational safety of radiation and nuclear facilities (JV 9). This requires that the operator of a radiation or nuclear facility must consider any change in the facility from the point of view of its effect on radiation or nuclear safety. The process for managing changes has to be established to ensure that temporary and permanent changes are timely and properly designed, inspected, controlled and implemented, and that all related safety requirements are met, taking into account Slovenian and foreign operating experience, as well as new insights gained from technical research and progress and the management of other radiation or nuclear facilities. For the proposed change to be justified, the scope and quality of the safety analysis performed must be consistent with the importance of the change for radiation or nuclear safety and must be based on data reflecting the actual condition of the facility as constructed and as operating and as maintained, taking into account operational experience.

Countries such as the UK and Poland mentioned WAC reviewing on an ongoing basis, respectively reviewing in a continued manner.

3.2.3 Factors driving previous WAC updates

	Austria	Belgium	Bulgaria	Czechia	Denmark	France	Germany	Greece	Hungary	Lithuania	The Netherlands	Poland	Romania	Slovakia	Slovenia	Spain	Sweden	Ukraine	United Kingdom
Operational facilities																			
Changes to the legal or regulatory framework	√	√	√	√						√	√	√	√	√	√		√	√	
New waste type, waste containers or waste forms, or other modification of waste inventory		√	√		√	√	√	√	√	√	√			√	√	√		√	√
Facility refurbishment/ reconstruction				√				√					√	√	√				
Experience from past operation	√	√	√	√		√									√	√			
Additional consideration of toxic substances of the waste							√			√					√	√			
Setting up requirements and verification of compliance										√					√		√		
Disposal facilities that are planned / in development																			
Reviewed / updated at each main milestones of the project development			√				√			√	√			√	√	√		√	
Change in the disposal concept				√					√						√				√

Table 7 – Factors that have influenced previous updates of WAC.

3.3 Analysis and conclusions

In countries with long-standing nuclear programmes, historic acceptance limits or specifications were typically formalised as WAC to comply with some general rules / norms imposed by the regulator.

For facilities that are planned / in development, or became operational in the last few years, the WAC were developed during the licensing process of the particular facility (either for treatment & conditioning or for storage/disposal), based on the safety assessment. Often, WAC form part of the safety case or Safety Assessment Report.

Usually, WAC are developed by the WMO or facility operator (which is sometimes the same entity) in consultation with other parties and agreed / approved by the regulator, but in some cases (e.g. Denmark, Lithuania) the WAC have been established by the regulator itself. Elsewhere (e.g. in Germany, Greece, The Netherlands, Slovenia), the regulator appears not to have had direct involvement in the development of WAC (or related requirements).

Most countries have provisions for periodic review and update of WAC, but the frequency varies and is not always explicitly set out. Often, WAC are updated, if necessary, as part of periodic or step-wise relicensing activities for a facility (conditioning / packaging, storage or disposal facilities) and the indicated frequency is related to the periodicity of licence revision / renewal.

Preliminary WAC (for disposal facilities that are planned / in development) are continuously reviewed, and updated from time to time, typically at each major milestone of the development programme.

Changes to the legal and regulatory framework were, in most cases, the main factor driving historical WAC updates. WAC were also updated in response to the introduction of new waste types, waste containers or waste forms and to consider the experience accumulated from past operations.

4. Analysis of responses to Question 7 of ROUTES questionnaire

4.1 Approach to review national responses

Question 7 from the ROUTES questionnaire is as follows. Guidance text is provided *in blue*.

> ***Q7: If generic WAC are in place, how are these implemented?***
> *There is no need to answer this question if the WAC in your country are all specific to a particular site or facility.*
>
> - *For cases where generic WAC are applied to multiple waste types and/or facilities, please explain how any requirements with limited or specific applicability are managed.*
> - *For cases where no management route currently exists (e.g. no disposal route), please explain how any generic WAC have been developed. E.g. are conservative assumptions made regarding waste behaviour?*
> - *Have these generic WAC affected conditioning / packaging / storage approaches (if so, please explain how)?*

This question aimed to explore the development and application of generic WAC in different countries, i.e. WAC that are in use but are not linked to a specific site or facility (as defined in Section 2.1).

Most countries did not provide a response to this question. The responses of those that did indicate a more varied interpretation and application of the term 'generic WAC' than that defined above so a tabulated summary of responses is not appropriate. Instead, the national responses are discussed on a case by case basis in Section 4.2 followed by some general observations and conclusions in Section 4.3.

4.2 Summary of responses

The following countries do not apply generic WAC in any form and therefore did not respond to this question (or only responded to confirm that it is not relevant to their national waste management arrangements): Austria, Belgium, Bulgaria, Czechia, Denmark, Germany, Greece, Hungary, Lithuania, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. The responses from other countries are summarised below (this summary also captures discussion of generic WAC elsewhere in questionnaire responses).

<u>Generic WAC by country</u>

Cyprus

Generic requirements are defined and in use for the storage and discharge of radioactive waste originating primarily from sources used in medical applications. The requirements are generic in the sense that the relevant legal obligations apply for any site or organisation making use of materials that generate radioactive waste.

France

Some overarching generic WAC for disposal of LLW have been laid down by the French regulator (ASN) at a national level, as discussed in Section 2.2.1. These are applied alongside site-specific criteria for individual facilities such as the CSA.

The Netherlands

As noted in Section 2.2.1, the term 'generic WAC' is used in the Dutch response to refer to WAC that are facility specific but not specific to acceptance of particular waste types. In particular, COVRA defines generic WAC for each of its storage facilities (e.g. dose rate limits). Other countries follow a similar approach but do not consider such WAC to be generic in nature.

Slovenia

Generic WAC were developed for the disposal of LLW in Slovenia before the site for disposal of LLW was identified. These are now superseded by preliminary WAC for the Vrbina facility. In Slovenia, the proper term for such WAC is considered to be 'very preliminary WAC'.

Spain

The Spanish approach is similar to that in The Netherlands in that the national response notes that WAC are applicable to generic nuclear and radioactive waste generated across the whole waste lifecycle. As in The Netherlands the WAC themselves are site- or facility-specific. However, the term 'generic WAC' is not used. This is also the case in many other countries although it is not explicitly stated in the national responses to the ROUTES questionnaire.

Ukraine

As noted in Section 2.2.1, facility-specific WAC are required for all existing and designed facilities (both pre-disposal and disposal). Such WAC are in use for all facilities in operation. They are developed initially during the design of the facility and form part of the safety case. These 'design-basis WAC' are preliminary; they are subsequently finalised in preparation for facility operation.

There is also provision for the development and application of generic WAC for radioactive waste disposal in Ukraine. The regulatory document "Recommendations for establishment of WAC for conditioned radioactive waste for disposal in near-surface disposal facilities" contains some recommendations for establishment and application of generic WAC for near-surface disposal facilities. Moreover, generic WAC were developed for the proposed geological disposal concepts developed in the framework of the INSC project, taking account of the possibility for disposal in various geological formations. As noted above, once a specific facility exists, specific WAC must be established.

Where WAC for long-term storage and/or disposal are not yet available, the waste owner shall apply criteria determined based on reasonable (conservative) assumptions concerning the planned route and facility type for long-term storage and/or disposal. These assumptions shall be justified in the safety case for the facility.

Generic WAC are not applied for pre-disposal management of radioactive waste.

United Kingdom

As noted in Section 2.2.1, RWM produces generic packaging specifications for HAW as a means of providing a baseline against which the suitability of plans to package waste for geological disposal can be assessed prior to identifying the disposal site. These specifications are generic in the sense that they make no assumptions regarding the geographical location of the GDF, the geological environment in which it will be constructed or the specific geological disposal concept which could be adopted. Accordingly, the packaging requirements are defined in such a manner as to be bounding of a range of disposal concepts that could be implemented for HAW in a number of geological environments that exist at a range of locations throughout England and Wales[8] [34].

RWM's generic Disposal System Specification (DSS) [32] notes that generic waste package requirements are defined so that they would be bounding of the eventual WAC for an operational GDF and as such the generic requirements for waste packages act as preliminary WAC for the GDF. This reflects a slightly different use of the term 'preliminary WAC' compared to that in other countries, where preliminary WAC are site or facility specific. Nevertheless, RWM's generic waste package specifications

8 Scotland has a different policy for HAW located in Scotland (near-site, near-surface disposal) and there are no plans to site a GDF in Northern Ireland.

are likely to form the starting point for the development of site or facility-specific WAC in due course and in this sense, use of the term 'preliminary WAC' is consistent with its application in other countries.

The WAC for the LLWR (and the LLWF) are not generic, so are not relevant to this discussion.

4.3 Analysis and conclusions

The development and application of generic WAC is only conducted in a limited number of European countries. Within these countries, the interpretation of what 'generic WAC' constitute varies widely.

Where generic WAC are defined, these tend to concern disposal activities, rather than upstream waste cycle stages. An exception is that radioactive waste storage facilities in many countries have WAC that are not specific to particular waste types and in some countries (e.g. The Netherlands) such WAC are considered to be generic.

The focus of generic WAC on disposal reflects uncertainty about the characteristics of disposal systems that are yet to be developed, and associated uncertainty about the safety functions to be placed on the waste package. It also reflects the relatively long lead times for siting and development of disposal facilities, particularly those for higher activity waste classifications, and the need for some form of interim waste packaging requirements to be available in the meantime.

With regard to disposal, it is only the UK that has developed and applied an extensive system of generic 'WAC' that is integral to its national approach to radioactive waste management (for HAW). Ukraine has used a similar approach for the initial development of WAC for a geological disposal facility as a basis for future planning, but employs site-specific WAC for other disposal facilities.

Elsewhere, generic WAC are not necessarily a precursor to site- or facility-specific WAC to be developed at a later date. In some cases they reflect an overarching set of requirements, beneath which site- or facility-specific WAC are specified (France), and in other cases they reflect a set of requirements that are to be universally applied (Cyprus).

Generic WAC / disposability criteria have also been defined by the IAEA [35] (for geological disposal) and through collaborative international programmes, e.g. THERAMIN [2,6] (to evaluate the disposability of thermally treated radioactive waste). None of these WAC / criteria are formally applied in any country in their original form, having all been produced as a starting point for development of WAC that are specific to the national context and facility in question.

The use of generic WAC for disposal might have benefit in other countries that are at relatively early stages of planning for radioactive waste disposal. Indeed, the Slovakian response notes that generic WAC are not used at the moment but may be helpful as an inspiration when developing specific WAC for a deep geological repository. It could be interesting to explore whether this view is more widely held as part of future Task 4 discussions. For example, the gap analysis as part of Sub-task 4.2 could involve group discussion of whether (and how) generic WAC could provide a tool to facilitate waste management (conditioning, packaging, storage and evaluation of disposability) for wastes where no disposal route is currently available.

5. Analysis of responses to Question 8 of ROUTES questionnaire

5.1 Approach to review national responses

Question 8 from the ROUTES questionnaire is as follows.

