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Radiological Characterisation From a Material and Waste End-state Perspective:

Evaluation of the Questionnaire by the NEA Task Group on Radiological Characterisation and Decommissioning

Intermediary Report

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The mission of the NEA is:

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FOREWORD

The Task Group on Radiological Characterisation and Decommissioning (TGRCD) is an expert group of the Working Party on Decommissioning and Dismantling (WPDD) and operates under the umbrella of the OECD Nuclear Energy Agency (NEA). The task group aims to identify and present the best practice for radiological characterisation at different stages of decommissioning and to identify opportunities for further development through international co-operation and co-ordination. The first phase of the task group's work develops guidance on selection and tailoring strategies for radiological characterisation, and gives an overview of best practice for radiological characterisation at different phases of the life cycle of a nuclear installation [ref:1].

The second (and current) phase of work seeks to develop the status on selection and tailoring of strategies for optimisation of nuclear facility characterisation from a waste and materials end-state perspective. One of the ways this has been explored is through a survey (questionnaire) of a broad range of international experts, including regulators and industry owners (referred to as ''owners'' throughout this report), who are able to draw upon practical experience in radiological characterisation of materials and waste. The experts were mainly identified through the different national representatives involved in the WPDD activities. This report provides the information obtained from this survey and an evaluation which seeks to draw out learning from experience and to establish good practice.

The questionnaire responses represent the views of individuals, drawn from their characterisation expertise and personal networks, and do not necessarily represent the overall opinion of the responder's country. The overall report findings are based on collation and evaluation of the questionnaire responses and therefore should not be taken as the opinion either of the authors or of the Nuclear Energy Agency (NEA), its Radioactive Waste Management Committee or its Working Party on Decommissioning and Dismantling (WPDD).

The second phase of the task group's work involves other activities, including the collation of case study information. A final report of the entire second phase of the work will be produced providing an overall status report on selection and tailoring of strategies for optimisation of nuclear facility characterisation from a waste and materials end-state perspective.

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LIST OF ABBREVIATIONS AND ACRONYMS

DQA	Data quality assessment
DQO	Data quality objectives
NEA	Nuclear Energy Agency
QA	Quality assurance
QC	Quality control
WPDD	Working Party on Decommissioning and Dismantling
HLW	High-level waste
IAEA	International Atomic Energy Agency
ILW	Intermediate-level waste
RPV	Reactor pressure vessel
USEPA	US Environmental Protection Agency
VLLW	Very low-level waste

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CHAPTER 1. INTRODUCTION

The Task Group on Radiological Characterisation and Decommissioning is an expert group of the Working Party on Decommissioning and Dismantling (WPDD) and operates under the umbrella of the NEA. The task group aims to identify and present the best practice for radiological characterisation at different stages of decommissioning and to identify opportunities for further development through international co-operation and co-ordination. The first phase of the task group's work develops guidance on the selection and tailoring of strategies for radiological characterisation, and gives an overview of best practice for radiological characterisation at different phases of the life cycle of a nuclear installation [ref:1].

The second (and current) phase of work seeks to develop the approaches to the selection and tailoring of strategies for optimisation of nuclear facility characterisation from a waste and materials end-state perspective. One of the ways this has been explored is through a survey (questionnaire) of a broad range of international experts who are able to draw upon practical experience in radiological characterisation of materials and waste. The experts were mainly identified through the different national representatives involved in the WPDD activities. This report provides the information obtained from this survey and an evaluation that seeks to draw out learning from experience and to establish good practice.

1.1 Objectives

The objectives of this study were to:

- Draw on the practical experience from a broad range of international characterisation experts.
- Understand the current international status of radiological characterisation, seeking to draw out a comprehensive picture of practical good practice for characterisation.
- Understand if the regulators and owners share a common view of good practice and if not, to identify which areas and to what extent views diverge.
- Understand similarities and differences in national contexts and how these can impact on radiological characterisation.

1.2 Methodology

A questionnaire structured around a lifecycle approach to characterisation [ref: 1] and the use of systematic planning approaches such as data quality objectives methodology [ref: 2] was developed. The questionnaires were sent to international characterisation experts who were identified primarily through the different national representatives in the Radiological Characterisation Task Group within WPDD and their supporting national networks. The Radiological Characterisation Task Group has undertaken a systematic evaluation of this information seeking to understand the international status of radiological characterisation, in particular for decommissioning, and has used this to draw out best practice. The collection and evaluation of the questionnaire responses was simplified through the use of a readily available web-based survey tool.

It was recognised at an early stage that there are significant differences in the roles of the regulators and owners and consequently two versions of the questionnaire were used to target the collection of views. Throughout this report, the term *"regulator"* is used to cover the regulators and other characterisation specialists who undertake work on the regulators behalf. The term "*owner"* refers to nuclear site owners and those who undertake work on the owner's behalf. This will include nuclear industry site operators and their staff who undertake characterisation work and the supply chain that supports such work.

It was also appreciated that aspects of radiological characterisation may change significantly prior to and during facility dismantling. Consequently, some questions were designed to explore the responders' views of good practice for characterisation prior to and during dismantling. Throughout the report "decommissioning" is used as a general term to cover the planning and actions taken to remove the regulatory controls from a nuclear facility, which normally involves facility dismantling and radioactive waste management and disposal.