Q8: Please describe how the WAC in your country take the following into account (for each stage of the waste cycle and with regard to different waste types, if relevant):
• *Concerning the radiological characteristics of the waste:* – *Activity content (related to the national waste classification scheme) including, e.g. activity concentration, concentration of alpha emitters and beta-gamma emitters* – *Radionuclide inventory (relating to transport, operational and post-closure safety)* – *Nuclear criticality, in terms of mass limits on fissile material, fertile material, potential moderators (including water) and poisons* • *Concerning the physical, chemical and biological characteristics of the waste:* – *Waste constituents (e.g. in terms of flammables, explosives, free liquids, biological or toxic materials, complexants, water-soluble chlorides and sulphates, other aggressive chemicals, …)* – *In the case of conditioned waste: the matrix (e.g. glass, cementitious, bituminous, …) and immobilisation method (e.g. solidification, encapsulation, embedding, …)* • *Concerning the waste package (including the container and any requirements on the waste form and container acting in concert):* – *Container type and material* – *Dose-rate limits (as related to national waste classification scheme)* – *Surface contamination (radioactive and non-radioactive e.g. salt deposits)* – *Thermal output (as a limit to the amount of waste in a single package)* – *Chemical durability* – *Gas generation (e.g. from corrosion, radiolysis and degradation of organic material)* – *Void spaces (voidage)* – *Waste package stacking* – *Waste package impact performance* – *Waste package fire performance* • *Concerning underpinning information requirements and process quality management (as applicable at all lifecycle stages):* – *Waste characterisation / treatment requirements (see also Q9)* – *Component pre-fabrication (e.g. components of the waste container)* – *Plant / infrastructure set-up* • *Concerning documentation of waste management:* – *ID / labelling* – *Other QA / QC requirements* – *Data management* • *Concerning secondary wastes:* – *Any requirements on the minimisation or characteristics of secondary wastes generated during waste management activities*

This overview focusses on short-lived low and medium active waste, i.e. LLW according to IAEA waste classifications, because WAC (or similar) for this type of waste exist in most countries. It also focusses on conditioned waste, because this enables waste properties related to disposal as well as to pre-disposal to be considered. The only countries that provided details on the content of WAC that are specific to HLW and/or long-lived waste, i.e. ILW according to IAEA waste classifications, are France and the UK (and to a limited extent also Czechia, although these WAC do not apply to deep geological disposal). This is not enough to allow for a European overview. Instead, Section 5.2.2 provides a comparison between the content of the WAC for (near-)surface disposal[9] and the WAC for geological disposal based on the inputs of these countries (France and UK).

The overview makes a comparison of which parameters are addressed in the WAC rather than a comparison of numerical limiting values. The parameters have been chosen based on international practice (e.g. as set out in Table 3 of IAEA-TECDOC-1817 "Selection of Technical Solutions for the Management of Radioactive Waste") [36] and to accommodate the responses to Question 8.

5.2 Summary of responses

5.2.1 Responses for LLW (and ILW if a shared disposal facility is considered)

Table 8 provides an overview of responses to Question 8 of the ROUTES questionnaire with respect to conditioned LLW (and ILW if a shared disposal facility is considered). A tick in this table (**√**) means that the concerned parameter is mentioned in the country's response to Question 8 and therefore in the WAC. A dash means that the parameter is not addressed in the WAC based on the national response. Blank cells indicate parameters that are probably not factored into national WAC, but this has not been explicitly confirmed.

The following points provide an explanation of the terms included in Table 8:

- 'Nuclide inventory' means that the WAC require characterisation of a certain set of radionuclides.
- 'Physical hazards' means that the WAC address the potential presence of flammable, explosive of chemically aggressive species in the waste.
- 'Reactive metals' means that the WAC address the potential presence of species such as Al, Na, K, and/or Be.
- 'Complexing agents' means the WAC address the potential presence of complexing or chelating agents (e.g. products used for decontamination, like EDTA). Such agents can accelerate the migration of radionuclides through certain barriers.
- 'Putrescible/fermenting' means that the WAC address the potential presence of organic materials that will decompose and may form complexing or chelating agents and (when fermenting) may also cause gas generation, release of free liquids and/or aggressive chemical reactions.
- 'Stability' of the waste form refers to the its ability to maintain its consistency (no decomposition) and volume (no swelling or shrinking).
- 'Chemical compatibility' of the waste package means that no detrimental reactions will occur between the different components of the package (waste, matrix, container).
- 'Qualifications' means the approval by the waste management authority of the methods by which the waste producer generates radioactive waste or performs characterisation, treatment or conditioning.
- 'Secondary waste' means that there are rules specifically addressing secondary waste.

[9] Different terminology is used in France (surface disposal) and in the UK (near-surface disposal).

The remarks following the table provide some additional information, by country, as to why a parameter was given a tick or a dash. The remarks also capture some information that was difficult to include in the overview table because of the specific nature of this information.

Overview of responses to Question 8 with respect to conditioned LLW (and ILW if a shared disposal facility is considered)		Austria	Belgium	Bulgaria	Czechia	Cyprus	Denmark	France	Germany	Greece	Hungary	Lithuania	The Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Ukraine	United Kingdom
Radiology	Nuclide inventory	√	√	√	√		√	√	√	√	√	√	√	√		√	√	√	√	√	√	√
	Total activity or activity concentration limits	√	√	√	√	√	-	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Criticality	√	√	√	-		√	√	√	√	-	√	√	-		√	√	-	√	-	√	√
Constituents	Physical hazards	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√		√	√	√
	Chemotoxicity		√	√	√			√	√		√	√	√			√	√	√	√		√	√
	Reactive metals		√				-	√				√	√			√	√					√
	Complexing agents		√	√	√			√								√	√	√			√	√
	Putrescible/fermenting	√	√	√			-	√	√		√	√	√		√	√	√	√	√		√	√
	Biohazard	√	√	√	√			√				√			√	√	√				√	√
Waste Form	Solid	√	√	√	√		√	√	√	√	√	√	√	√	-	√	√	√	√	√	√	√
	Matrix type(s)	√	√	-	√				-		√	√	√	√		√	√	-		√	√	√
	Leaching		√	√	√			√			√	√	√	√		√	√		√		√	√
	Porosity		√					√			√	√	√					√			√	
	Homogeneity		√	√	√			√				√	√					√			√	
	Stability	√	√	√	√		-	√	√			√	√			√	√	√	√		√	√
Waste package	Dose rate	√	√	√	√		√	√	√	√	√	√	√	√		√	√	√	√	√	√	√
	Surface contamination	√	√	√	√		√	√	√	√	√	√	√	√		√	√	√	√	√	√	√
	Voids (zero or small)		√	√				√	-		√	√	√			√		√	√	√	√	√
	Free liquids	√	√	√	√		√	√	√	√	√	√	√	√		√	√	√	√	√	√	√
	Thermal output		-	√					√		-	√	√				-		-		√	-
	Gas generation	√	-	√			√	√	√	√	√					√	√	√	-		√	√
	Chemical compatibility		√	√	-			√	√			√	√	√		√		√	√		√	√
Container	Prescribed type	√	√	√	√		√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Stacking considerations		√		√		√	√	-	√	√	√	√	√			√	√	√	√	√	√
	Impact considerations	√	√		√			√	√		-	√	√				√	√	√	√	√	
	Fire considerations	√		√	√			√	√	√	√		√				√	√	-	√	√	
QA/QC	ID / data management	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Qualifications		√		√			√				√					√					
	Secondary waste	√		√	√							√	√	√		√	√	√	√	-	-	√

Table 8 – Overview of responses to Question 8 with respect to conditioned LLW (and ILW if a shared disposal facility is considered).

Observations by country

Austria

- Final destination considered in the table: not applicable. The temporary solution is long-term storage (facility is in operation).
- Waste form: cementitious matrix or high-pressure compacted waste. Also encapsulation (for ashes and sealed sources).

Belgium

- Final destination considered in the table: Dessel (surface repository for LLW); license has been applied for.
- Waste form: only cementitious matrices are considered.
- Waste package: gas generation is minimised by the disposal design.
- Container: prescribed standard type is the 400-litre drum, but specific other types are tolerated.

Bulgaria

- Final destination considered in the table: Radiana NDF (National Disposal Facility) near Kozloduy (surface repository for LLW); under construction.
- Constituents: putrescible materials are forbidden; however, wood and textiles are exceptions.
- Waste package: voidage should be minimised.
- Container: prescribed types of reinforced concrete containers.

Czechia

- Final destinations considered in the table:
    - Richard: near-surface repository; in operation.
    - Bratrství: near-surface repository; in operation.
    - Dukovany: surface repository; in operation.
- Waste form: Cementitious (for disposal at Richard and Bratrství); also bituminous and aluminosilicate matrices (SIAL®).
- Container: the prescribed type is a “drum in drum” (200 litre) system with concrete biological shielding.

Cyprus

- Final destination considered in the table: not applicable. Current waste management consists of discharge to the environment once the activity of the short-lived waste is/falls below the exemption / release levels provided for by law.
- Waste requiring interim storage prior to discharge is usually stored in the original containers or else waste products are placed in glass containers.
- Packages are labelled as radioactive waste.

Denmark

- Final destination considered in the table: geological disposal (by 2073), until then long-term storage (facility planned to be in operation in 2023).
- Constituents / waste package: reactive metals, putrescible/fermenting materials, gas generation and waste form stability are not explicitly mentioned in storage WAC. However, associated restrictions on such materials are implicit, since anything that can lead to pressure build-up may not be placed in waste packages consigned for storage.
- Container:
    - Waste from external users is sorted and compressed into drums. Smoke detectors and combustible material are removed, if possible, for alternative management.
    - Decommissioning waste is sorted according to its constituents (e.g. metal, concrete,…) and packaged for storage in three types of containers: steel containers, ISO containers and ‘jumbo’ containers.
    - Combustible waste is sent abroad for incineration.

France

- Final destination considered in the table: CSA (surface repository for LLW); in operation. The facility for VLLW (CIRES) is not considered because it is a separate facility from the CSA. Nevertheless, it is noted that the WAC for the CIRES differ from those for the CSA in the following ways:
    - Lower activity limits are specified for the CIRES, reflecting the acceptance of VLLW only at this facility.
    - Chemotoxicity constraints are the same as for non-radioactive waste.
    - There are no criteria on waste package chemical durability.
    - Containers have to be carefully filled to avoid the presence of void spaces that could reduce the mechanical strength of waste package stacks.
    - There are no criteria on impact performance or fire performance.
- Constituents:
    - The following constituents are forbidden: those that pose physical hazards, biohazards, putrescible materials (e.g. animal carcasses), and materials that are reactive in contact with water (like reactive metals).
    - Limitations are placed on the amount of some other organic materials (e.g. wood) permitted within each package.
    - Chemotoxicity: there is required reporting of specific toxic materials (mostly heavy metals).
- Waste package:
    - Voidage: small (3% in CSA).

Germany

- Final destination considered in the table: Konrad (geological repository for LLW and ILW); under construction.
- Constituents: there is a “white list” of allowed compounds (under certain conditions). Requests for exceptions have to be submitted to the competent authority (BGE).
- Waste package: must withstand a drop from 5 m, an external pressure of 30 MPa and a temperature of 300°C (in case of fire).
- QA/QC: the quality system for disposal activities is licensed by the regulator (BMU/BGE).

Greece

- Final destination considered in the table: not applicable. The final destination for radioactive waste in Greece has not been decided. There are also no facilities for treatment and conditioning as yet; virtually all waste is in its raw form.
- The WAC summarised in Table 8 are therefore acceptance criteria for waste to be stored in the NCSR “Demokritos” interim storage facility.
- As noted in Section 2.2.1, criteria for storage at the NCSR “Demokritos” facility include quantitative limits on:
    - Dose rates at the package surface (and at 0.7 m).
    - Surface contamination.
    - The waste package mass (weight), to enable handling using a forklift truck (reflected in Table 8 as a tick against ‘prescribed container type’).
- Waste packages are placed in the storage facility to optimise worker safety [10].
- There are also some qualitative criteria for acceptance, including requirements on the category of radioactive sources, prohibition of liquid waste in vessels, requirements relating to nuclear safeguards, and restrictions on sources which produce airborne radioactivity.
- Other requirements are examined on a case-by-case basis.

Hungary

- Final destination considered in the table: Bátaapáti (repository for LLW and ILW originating from the Paks NPP); in operation.

- Radiology: there are activity and activity concentration limits that are nuclide-specific and waste form specific. Hence, the characterisation of a certain set of radionuclides is required.
- Constituents: limited quantities of (putrescible) organic materials are allowed.
- Matrix type: cementation of waste is required.

Lithuania

- Final destination considered in the table: Ignalina NSR (near-surface repository for LLW); under construction.
- Constituents: chemotoxic materials are allowed to certain limits (agreed with the regulator).
- Waste form: cementitious matrix.
- Container: concrete containers.

The Netherlands

- Final destination considered in the table: geological disposal (by 2130), until then long-term storage (on the COVRA site; facility is in operation).
- Radiology: the nuclear inventory, activity and fissile content are provided by the customer.
- Constituents: hazardous materials in the waste should be identified by means of an EURAL code.
- Waste form: COVRA is a certified concrete supplier. It developed the grout formulation to be used and it has been tested to demonstrate compliance with applicable requirements. The standard grout is made with CEM III/B.
- Container: COVRA provides the containers or describes to the customer what is required.
- Waste package: voidage should be minimised.
- Secondary waste: All water used for cleaning the equipment used for processing the waste and floors are treated at COVRA's premises.

Poland

- Final destination considered in the table: Różan KSOP (surface repository for LLW); in operation.
- Radiology: the nuclide inventory is taken into account via the national radioactive waste classification in which the half-life of nuclides plays an important role.
- Waste form: cementitious matrix.
- Waste package:
  - Free liquids: unbound water is allowed to a certain limit (1% mass).
  - Chemical compatibility: container (packaging) must take account of physical/chemical waste properties.
- Container:
  - Disposal in specially designed concrete or metallic containers (protected against corrosion).
  - Large pieces of radioactive waste can (under certain conditions) be placed in the repository without packaging.
- ID/data management: documentation only contains radiological characteristics, QA/QC is under development.

Portugal

- Final destination considered in the table: not applicable. The temporary solution is interim storage (at the CTN/IST site; facility is in operation).
- No WAC exist. There are only procedures for measuring dose rate and surface contamination, basic waste characterisation and waste management according to the national radioactive waste classification.
- Waste form:
  - a priori no exclusion of other than solid waste forms.
  - Some waste is treated via compaction.

- Container: ADR rules.

Romania

- Final destination considered in the table:
  - Future near-surface repository for LLW from the Cernavoda NPP, later also institutional waste (Saligny is the preferred site); under siting.
  - Baita Bihor (near-surface repository for institutional LLW); in operation.
- Radiology:
  - At Saligny, limits per waste package exist for specific nuclides and for the total of alpha-emitters and the total of beta-emitters.
  - At Baita Bihor, no fissile materials are accepted and only limited quantities of long-lived radionuclides are accepted.
- Constituents:
  - putrescible waste, biohazard waste:
    - Saligny: not accepted.
    - Baita Bihor: accepted under certain conditions.
  - Chemotoxic materials, complexing agents, electropositive metals, wood, absorbing materials are acceptable at Saligny under certain conditions.
- Waste form: Cementitious matrix is standard, but other matrices are possible.
- Waste package:
  - Voidage should be small (<10 v% at Saligny).
  - Free liquids should be small (<1 v% at Baita Bihor).
- QA/QC: the quality system for treatment, conditioning and disposal activities is licensed by the regulator (CNCAN).

Slovakia

- Final destination considered in the table: Mochovce national repository (surface repository for VLLW and LLW in separate sections of the repository); in operation.
- Constituents:
  - All kinds of flammables, explosives, free liquids, biological or toxic materials, complexing agents, water-soluble chlorides and sulphates, other aggressive chemicals are excluded from disposal.
  - Significant gas-generating materials (e.g. aluminium powder) are excluded from disposal.
  - Cellulose-rich wastes require treatment (by means of incineration) prior to disposal.
- Waste package: Voidage should be small (<5 v%).
- Container: specific fibre-reinforced concrete containers (VBK) are standard. These have been developed based on safety assessments of the repository and waste handling facilities (hereby considering stacking, impact performance, fire performance, chemical durability, …).
- QA/QC: JAVYS is the license holder for the fabrication of VBK containers.

Slovenia

- Final destination considered in the table: Vrbina near Krško national repository (near-surface repository for LLW and some ILW); licence has been applied for.
- Radiology: criticality is not relevant to Vrbina because it only needs to be addressed for relevant waste types (like spent fuel).
- Waste form:
  - Density is also a parameter for the WAC.
  - The WAC do not require a specific waste matrix to be used, provided the selected material(s) do(es) not give rise to any conflicts with the acceptance criteria.
- Waste package:
  - The waste is grouted in the container, primarily to fill void spaces.

  - Corrosion is mentioned as a possible source of disturbance of the chemical compatibility of the waste package (including the stability of the waste form).
- Container: specific concrete containers (N2d) are standard. Limits must be specified for structural strength, which is inferred to included consideration of container stacking.
- QA/QC: The disposal container factory is operated in accordance with the licence.

Spain

- Final destination considered in the table: El Cabril (surface repository for VLLW and LLW); in operation.
- Radiology: limits per waste package exist for specific nuclides. There are also maximum limits per waste package for the total activity of alpha-emitters and the total activity of beta-emitters.
- Constituents:
  - Required reporting of quantities of lead, aluminium, copper and asbestos.
  - Biological and organic wastes are sorted out and sent to the incinerator.
- Waste package:
  - Voidage should be minimised.
  - Gas generation is minimised by the disposal design.
  - Chemical compatibility is assured via the classification of non-conditioned waste.
- QA/QC: characterisation, treatment and conditioning activities occur at the disposal site.

Sweden

- Final destination considered in the table: Forsmark SFR (shallow geological repository for LLW); in operation. An extension to the repository is planned.
- Radiology: there exists a repository total activity limit.
- Waste form: cementitious matrix, bituminous matrix or high-pressure compaction.
- Waste package: no voidage.
- Container: fire performance is considered only for the prescribed container type for LLW.
- Secondary waste: No acceptance requirements from SKB. It is more a strategy for the waste producers to optimise the generation of secondary waste.

Ukraine

- Final destination considered in the table: Engineered Near-Surface Disposal Facility (ENSDF) at the Vector site near Chornobyl (near-surface repository for LLW); in operation.
- Radiology:
  - Average and maximum limits per waste package exist for specific nuclides. There is also a maximum limit per waste package for the total activity.
  - Criteria also consider the homogeneity of the spatial distribution of radionuclides.
- Waste form: stability criteria take account of the effects of radiation and of thermal loads.
- Waste package: criteria on chemical compatibility, contents of chemically active components and corrosion resistance.
- Container: criteria also take account of mechanical loads (stacking, impact) and thermal loads (reflected in Table 8 as a tick against 'fire considerations').
- Requirements relating to the waste form matrix type and container type may be applicable, depending on whether they underpin the facility design.

United Kingdom

- Final destination considered in the table: the LLWR in Cumbria (near-surface repository for LLW); in operation. WAC for the facilities for VLLW disposal are not considered because of the very different nature of these landfill sites compared to the LLWR and, as mentioned previously, WAC for the LLWF are not publicly available.
- Radiology: maximum limits per waste package exist for specific groups of nuclides. There are also maximum limits per waste package for the total activity of alpha-emitters and the total activity of beta-emitters.

- Constituents:
  - Waste shall not contain materials that, in contact with air, water, grout or otherwise, generate or are capable of generating, toxic liquids, gases, vapours or fumes harmful to persons.
  - Liquid waste may be accepted for disposal, but only on a specific approval by the disposal operator, with justification provided.
  - Waste containing complexing or chelating agents is managed using the following categories:
    - Category 1: materials requiring control but not requiring allocation; the quantities of the materials must be recorded. These materials include carboxylic acids and inorganic compounds.
    - Category 2: materials requiring an allocation; these may be accepted for disposal subject to there being sufficient capacity at the LLWR. These materials include EDTA, DTPA and NTA.
  - There are also requirements to report and/or control quantities of materials that would result in the waste being categorised as Hazardous Waste under European Council Directive 91/689/EEC if it were not deemed to be radioactive waste, as well as materials regarded as Hazardous Substances or Non-Hazardous Pollutants, as defined by the Joint Agencies Groundwater Directive Advisory Group (JAGDAG). Some of these materials have a specified capacity at the LLWR, whilst others are managed by understanding the overall population of these wastes to determine whether specified capacities should be introduced.
  - The presence, physical form and quantity of asbestos and asbestos-containing products must be reported. Limits may be placed on the amount of asbestos within a waste consignment, depending on the form of the asbestos and its friability.
- Waste form:
  - Matrix: cementitious (through grouting) is standard.
  - Leaching test is required to ensure solidity of the waste form.
- Waste package:
  - Gas generation is controlled by limiting the surface area of reactive metals and the putrescible materials volume.
  - Voidage is limited (<20 v%).
  - Chemical compatibility: waste should not include corrosive materials unless treated, prepared or made safe by a method approved by the disposal operator.
- Container:
  - Stacking considerations are considered, but not explicitly addressed in the WAC.
  - Impact and fire performance are not explicitly considered.
- QA/QC: qualifications occur via the Waste Assurance Process.

5.2.2 Geological versus (near-)surface disposal: comparison of WAC for conditioned waste

Geological versus (near-)surface disposal: comparison of WAC for conditioned waste		**(Near-) surface disposal**		**Geological disposal**	
		France	UK	France	UK
Radiology	Nuclide inventory	√	√	√	-
	Total activity or activity concentration limits	√	√	-	√
	Criticality	√	√	√	√
Constituents	Physical hazards	√	√	√	√
	Chemotoxicity	√	√	√	√
	Reactive metals	√	√	√	√
	Complexing agents	√	√	√	√
	Putrescible/fermenting	√	√	√	√
	Biohazard	√	√	√	
Waste Form	Solid	√	√	√	√
	Matrix type(s)		√		
	Leaching	√	√	√	
	Porosity	√			
	Homogeneity	√			√
	Stability	√	√		
Waste package	Dose rate	√	√	-	√
	Surface contamination	√	√	√	√
	Voids (zero or small)	√	√	√	√
	Free liquids	√	√	√	√
	Thermal output		-	√	√
	Gas generation	√	√	√	√
	Chemical compatibility	√	√		√
Container	Prescribed type		√		-
	Stacking considerations	√	√	√	√
	Impact considerations	√		√	√
	Fire considerations	√		√	√
QA/QC	ID/data management	√	√	√	√
	Qualifications	√		√	
	Secondary waste		√		-

Table 9 – Geological versus (near-)surface disposal: comparison of WAC for conditioned waste. Symbols should be interpreted as for Table 8.

Observations / remarks by country

France

- Final destination considered in the table: Cigéo (geological repository for HLW and ILW); in development.
- The development of WAC for deep geological disposal has been, and continues to be, an iterative process. Preliminary disposal WAC have been drawn up, taking into account the waste package inventory as a basis for development of the geological disposal safety case. Concurrently, waste packages are produced against specifications approved by the regulator and must also fulfil the preliminary WAC.
- The properties of the waste form are an important input to the safety case for geological disposal, which draws on the framework and data of the national waste programme. This gives rise to requirements on the waste form (applied on a case-by-case basis).
- Activity content: no specific limitation.
- Constituents: no limitation, but quantities of certain materials must be declared (heavy metals, asbestos, chlorides, fluorides, sulfates, complexing agents, …).
- Waste form: the matrix should have limited leachability.
- Waste package/container:
    - Gas generation limit is focussed on hydrogen generation (explosion danger).
    - ILW and HLW: the mechanical properties of the packages disposed of in Cigéo should be maintained for 150 years (to allow for reversibility of disposal).
    - HLW: the designs for geological disposal envisage that containers of HLW (mainly vitrified waste) will be inserted into an overpack that should resist corrosion for several hundred years (at least until the waste has cooled down to 70°C).

United Kingdom

- Final destination considered in the table: generic packaging specifications for a GDF (geological repository) for HAW, as defined in Section 2.2.1; to be situated somewhere in England or Wales.
- Nuclide Inventory: there are no direct limits, since radioactive waste that cannot be accepted elsewhere requires geological disposal (at an, as yet, unknown site). There are indirect limits controlled through other factors (such as dose rates and the choice/design of transport and disposal containers).
- Activity content: controlled to comply with the radionuclide related assumptions that underpin the safety cases for transport and the GDF operational period.
- Constituents: Complexing agents should be minimised and not introduced during waste conditioning or packaging.
- Waste form:
    - Requirements for low heat generating waste (ILW and LLW) [34] are to:
        - Provide physical immobilisation (including minimising particulate material and excluding free liquids where possible). Waste that has not been immobilised / encapsulated can sometimes be accepted.
        - Provide suitable mechanical and physical properties (including minimising voidage and potentially detrimental heterogeneities).
        - Provide chemical containment.
        - Manage any hazardous materials by exclusion or use of pre-treatment and/or packaging so they are safe over all phases of the GDF.
        - Manage gas generation so it does not compromise the package integrity.
        - Provide a stable matrix over long timescales (considerations here include: heat output, shrinkage, corrosion, microbial activity and effects of radiation).
    - Waste packages containing HLW will generally be manufactured using highly robust waste containers such that the waste form will have a relative lesser role. Nevertheless, it still plays a key part in ensuring the passive safety and wider performance of the waste package [37].

- Waste package/container:
  - Criteria are based on Generic Waste Package Specifications.
  - The integrity of the waste container should be maintained for a period of 500 years.
  - There are limiting values for the release of radioactive gas (H-3, C-14, Rn-222).
- QA/QC: Waste owners are responsible for waste characterisation, treatment / conditioning and packaging. The waste packaging approach has to be approved by RWM.

5.3 Analysis and conclusions

Observed commonalities are that WAC for LLW devote a lot of attention to radiological characteristics (nuclide activities) and properties (dose rate, surface contamination), but less to physical, chemical, biochemical and biological characteristics or properties. Nevertheless, the WAC of most countries address physical hazards (explosion, fire, …), putrescible materials, waste form stability, voidage, free liquids and prescribe the use of a certain type of container (or containers). Organic and reactive wastes that have the potential to produce gas, complexants and/or free liquids as they degrade generally require treatment to convert them to a more passively safe form prior to conditioning and packaging, particularly where WAC preclude their acceptance for storage and/or disposal.

For geological disposal, long-term safety mainly relies on the host rock as a barrier. Nevertheless, WAC for HLW and ILW still set out specific requirements and/or values for the integrity of the waste package, container and waste form under disposal conditions, reflecting the assignment of long-term safety functions to these barriers as well. The applicable WAC are currently preliminary (France) or generic (UK) and are therefore expected to be developed further before geological disposal is implemented.

The heat output, which is a specific characteristic of HLW, appears to be controlled through the design of the waste package and the repository rather than through WAC.

6. Analysis of responses to Question 9 of ROUTES questionnaire

6.1 Approach to review national responses

Question 9 from the ROUTES questionnaire is as follows.

Q9: For each of the WAC described above, please explain how compliance with these is determined.
• *What methods for characterisation are implemented to determine compliance?* • *Who has responsibility for applying WAC, reporting how WAC are met, and for compliance verification? Also, who is responsible for the qualification of processes that are employed (such as characterisation, treatment / conditioning, pre-fabrication of e.g. waste containers, …)?* • *Are there any areas where it is difficult to measure or determine compliance?*

As for the responses to Question 6 (see Section 3), most of the national responses concerning the means for checking compliance with WAC refer to *radioactive wastes that are suitable for disposal in near-surface facilities*.

Table 10 summarises responses related to the methods used in EU countries to check the compliance of conditioned waste to WAC for storage/disposal facilities.

In Table 11, the responsibilities for applying WAC for storage/disposal facilities, reporting how WAC are met, and for compliance verification in EU countries are indicated.

The various difficulties encountered in determining compliance with WAC for storage / disposal are summarised in Table 12.

In these tables, a tick (**√**) means that the entry is mentioned in the country's response to Question 9, while a dash means that the entry is explicitly noted as not being included / relevant. Blank cells indicate aspects that are probably not relevant, but this has not been explicitly confirmed.

Notable observations and points of context are recorded by country (where relevant) after each table, followed by remarks that are commonly applicable. For more details, the full national responses to the ROUTES questionnaire can be consulted; as discussed earlier, these have been compiled in a consolidated report [5].

6.2 Summary of responses

6.2.1 Characterisation methods implemented to determine compliance

Methods used to check the compliance of the waste packages with WAC for storage/disposal	Austria	Belgium	Bulgaria	Czechia	Cyprus	Denmark	France	Germany	Greece	Hungary	Lithuania	The Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Ukraine	United Kingdom
Dose rate	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Physical inspection	√	√		√					√		√	√			√	√	√	√		√	√
Gamma spectrometry	√	√	√	√	√	-	√	√	√	√	√	√		√	√	√	√	√	√	√	
Scaling factors		√		√			√	√		√	√	-				√	√	√	√	√	
Dose to Bq method		√							√		√	√				√	√	√			
Destructive chemical and radiochemical analysis		√	√				√				√	-				√		√		√	
Gas generation & identification of gas generated			√				√					-								√	
Fall (drop) tests				√			√					√				√					√
Characterisation data covering the entire lifecycle of the radioactive waste (e.g. to understand waste inventory, or in relation to process control of predisposal activities)	√			√								√			√		√	√		√	
Leaching tests				√			√				√	√				√		√		√	√

√ responsibility indicated in the country's response

\- not used

Table 10 – Methods used in EU countries to determine compliance of waste packages with WAC for storage / disposal facilities.

Observations / remarks by country

Austria

- For raw waste:
  - Gamma spectrometry: for solid waste 10% of the incoming waste is checked, for liquid waste 100% of the waste is sampled and measured.
  - Dose rate measurements and swipe tests are carried out.
  - Flammability tests, LSC measurements and chemical oxygen demand can be performed if needed.

- For conditioned waste:
    - Characterisation data covering the entire lifecycle of the radioactive waste are required by NES to assemble the obligatory documentation for interim storage for each drum.
    - At the end of the conditioning process (prior to placing the drums in storage) a gamma assay is performed on each finished drum and cross-checked against characterisation data from other sources.
    - Checks are conducted by NES for each drum using the 4-eyes principle (by two persons from different departments).

Belgium

- Methods indicated are for conditioned waste.
- The radionuclides inventories (Bq) are derived from dose rate measurements and the application of a nuclide vector specific to each waste stream – *so called dose to Bq method*.
- Physical/chemical properties are derived based on general knowledge of the waste, supported (if needed) by physical inspections.
- If needed, radiochemical analysis is performed to identify specific materials or chemical species.

Bulgaria

- Various characterisation methods are specified (i.e. spectrometry for determination of radionuclides for inventory and total activity; radiometry, radiochemical analysis, volumetry, chemical analysis and chromatography for detection of gas generation and Identification of the gas, etc), which are applied to both conditioned waste and raw waste.

Cyprus

- There are no formal WAC against which to determine compliance.
- Characterisation involves external gamma dosimetry and inventory estimations based on the amounts of waste to be disposed of and its physical properties.
- In the case of a legacy waste (phosphogypsum), gamma spectrometry, radon emanation and alpha-spectroscopic measurements have been conducted to determine radiological characteristics.

Czechia

- Common radiological methods are used to check compliance with WAC.

Denmark

- Dekom is both a waste producer and responsible for waste handling. Consequently, compliance with WAC is ensured at the stage of handling and waste packaging.
- A Dekom Waste Coordinator discusses a proposed waste packaging approach with the relevant project team before and during packaging activities to ensure an appropriate approach is applied that will meet storage WAC. Once packaging is complete, compliance with WAC is checked by dose rate measurements.

France

- *Methods used for CIRES*:
    - Leaching test for toxic elements.
    - Punctual invasive tests: visual inventory, gamma spectrometry.
- *Methods used for CSA:*
    - Tritium gas measurement.
    - Leaching tests.
    - Homogeneity of the matrix.
    - Fall (drop) tests.
    - Punctual destructive & non-destructive analyses: visual inventory, spectrometry.

Germany

- Elemental composition and radionuclide vectors are determined through chemical and radiochemical characterisation.
- Methods used have to be described and need a permit by the relevant authority or BGE.

Greece

- The methods used at present (prior to refurbishment and reconstruction of the NCSRD interim storage facility) include: dose rate measurements, gamma spectrometry (destructive and in-situ), and dose to Bq methods for the characterisation of disused radioactive sources.

Hungary

- Gamma scanning and a scaling factor method are used for checking the conditioned waste.

Lithuania

- VLLW: Gamma spectrometry on 1 m^3 bales, 1 m^3 Flexible Intermediate Bulk Containers (FIBCs) (including high density waste) and half-height iso-freight (HH-ISO) containers.
- LLW: Gamma spectrometry on 200-litre drums and solid radioactive waste (SRW) items (piece by piece); dose rate measurement on concrete containers.
- ILW: Dose to Becquerel methodology (dose rates are measured and, based on the nuclide vector for a specific waste stream, activities of the radionuclides, in Bq, are derived).

The Netherlands

- Dose rate measurements and physical inspections are carried out on all packages stored by COVRA.
- Random checks of characterisation data provided by the customer (including application of the dose to Bq method) are conducted, including tests using gamma spectrometry.
- Drop tests are conducted as part of certifying container types for use.
- Leaching tests on waste form grout formulations are conducted as part of developing and certifying them for use. Tests are only repeated if grouting is applied to a new type of waste.

Poland

- For checking the compliance with WAC for storage and disposal facilities, only radiometric method (dose measurement) is used.

Portugal

- All the waste received at the waste management facility is checked by gamma spectrometry and dose rate measurement.

Romania

- Visual inspection.
- Random dose rate measurements.
- In situ gamma spectrometry if needed.
- Compliance with limits on the content of alpha and beta emitters is checked based on the conformity data sheet for each waste drum.

Slovakia

- QA/QC methods employed to check compliance with WAC include:
    - Visual inspection.
    - Dose rate measurements
    - Gamma spectrometry.
    - Leaching tests.

- Compliance with limits on the content of alpha and beta emitters is checked based on the conformity data sheet for each waste drum.
- Scaling factors are derived for each waste stream produced.
- Drop tests of fibre-reinforced concrete containers (VBK) were conducted prior to licensing them for use.

Slovenia

- All LLW and ILW to be disposed of in the Vrbina facility will be treated, conditioned and packaged at the NPP site prior to transport to the disposal facility. On receipt at the disposal site, responsibility for the waste packages will transfer to the WMO. The following will be checked:
    - All WAC as defined for waste packages at the NPP site.
    - Control of the waste package specification (WPS), which defines requirements as set out in WAC, and the waste package datasheet (WPDS), which assures fulfilment of the WPS by:
        - Examination of the container design and comparison to design specifications.
        - Manufacturing controls (fabrication inspections and controls).
        - Test and control measures during waste conditioning (in-process control).
        - Tests or controls on the waste packages.
- The WPDS includes the following data:
    - Waste package identification:
        - Identification number.
        - Category (class).
        - Radioactive waste type.
        - Specification (WPS) number.
    - Waste package characterisation:
        - Waste stream / raw waste.
        - Treatment / procedure.
        - Conditioning / procedure.
        - Container type / specification.
        - Container serial number.
        - Immobilisation material.
        - Package content: waste form identification; waste form description.
    - Waste package properties:
        - Mass (weight): gross and net.
        - Void (%) – estimation prior to backfill/grouting and after completing backfill/grouting.
        - Dose rate: contact and at 1 m.
        - Surface contamination: alpha and beta/gamma.
    - Waste package history:
        - Date of treatment.
        - Date of conditioning.
        - Date of storage (start / end).
        - Storage location.
        - Date of loading into overpack.
        - Overpack type.
        - Overpack identification number.
    - Waste package quality control:
        - Dose rate.
        - Waste package specification conformity.
        - Date of quality control.

          Conformance with WPS, or if not: reason(s) for non-conformance; compensatory actions and their approval.

  - Isotope content:
    - Gamma-emitting nuclides (result, with measurement protocol attached).
    - Beta-emitting nuclides (measured/calculated, result and correlation nuclide and vector used, with measurement protocol attached).
    - Alpha-emitting nuclides (measured or calculated).
    - Specific activity content (average and variation).
    - Nuclide vector(s).
- The WMO controls the WPDS and notifies the nuclear and radiation authority regularly on waste package compliance.

Spain

- Dose rate and surface contamination measurements are performed prior to transportation to El Cabril repository.
- A gamma scanner is used at the repository.
- Gamma scanning is also used on NPP sites when dismantling containers.
- Dose to Curie method is applied at NPP.
- Gamma camera to perform simple tomography of large pieces.
- *For raw waste:*
  - scaling factors are derived at each production waste stream of each NPP.
  - QC/QA of the immobilisation process for selection of the appropriate mortar formulation in order to fulfil the WAC.

Sweden

- Before conditioning water samples are taken and the transuranic inventory is measured.
- After conditioning dose rate and gamma spectrometry measurements are taken.

Ukraine

- Radiometry, radiochemical analysis, physical inspection, spectrometry for determination of radionuclide inventory and total activity; volumetry, chromatographic analysis, chemical analysis for detection of gas generation, and leaching tests are all employed to determine compliance.
- Most of these methods are applied, where needed, to both raw and conditioned wastes, but some approaches (e.g. the use of scaling factors) can only be applied for raw wastes, whilst destructive analysis is only applied to conditioned waste.

United Kingdom

- The following are required to check compliance with WAC for the LLWR:
  - Sampling and sample analysis.
  - Derivation of a waste fingerprint.
  - Categorisation of the waste.
  - Radioactivity measurements, including determining the amount of certain radionuclides. The characterisation techniques to be used are not prescribed.

6.2.2 Responsibilities relating to WAC application

Country	Responsible for applying WAC			Responsible for compliance verification			Responsible for reporting to regulator how the WAC are met		Responsible for qualification of the employed processes			
	Waste package producer	Storage / disposal facility operator	WMO	Storage / disposal facility operator	WMO	Regulator	Storage / disposal facility operator	WMO	Waste package producer	Storage / disposal facility operator	WMO	Regulator
AT		√		√				√			√	√
BE	√	√			√		N/A				√	
BG	√	√		√			√		√	√		
CZ	√	√	√		√		√	√		√	√	
DK	√	√	√	√			not mentioned					
FR	√			√	√	√	√		√	√	√	√
DE	√				√			√	√			
GR		√		√			√			√		
HU	√		√		√			√			√	
LT	√	√		√		√		√	√	√		
NL	√			√	√			√				
PL			√		√			√				
PT	√		√		√	√		√			√	√
RO	√			√			√		√			√
SK	√	√	√		√	√	√	√	√			
SI	√	√	√	√	√	√	√	√	√	√	√	
ES	√		√	√			√			√	√	
SE	√				√			√				
UA	√			√			√		√	√		
UK		√		√			√			√		

Table 11 – Responsibilities relating to WAC application in EU countries.

<u>Observations / remarks by country</u>

Austria

- The head of the interim storage facility, which is a staff position within the WMO (NES) is indicated as the responsible person.
- The head of the interim storage facility is responsible for applying WAC, for compliance verification and also for reporting to the regulator (annually) on how WAC are met.
- The 4-eyes principle is observed, meaning that both the storage facility manager and a representative from the WMO department are involved, and both have to sign-off compliance checks.

- The process employed (and its qualification) is developed by NES and approved by the regulator.

Belgium

- The waste producer is responsible for applying WAC to NCW; the waste conditioner (waste package producer) is responsible for applying WAC to CW.
- Compliance with WAC is verified by the WMO (ONDRAF/NIRAS).
- Reporting how WAC are met to the regulator is not currently required.

Bulgaria

- The operator of a conditioning / storage facility is responsible for WAC implementation, compliance verification and reporting of compliance with the WAC.
- The regulator approves WAC and performs compliance verification via inspections, analysis of the operator's documentation, and other documentation.

Cyprus

- The Radiation Protection Section of the Department of Labour Inspection would be the responsible authority if WAC were in place.

Czechia

- SURAO (the Czech WMO) is responsible for applying WAC, and for recording and reporting how WAC are met.
- The waste producers are responsible for characterisation, treatment and conditioning the waste into a form suitable for disposal.
- SURAO applies controls on how WAC are met by the waste producers.

Denmark

- In most cases, Dekom is the waste producer as well as the storage facility operator and WMO. It is therefore responsible for applying storage WAC and for compliance verification.
- For the 6-8 m^3 waste received from external users each year, Dekom is responsible for packaging the waste and thus also for applying WAC (and compliance verification).

France

- The French regulator (ASN) requires that the licensee of a disposal facility defines and implements acceptance provisions for waste packages intended for disposal in its facility. These must include procedures for inspection and management of received waste packages, as well as conditions for the management of packages that would be non-compliant with the acceptance criteria [38].
- The licensee of a disposal facility is required to draw up an annual report to ASN describing approvals against WAC that are in force, being processed or suspended, along with any exemptions granted to acceptance criteria and justifications of compliance.
- Waste packagers are required to send ASN a report on the production of radioactive waste packages intended for disposal and management of any deviations detected. A copy of this report is sent to the licensee of the disposal facility to which the waste packages are intended for consignment and to Andra, which then have a period of six months in which to notify ASN of their opinions. Conditioning approval is issued by ASN.

Germany

- In Germany, waste producers are not the same as waste package producers. Responsibility for applying WAC rests with the waste producer (or waste owner, in cases where ownership has been transferred to the state). Waste package producers are typically companies that treat and condition waste, but they are not responsible for applying WAC, only for carrying out the relevant process(es).

- The producers of wastes with negligible heat generation are obliged to declare the radionuclide inventory and chemical composition of waste, and to provide a plan for the treatment, conditioning and packaging of wastes to BGE (the WMO).
- BGE as the implementor and operator of geological disposal facilities supervises every step of the waste management process. If a waste producer's plan is approved by BGE, BGE then sub-contracts the supervision of the process on site to an independent expert company (TSO), like Technischer Überwachungsverein (TÜV) or Produktkontrollstelle (PKS).
- Once waste packaging is complete, the TSO provides its report (documentation of the process) to BGE, at which point, a decision about the disposability of the waste is made (by BGE).
- BGE then requests approval from NLWKN (Niedersächsische Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz, in English: Lower Saxony state company for water management). Upon approval of NLWKN, the conditioned and packaged waste can be transferred to Konrad (which is planned to be operational in 2027).
- Such decisions have to be made about every single waste package and documentation about the waste packages has to be stored by BGE indefinitely.
- Procedures with respect to heat-generating wastes have not been established to date.

Greece

- At the NCSRD interim storage facility, the facility operator is responsible for all aspects of applying WAC.

Hungary

- In the case of NPP operational waste, the NPP operator is responsible for compliance with WAC for acceptance to the NRWR.
- In the case of institutional waste, the waste producer is responsible for compliance with WAC for storage and/or disposal.

Lithuania

- Both waste producers and disposal facility operators are responsible for packaging waste for disposal (since some packages are grouted at disposal facilities). These parties are also responsible for qualifying the processes employed.
- The WMO (IAE) is responsible for checking how waste packages are produced, including independent verification of waste package compliance with WAC. This role is performed by the waste package checking group, which is part of the disposal facilities division.
- The regulator (VATESI) performs periodic inspections on waste package production to ensure compliance with WAC.

The Netherlands

- Waste producers (customers) are responsible for applying COVRA's storage WAC and providing data / information about the waste to demonstrate compliance (e.g. nuclide inventory; total activity; fissile material content; waste physical/chemical characteristics).
- Random checks are carried out by COVRA to confirm compliance.

Portugal

- The WMO is responsible for applying requirements analogous to WAC (together with the waste package producer), and for compliance verification and qualification of the employed processes (together with the regulator). The WMO is also responsible for reporting to the regulator how WAC are met.

Romania

- The disposal operator (IFIN-HH) reports annually to the regulator about the activities carried out including any cases of non-compliance with WAC.
- Reporting on how the WAC are met is not currently done.
- Regulator can check compliance with WAC during regular inspections.

Slovakia

- Qualification requirements on processes are specified in the operating rules of those installations intended for waste characterisation, treatment / conditioning and pre-fabrication of waste containers.
- The licence holder is responsible for developing these operating rules.
- NPP operators are responsible for fulfilling WAC for radioactive waste pre-treatment. The WMO (JAVYS) operates waste treatment, storage and disposal facilities and is therefore responsible for fulfilling WAC for radioactive waste treatment and disposal.

Slovenia

- In general, the waste producer is responsible for applying WAC to the waste it generates. In the case of small producers, this responsibility can be transferred to ARAO (the WMO). Responsibilities for waste characterisation can also be delegated to other organisations. There should always be a clear allocation of responsibility.
- More specifically, the distribution of responsibilities below is typically applied to cover all aspects of waste management and ensure compliance of waste packages with the WPS.
- The waste producer is responsible for:
    - Collection and segregation of the waste.
    - Characterisation and categorisation of the waste.
    - Treatment and conditioning of waste, observing interdependencies in waste management steps to respect WAC for storage and disposal.
    - Definition and recording of information on radiological, chemical, physical, mechanical, biological and thermal properties of the waste.
    - Record keeping and quality assurance of data.
    - Storage of waste packages in accordance with the requirements of operating procedures established and justified based on the Safety Analysis Report for a specific storage facility.
    - Transfer and hand-over of waste and related documentation to the operator of a downstream facility (e.g. conditioning plant) or to ARAO.
- The operator of a facility for final conditioning of waste is responsible for:
    - Receipt of disposal containers from the manufacturing plant and receipt of radioactive waste packages from waste producers and ARAO, including checking the completeness of documentation on waste / container characteristics.
    - Final conditioning of the waste in compliance with the WPS to meet WAC for disposal in the specified repository.
    - Record keeping and quality assurance of data on characteristics of the resulting disposal waste package.
    - Transfer and hand-over of the disposal waste package and related documentation to the repository operator.
- The repository operator is responsible for:
    - Implementation of a disposal package receipt procedure (i.e. checking compliance with disposal WAC).
    - Disposal of packages.
    - Record keeping on already disposed waste.
    - Notifications to the regulator on disposed waste.

Spain

- The operators of NPPs and other nuclear facilities performing waste conditioning (e.g. El Cabril and CIEMAT) are responsible (as mandatory) for fulfilling the WAC for disposal.
- ENRESA as the WMO is responsible for applying the WAC.
- As the operator of the El Cabril repository, ENRESA is responsible for compliance verification for both:
    - Waste conditioning performed by CIEMAT and the NPP operators.
    - 'Special' conditioning performed at El Cabril (e.g. for some VLLW, biological waste, combustible waste,…).
- ENRESA reports data on compliance verification to the regulator (CSN).
- ENRESA is also responsible for the qualification of processes from waste generation to disposal. This control ensures the absence of organic wastes, which are incinerated, with the resulting ashes encapsulated in mortar to produce a solid, monolithic waste form.

Sweden

- The WMO (SKB) is responsible for the WAC process.
- Waste producers are responsible for applying WAC. SKB is responsible for repository long-term safety and transportation.
- All WAC-documents are reported to the safety authority (SSM) before they can be applied. A waste type description must comply with the WAC and must be approved by the authority before any waste according to that particular waste type description can be disposed of.
- Reporting on how WAC are met is not conducted unless a mistake is discovered concerning compliance. In such cases, the responsibility for further action is placed on SKB if the mistake is discovered after disposal; otherwise it is placed on the facility operator.

Ukraine

- The radioactive waste supplier / generator is responsible for applying WAC.
- The operator of a radioactive waste management facility that receives radioactive waste is responsible for compliance verification and reporting how WAC are met.
- The regulator agrees WAC and performs compliance verification by inspections, analysis of operator's documentation, etc.
- The operator of a radioactive waste disposal facility can perform both control on supplier's site (process control) and control of radioactive waste packages upon arrival at the disposal site (visual, destructive, non-destructive control).

United Kingdom

- LLW Repository Ltd, as operator of the LLWR has responsibility for applying WAC and for compliance verification.
- LLW Repository Ltd also acts on behalf of the NDA to oversee the National Waste Programme (NWP), ensuring that lower activity waste is managed effectively across the UK. The NWP team promotes the use of alternative waste management routes to disposal at the LLWR.
- LLW Repository Ltd submits an annual review to the Environment Agency, the environmental regulator for activities at the LLWR, covering matters that are relevant to the ESC, including any mis-consignments. Issues such as omissions from waste consignment information are resolved between the waste producer and LLW Repository Ltd and are not included in this reporting.
- For non-standard wastes, a disposability assessment is made against the WAC and this is reported to the Environment Agency by LLW Repository Ltd's ESC team.

6.2.3 Areas where it is difficult to measure or determine compliance

	Austria	Belgium	Bulgaria	Cyprus	Czechia	Denmark	France	Germany	Greece	Hungary	Lithuania	The Netherlands	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	Ukraine	United Kingdom
The masses of specific materials or chemical / toxic species in the waste		√			√		√			√	√	√			√	√		√	√		
Characterisation of challenging wastes, such as legacy wastes or heterogeneous wastes			√	√	√	√	√	√	√	√	√	√		√		√		√		√	
Measurement of difficult to measure radionuclides			√		√		√		√					√		√	√			√	
Reference radiological spectra & scaling factors					√		√		√							√	√				
Sample representativeness							√		√								√	√			
Dust content, void space volume										√							√	√			
Gas formation																	√	√	√		
Inaccessible voids before grouting																		√			√
Inclusion of high activity (discrete) items in a large volume of low activity items giving an acceptable overall average over the consignment																					√

Table 12 – Overview of responses with respect to difficulties to determine the compliance with WAC in EU countries.

Observations / remarks by country

Austria

- No areas of difficulties have been encountered, largely due to the procedure followed to examine both original waste data records and data from reconditioning work to determine compliance.

Belgium

- It is difficult to measure the masses of specific materials or chemical species in the waste (e.g. chloride ions, sulphate ions, cellulose).
- It is difficult to deal with the peripheral conditions of tests related to alkali-silica reactions (ASR) and delayed ettringite formation (DEF) (e.g. long testing times, heterogeneity of the concrete rubble, …).

Bulgaria

- Identification of difficult-to-measure radionuclides.
- Characterisation of legacy waste, and other challenging wastes, in particular on suppliers' sites.

Cyprus

- Legacy radioactive waste (e.g. phosphogypsum) is difficult to characterise, although compliance with WAC is not relevant, since there are no formal WAC in place.

Czechia

- It is difficult to determine the potential content of free liquids in heterogeneous conditioned waste.

Denmark

- For waste received from external users, data on radionuclide activities are provided by the external user. Dekom personnel package the waste and note the material composition during packaging and registration for storage. Radionuclide activities are not checked by Dekom.
- For decommissioning wastes, characterisation is most often conducted by analysing samples or by calculation of activities based on scaling factors. A rough description of materials in the waste has to be provided during registration (by placing tick-marks in check boxes).

France

- As difficulties, the following were specified:
  - Measurement of toxic compounds.
  - Measurement of hardly measurable radionuclides (i.e. ^{36}Cl, ^{94}Nb).
  - Reference radiological spectra & scaling factors.
  - Sample representativeness and reproducibility.

Germany

- Characterisation of heterogeneous wastes.
- Characterisation of wastes to be retrieved from Asse mine - there is no identification on the drums to allocate some information still existing from the emplacement of the drums and there is no specific procedure implemented to characterise this waste in a non-destructive way.

Greece

- For the characterisation of legacy wastes, additional sampling is performed to determine the presence and quantity of difficult to measure radionuclides.

Hungary

- Dust content, void space volume and composition are reported to be areas where it is difficult to determine compliance.

Lithuania

- The masses of specific materials or chemical / toxic species present in waste packages are difficult to check and to verify. Checking focuses on periodic inspection of packaging processes to ensure that they are well organised and that packages are produced in accordance with WAC.
- Characterisation of challenging legacy wastes is already conducted. However, some problems with characterisation are anticipated when conducting planned retrievals of radioactive waste from a RADON type facility (an upcoming decommissioning project).
- Nuclide vectors are used as the main method for waste characterisation. This can lead to some differences in results when other methods for waste package verification (for example at the NSR for LLW) are used, mainly due to differences in the methodology for establishing the radionuclide composition.

- Not all difficult to measure radionuclides can be measured.

The Netherlands

- Most characterisation information is gathered during waste generation.
- Legacy waste characterisation is difficult as little or no information is available; opening the waste packages leads to exposure risks.
- Chemical/physical substances in the waste that cause a very slow degradation of the package are difficult to measure.

Poland

- No areas of difficulties have been specified since only radiological methods are used for checking the WAC compliance.

Portugal

- Difficulties in characterisation of historical waste.

Romania

- Difficult to measure the masses of specific materials or chemical species in the waste (substances considered hazardous).
- Difficult to measure radionuclides.

Slovakia

- Measurement of hardly detectable radionuclides, especially when heterogeneously scattered in metallic materials.
- Lack of information regarding NPP A1 mainly in terms of radionuclide inventory in activated waste: legacy wastes, graphite, activated and/or contaminated concrete; some components are hardly accessible; therefore, it is difficult to measure or determine compliance.

Slovenia

- Chemical content of the waste and identification of difficult to measure radionuclides.
- For decommissioning waste uncertainties are associated with both activity and volume and further calculations should be performed.

Spain

- Difficulties are encountered in relation to:
  - Determining the masses of specific materials or chemical / toxic species in the waste.
  - Characterisation of challenging wastes, such as legacy wastes or heterogeneous wastes.
  - Sample representativeness.
  - Determining the dust content and void space volume in the waste.
  - Understanding Gas formation.
  - Identifying inaccessible voids before grouting.

Sweden

- The amount of complexants in waste.
- Gas formation.

Ukraine

- Difficult-to-measure radionuclides.
- Difficulties with waste characterisation on supplier's sites (e.g. legacy waste, "Radon" facilities, etc.).

United Kingdom

- The amount of inaccessible voidage before grouting.
- The inclusion of high activity (discrete) items in a large volume of low activity items giving an acceptable overall average over the consignment.

6.3 Analysis & conclusions

The methods used to verify compliance with WAC are quite different among EU countries: from simple radiometric measurements (such as dose rate measurements) to more involved methods such as chemical analysis and chromatography for detection of gas generation and identification of the gas. Both non-destructive methods, such as physical inspection, radiometric measurements, or gamma spectrometry, and destructive methods, such as radiochemical analysis, are used to check waste package compliance with WAC either for storage or for disposal.

Dose rate measurement is the most widely used radiometric method for checking compliance of waste packages with WAC (Austria, Belgium, Bulgaria, Lithuania, Poland, Romania, Spain and Sweden). In some countries, specific nuclide vector / scaling factors (Belgium, France, Germany, Hungary, Lithuania) or the dose to Becquerel methodology (Belgium, Lithuania, Spain) complement dose rate measurements to derive radionuclide activities. It is noted that these methods require good knowledge of the origin and/or history of the waste, which can be problematic for legacy wastes.

Measurement of the masses for specific materials or chemical / toxic species in the waste, characterisation of challenging wastes, such as legacy wastes or heterogeneous wastes, and measurement of difficult to measure radionuclides are indicated as the biggest difficulties for checking waste package compliance with WAC.

The detailed roles of different parties during application of WAC and compliance verification vary from country to country. It is important to recognise that Table 11 provides a generalised summary of roles associated with WAC, but there are distinct nuances in the responsibilities applicable in each country that are not always apparent from simply inspecting this table. In some countries, a single organisation fulfils several of the roles captured in Table 11 (e.g. different divisions of ONDRAF/NIRAS in Belgium, and Andra in France, act as facility operator and WMO). Often, several organisations (or representatives of different divisions within a single organisation) are responsible for specific compliance activities. Such cross-over can help to ensure that any non-compliances are identified.

The national safety authority (regulator) is generally responsible for approving the framework within which waste management activities are carried out. However, this does not always explicitly include a role in the development and/or application of WAC, nor in the selection or qualification of approaches to determine compliance.

7. Analysis of responses to Question 10 of ROUTES questionnaire

7.1 Approach to review national responses

Question 10 from the ROUTES questionnaire is as follows.

Q10: What is the standard response when a non-compliance with one or more WAC is detected by the waste management authority, the waste producer, the site operator (for operational facilities) or the regulator?

The potential non-compliances occurring in different waste management steps are diverse and are treated differently for conditioned radioactive waste (CRW) and non-conditioned radioactive waste (NCRW). Of course, the non-compliances can be more easily fixed and then the waste package re-evaluated in the case of NCRW.

7.2 Summary of responses

Austria

- The non-compliance has to be fixed and the waste package are then re-evaluated.

Belgium

- Non-compliances are treated differently, depending on who detects them:
    - *Detection by WMO* – depending on the non-compliance, a standard procedure within ONDRAF/NIRAS is followed, with four possible outcomes:
        - The waste is not acceptable - the waste holder has to physically modify the waste and make it compliant with the WAC.
        - The waste is acceptable, but on the basis of another WAC - a different management route is chosen for the future management of the waste.
        - The waste is acceptable under the condition that the waste holder can demonstrate that the non-compliance poses no threat to the safety and feasibility of the future management of the waste.
        - The waste is acceptable without the holder of the waste having to demonstrate that the non-compliance poses no threat to the safety and feasibility of the future management of the waste.
    - *Detection by the waste producer:* waste producer may provide the WMO with proof that the non-compliance poses no threat to the safety and feasibility of the future management of the waste.
    - *Detection by the facility operator:* same response as in the case of the waste producer.

Bulgaria

- The standard response should be return of the waste package to the radioactive waste producer.
- If return is not possible or in a questionable situation, a committee is created to identify the possible reasons for the non-compliance and how it should be addressed; it is recommended to adopt the decision if all members of the committee agree with the decision's correctness.

Cyprus

- When a non-compliance with generic requirements is detected the affected parties are informed and form an ad hoc committee to handle and address the non-conformity.

Czech Republic

- SURAO controls the mechanisms and methods of waste conditioning employed by the waste producers.
- The waste producer is responsible for characterisation of waste and for treating and conditioning the waste into a form suitable for disposal. SURAO oversees each waste package during the acceptance process to determine how the relevant WAC have been met.
- In the event that any waste package exceeds limits specified in the WAC, the package is not accepted for disposal and the regulatory body (SURO) is informed.
- A decision is then taken on whether the package must be re-conditioned (by the waste producer) or, in certain well-founded cases, whether the waste package can be stored or disposed of under certain conditions.

Denmark

- The specific non-compliance is discussed between the decommissioning project and the waste handling team. A practical solution is then agreed upon before commencing / continuing packaging.

France

- Detection at the producer's facility - remediation actions are taken to eliminate the non-compliance; if this is not possible, waste packages are stored at the production facility and eventually repackaged.
- Detection at the disposal site:
  - Non-acceptance of waste package at the disposal site - Potentially return the package back to waste producer's site; temporary suspension of the waste producer's agreement to consign waste to the site could be possible.
  - If packages are already disposed of in the vault - an impact assessment is made in order to check if the consequences on safety are acceptable.

Germany

- Waste has to be treated until it is compliant with WAC; otherwise, the wastes can be stored until the alternative disposal site is licensed.

Greece

- When dose rate criteria are not met, additional shielding is provided.
- When surface contamination on a waste container exceeds limits specified in the WAC then decontamination is carried out.
- In the event that a spent radioactive source were found to be leaking then additional containment is foreseen.

Hungary

- In the case of detection on the waste producer site: the package is not sent to disposal until the non-compliance is solved.
- In the case of detection on the WMO site (by the disposal operator):
  - over-packing – if this can solve the non-compliance.
  - shipped back to the producer - if it cannot be over-packed.

Lithuania

- Non-compliances with WAC are reported to the regulator.
- If the non-compliance is detected on a storage / disposal site, the waste package is returned to the producer. If that is not possible or in questionable situations, a committee is established, with participation of the responsible persons from the disposal facility, the operator, the WMO waste package checking group and other department representatives (e.g. quality assurance

department). A decision is adopted if all members of the committee agree with the decision's correctness.

- In case of disagreement between the participating committee members, decision-making will be done at the highest level, by involving the regulator in the final decision-making process. All problematic questions are periodically (once per quarter) discussed between the WMO (IAE) and the regulator (VATESI).

The Netherlands

- If the non-compliance is detected on the waste supplier's premises then they have to make corrective measures.
- For non-compliances detected on COVRA premises, COVRA sends an invoice of extra work done to resolve the non-compliance.

Poland

- Non-compliant waste packages are not accepted for storage / disposal at the KSOP radioactive waste repository.
- Since the responsibility for the form of the waste (its processing, conditioning, and preparation for transport to the repository) rests with the WMO (ZUOP), this organisation is responsible for resolving all storage problems.
- Any issues concerning the content and characteristics of waste received from the waste producers are addressed on receipt of the waste by ZUOP.

Portugal

- The Competent Authority (regulator) is informed of any non-compliance. The WMO then acts in accordance with the regulatory decision on how to respond.

Romania

- For raw waste: transfer of waste that is non-compliant with WAC for treatment / conditioning is refused.
- For the waste packages sent for disposal at Baita Bihor: if a non-compliance is detected, a non-compliance report is issued and the waste package is returned to the waste package producer.

Slovakia

- If the non-compliance is detected by the regulatory body during inspection:
    - A protocol from inspection is issued and sent to the licence holder, which is obliged to solve the identified non-compliance and to implement corrective actions as soon as possible.
    - In particularly serious cases, the regulatory body may withdraw the licence and thus stop operation of the nuclear installation. In addition, a fine might be imposed by the regulatory authority.
- If the non-compliance is detected by the operator of a nuclear facility then the procedure specified in the operating rules of the facility must be followed. In some cases, operation of the affected nuclear installation would need to be interrupted until corrective actions are taken.
- Non-compliant waste packages are not accepted for disposal in the Mochovce repository.

Slovenia

- The operators of radioactive waste and SNF facilities have to report the non-compliance to the regulator.
- The regulatory authority has several options in such cases:
    - Issue decisions and orders within the framework of administrative proceedings.

- Order measures for radiation protection and measures for radiation and nuclear safety to ensure that the licensee fulfils all legal requirements regarding safety.
- Order the termination of a radiation practice or use of a radiation source where the inspector finds that a proper licence has not been issued or if there is a failure in following the prescribed methods for handling the radiation source or radioactive waste; an appeal against such a decision of an inspector shall not hinder its execution.
- Seal any radiological device which does not meet the acceptance criteria for proper operation.

Spain

- There is a procedure that categorises non-compliances as a function of the involved WAC deviation, and also the way to solve them, if possible.
- A non-compliance form / sheet is produced and the non-compliance has to be tracked until the final solution is implemented.

Sweden

- The standard response is to perform an impact analysis to see what the consequences are to deposit the waste regarding long-term safety.

Ukraine

- For predisposal management:
  - For waste that does not meet the WAC, safe handling measures shall be defined and corrective actions shall be undertaken.
  - A non-compliance report is issued that includes a list of non-compliances.
- For disposal - procedures and arrangements specified in the disposal facility construction design include the following provisions for managing non-compliances:
  - Individual waste packages that do not comply with WAC are allowed to be disposed if it is proven that the safety of the disposal facility during operation, closure and post-closure is not affected; information regarding the inconsistencies found with individual accepted waste packages and relevant compensatory actions has to be maintained in the database of waste package records.
  - The disposal operator may return the non-compliant waste packages to the waste packages producer.

United Kingdom

- For non-compliance(s) detected before and after the waste packages have been accepted:
  - Any non-compliant wastes transferred to the disposal site is quarantined and may require collection by the waste producer in accordance with the relevant conditions in the Waste Services Contract between the operator of the disposal facility (LLW Repository Ltd) and the producer.
  - Treatment, re-packaging and/or return to the producer – is the responsibility of the operator of the disposal facility.
  - Waste producers have responsibility for ensuring that any returned waste is appropriately received and managed.
- For waste that has been accepted and is subsequently identified to be non-compliant, LLW Repository Ltd must inform the Environment Agency of the breach of any limits in the permit “without delay”.

7.3 Analysis and conclusions

Non-compliances can be detected by a range of different stakeholders including the WMO, waste producers, facility operator or the regulator. Belgium provided specific answers for the non-compliances detected by each of these stakeholders, except for the regulator, which is not presently involved in checking WAC compliance. In contrast, the answer given by Slovakia refers only to the situation of a non-compliance detected by the regulator during inspection. In this situation, the license holder is obliged to solve the identified non-compliance and to implement corrective actions as soon as possible and within the timeframe specified by the regulator. In particularly serious cases, the regulatory body may withdraw the license and thus stop operation of a nuclear installation.

In most cases, the waste is not accepted if a non-compliance with one or more WAC is detected. The waste package can generally be sent back to the waste producer for remediation actions to eliminate the non-compliance (Belgium, Bulgaria, France, Hungary, Lithuania, Poland, Romania, Ukraine, UK) if no means of remediation can be taken on the site where the non-compliance was detected. However, there are situations in which the waste package can be accepted without remediation (Belgium, France, Lithuania, Sweden, Ukraine) if the producer performs an impact analysis and demonstrates that the consequences regarding long-term safety are acceptable.

If the detected non-compliance cannot be remediated, the waste package can be stored at the producer facility and eventually repackaged / overpacked (France, Germany, Hungary). Furthermore, in France if a non-compliance is detected at the disposal site, the waste producer’s agreement to consign waste to that site can be temporarily suspended.

In Spain, there is a procedure categorising non-compliances as a function of the involved WAC deviation as well as the way to solve them, if possible. A non-compliance form / sheet is elaborated and the non-compliance has to be tracked until the final solution is implemented.

A particular situation is encountered in Bulgaria and Lithuania where, in the case of detecting a non-compliance when the waste package cannot be returned to its producer, or in questionable situations, a committee is created and the recommended decision is adopted if all members of this committee agree with decision correctness. In case of disagreement (in Lithuania, at least), the final decision rests with the regulator.

Also, a particular situation is met in Belgium, where in case of non-compliance detected by the WMO, the waste can be accepted but on the basis of another WAC and consequently choosing a different route for the future management of the waste.

In the case of Denmark, the same institution (Dekom) is both waste producer and WMO, and when a non-compliance is detected it is discussed and solved between the teams involved.

8. Waste Acceptance Criteria in other European countries

This section presents information on WAC in various European countries that did not provide national responses to the ROUTES questionnaire (either because they are not participating in EURAD or because they are not participating in ROUTES).

Five countries are discussed below: Croatia, Finland, Italy, Norway and Switzerland. In the case of Finland, Italy and Switzerland, some information on WAC is available in the public domain, drawn primarily from inputs provided to previous collaborative EC projects, notably THERAMIN and CHANCE and included in published deliverables from these projects [6,7]. Croatia and Norway are mentioned for completeness, since these countries will both have significant inventories of (non-institutional) radioactive waste requiring long-term management. However, no sources of information on WAC in these countries have been identified.

Other European countries are not discussed because they only have small inventories of radioactive waste, primarily from medical, industrial and research uses, and because no sources of information on associated WAC have been identified.

8.1 Croatia

Croatia shares responsibility for wastes arising from the Krsko NPP with Slovenia and has to manage one-half of the radioactive waste and spent fuel generated by this NPP. Other radioactive wastes are generated from medicine, industry, science and education [39].

Currently the radioactive waste and SNF generated by Krsko are stored on site, whilst the institutional waste is stored in two storage facilities that does not accept any more waste for storage. The national strategy foresees commencing of a Central National Storage Facility for institutional waste and a near-surface disposal facility for nuclear fuel cycle waste.

No information regarding WAC in Croatia was found in the National Report submitted in support of the Convention on Nuclear Safety, or in other public domain reports.

8.2 Finland

The information below is based on work conducted under the THERAMIN project [6].

In Finland, general guidance from the regulator (STUK) and from international organisations such as the IAEA and WENRA are applied. However, as LLW and ILW are mainly managed by waste producers, relatively little information about WAC is available in the open literature.

For WAC, national regulatory guidance reports YVL D.4 [40] and YVL D.5 [41] have to be applied for LLW and ILW; the former covers pre-disposal management of LLW and ILW and nuclear facility decommissioning, whilst the latter covers disposal of nuclear waste. However, it is difficult to set unambiguous acceptance criteria for all LLW and ILW due to waste type differences, handling technologies and disposal concepts (e.g. waste packages). Therefore, WAC for waste and waste packages have to be derived from the safety analysis report and from the safety case. The Final Safety Analysis Report (FSAR) shall include a description of each waste package category to be disposed of; such descriptions shall include at least:

- Waste type and conditioning specifications.
- Surface dose rate.
- Upper bounds for the activities of the most significant radionuclides.
- Average values of other properties relevant to safety, such as:
    - Mechanical strength.
    - Chemical durability.
    - Radionuclide release characteristics (leaching or diffusion rate).
    - Free liquid content.
    - Flammability.

- Swelling capacity.
- Gas generation potential.
- Concentrations of substances which may cause the waste package to degrade or decrease sorption in surrounding media.

8.3 Italy

The information below is drawn from work conducted under the CHANCE project [7].

Radioactive waste is classified into three categories on the basis of its isotopic characteristics and concentrations, and considering the possible options for final disposal as the main guiding criteria:

- Category I: waste that decays in a few months to radioactivity levels below safety concerns (mainly hospital and research waste with a half-life of less than one year).
- Category II: waste which decays to radioactivity levels of a few hundreds of Bq/g within a few centuries.
- Category III: long-lived waste not included in Category I and II; HLW from reprocessing of SNF and alpha emitting waste from the fuel cycle and R&D activities.

Since the site for the National Repository has not yet been selected and WAC are site-dependent, only an indication on the activity concentration and specific heat power are included in the current, preliminary WAC. However, additional requirements are specified elsewhere:

- The inventory of toxic species, resistance to leaching, and off-gas production are limited.
- There are limits for compression resistance, drop resistance, fire resistance, thermic cycles resistance.
- Cemented matrices are foreseen for LLW and ILW conditioning, whilst VLLW does not need conditioning.

An integrated approach combining different methods (such as physical scanning, gamma spectrometry and neutron counting measurements) is used for characterisation of conditioned radioactive waste. For the physical scanning, an X-ray tube is used in order to analyse the matrix and its density distribution. Gamma spectrometry is performed by using high purity germanium detectors and keeping the item (typically a drum with variable volume) in rotation to reduce the radial matrix effect. The item is investigated using several techniques: besides analysing it in open-geometry (one measurement per item), it can be “cut” in segments (reconstructing the vertical distribution of both matrix and contamination) or by means of a tomographic approach (thus with a 3-dimensional reconstruction of matrix and contamination distributions).

For the neutron counting measurements, a dedicated piece of equipment able to detect neutrons coming from both spontaneous fissions (passive mode) and induced fissions (active mode), and able to detect both fertile and fissile materials, is used.

8.4 Norway

The information below is drawn primarily from the NEA’s Norwegian summary of radioactive waste management programmes in OECD/NEA member countries [42].

In Norway, radioactive waste is generated from research reactor operations and through the use of radioactive materials in medical, research and industrial applications. No national waste classification scheme applies, but the recommendations of IAEA Safety Series report No. 111-G.1.1. (now superseded by GSG-1 [13]) are applied as far as reasonably practicable.

LLW and ILW are disposed of / stored in the National Combined Disposal and Storage Facility (KLDRA) in Himdalen and in the Institute for Energy Technologies (IFE’s) storage facilities in Kjeller. SNF is also stored in IFE’s storage facilities.

No information regarding WAC in Norway was found in the National Report submitted in support of the Convention on Nuclear Safety, or in other public domain reports.

8.5 Switzerland

The information below is based on work conducted under the THERAMIN project [6]. It provides an extract from preliminary WAC, concerning requirements on waste package properties.

The properties of waste packages for disposal have to meet various criteria in order to ensure that, considering the design of the repository, the waste emplacement process is technically feasible and that the necessary level of safety can be assured during the operational and post-operational phases (protection of personnel, population and the environment).

Principles for the design and content of waste packages:

1) Minimisation of organic material in the conditioned waste: minimisation of organics in raw waste, abandonment of organic or organic-containing additives in the waste conditioning, if possible, at the state of science and technology (SST).
2) Minimisation of mass and available surface of inorganic material in the conditioned waste, which can generate gases when in contact with underground water (e.g. Zn, Al, Fe, steel) and, if possible considering the SST: Avoidance of corresponding raw waste; chemical reaction (oxidation) of corresponding raw waste, abandonment of corresponding additives in the waste conditioning.
3) Minimisation of secondary waste production in the waste conditioning.
4) Stabilisation of gaseous, liquid of solid dispersed waste or intermediate products by transforming into forms which are difficult to disperse (gastight enclosure, immobilisation on sorbents, or solidification via the production of waste/additive matrices).
5) Protection of heat sensitive and combustible waste against thermal impact: thermal insulation by non-combustible packaging and avoidance of thermal bridges if technically feasible.
6) Well-balanced mass distributions in waste packages that remains balanced at transport, operation and stacking.
7) Resistance (chemical transformation, dissolution) of waste packages and their components against aqueous media in the DGR after closure.

In terms of thermally treated waste products, the most important criteria are as follows:

- Resistance against aqueous media.
- Non-ignitable / combustible or hard to ignite / combust.
- Non-dispersible, mechanically stable.
- Pressure resistance of minimum 10 MPa.

9. Conclusions

This report has examined the use of WAC in Member-States and some Associated Countries, focusing on the use of WAC as a management tool across the waste lifecycle. It has discussed commonalities and differences between national approaches to develop and apply WAC, drawing primarily on national responses to WAC-related questions in the ROUTES questionnaire. The responses are detailed and extensive, covering waste management activities in 22 European countries. They provide a considerable body of information to analyse, and much experience to share and learn from.

A detailed analysis and comparison of national approaches to develop and apply WAC has been presented in this report, including consideration of:

- The type, scope and applicability of national WAC and detailed requirements set out within these WAC.
- How the WAC were developed and what (if any) provisions are in place to update them.
- How compliance with WAC is determined and arrangements to respond to any non-compliances.

Even so, it has not been possible to integrate all of the details provided in the national responses into this report, particularly with regard to numerical requirements or limits. The reader is therefore recommended to also refer to the report compiling national responses to the ROUTES questionnaire [5], particularly if seeking further details on specific national approaches. It is noted that most quantitative criteria are not directly comparable between countries since they depend on national waste classification systems and on the safety case for a particular facility.

WAC applicable during different stages of the waste lifecycle have been compared, noting that the term 'WAC' is typically used in relation to the receipt of waste at storage and disposal facilities. The greatest variation in the nature and status of WAC is observed for disposal, including considerable variation for different waste classifications within individual countries.

Relatively few countries currently employ generic WAC but it is noted that such WAC can help to facilitate timely waste management when a disposal route is not yet available, as well as providing a baseline from which to develop WAC for a specific disposal facility / repository once the site and associated conditions are known. It could be interesting to explore whether this view is more widely held as part of future Task 4 discussions. For example, the gap analysis as part of Sub-task 4.2 could involve group discussion of whether (and how) generic WAC could provide a tool to facilitate waste management (conditioning, packaging, storage and evaluation of disposability) for wastes where no disposal route is currently available.

This report will inform subsequent activities under ROUTES Task 4, including sharing of waste management experiences when WAC are / are not available under Sub-task 4.2; and identification of R&D needs and opportunities for collaboration under Sub-task 4.3. In due course, it will feed into the final Task 4 deliverable (ROUTES Deliverable D9.9).

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