1.3 **Scope of the report**

The report summarises the content of the questionnaire (Chapter 2) and provides an overview of the survey responses (Chapter 3). For reference purposes, the detailed questions and the collated survey results are provided in the Annex to this report. Chapter 4 presents and discusses the results, seeking to draw out practical good practice for characterisation. Chapter 5 provides the summary conclusions from the survey.

Within the text the following labelling is used: R# or I#, where ''R'' corresponds to a question in the regulator questionnaire; ''I'' corresponds to questions in the owner questionnaire; and ''#'' to the question number. This labelling is to allow the reader to easily locate the more detailed survey results in the Annex.

CHAPTER 2. CONTENT OF QUESTIONNAIRE

The questionnaire was structured around a lifecycle approach to characterisation [ref: 1] and a systematic planning approach such as the data quality objectives methodology [ref: 2]. The main areas which the questionnaire covered are given in Table 1. Some of the key issues the task group sought to explore were:

- Strategic approaches to the lifecycle of characterisation.
- Regulatory requirements, established methodologies, industry standards, including what level of accuracy and precision is required and why.
- Optimisation of the collection of information, including what type, quality and quantity of information is needed, by which date, and how should it be collected and developed.
- Systematic approaches to characterisation data management, including evaluation (e.g. data quality objectives/assessment approaches).
- Dealing with heterogeneous distributions of radioactive substances (including recognition, quantification and waste acceptance criteria compliance demonstration).
- Traceability and quality assurance.

In all cases, the role and experience of the responder was required. The regulator questionnaire focused on establishing the national regulatory framework and regulatory expectations regarding the initiation, assessment and quality assurance for radiological characterisation. The owner questionnaire focused on the practical aspects of initiating, planning, implementing, assessing and quality assuring radiological characterisation. The main sections of the regulator and owner questionnaires are given in Table 1. The detailed questions in each area of the questionnaire are provided in the Annex, highlighting which questions were put to regulators and owners or to all experts.

Table 1: Questionnaire overview

Topic	Regulators	Owners
Responder's role and experience	X	X
National context and overview	X	
Initiation phase	X	X
Planning phase		X
Implementation phase		X
Data assessment phase	X	X
Quality assurance	X	X

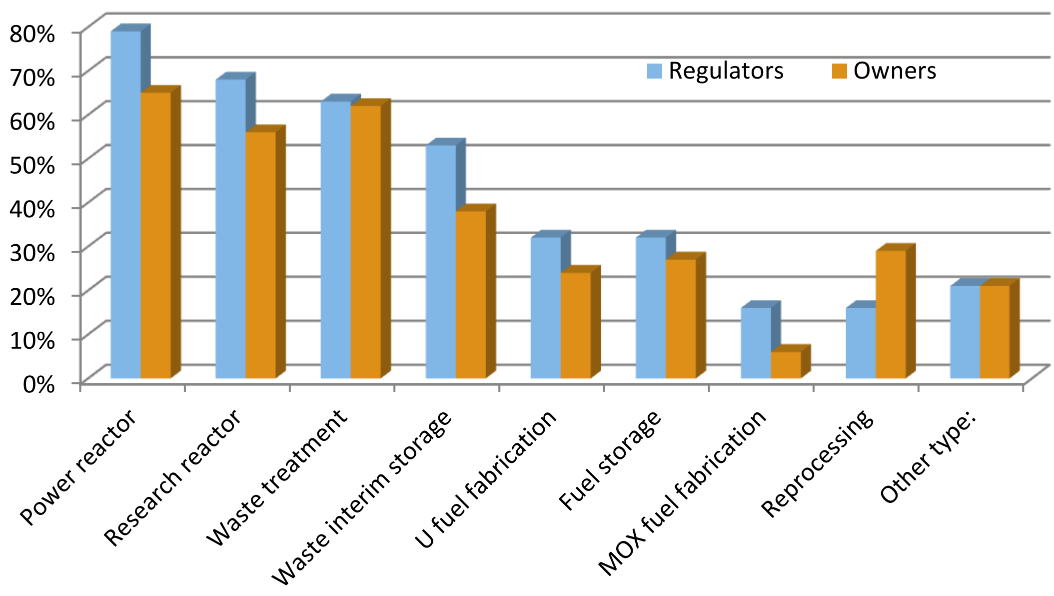
X = included in the scope of the regulator and owner questionnaires.

CHAPTER 3. QUESTIONNAIRE RESPONSES

Overall, 53 questionnaire responses were received from characterisation experts from 13 countries, including 10 European countries, Canada, Japan and the USA. 19 responses were from the regulatory community covering 11 countries and 34 responses were from owners covering 12 countries. Multiple responses for the regulator and/or owner communities were received from France, Germany, Sweden and the UK [R2, I2]. It should be noted that the survey respondents were generally from countries with significant nuclear facility decommissioning and concomitant characterisation experience. If responses from countries with less mature decommissioning/characterisation programmes had been included, the results may have been different, and in particular greater variation may have been expected in the responses.

The regulator responses are dominated by direct responses from the regulators (79%) with the other responses being from specialist consultants or others (21%), who work with the regulators. The owner responses come from a broad range of experts currently representing nuclear power plants (29%), waste processing or disposal organisations (9%), other nuclear facilities (29%) and specialist consultants and others (33%) [R3, I3].

Figure 1: Areas of experience of responders (regulators and owners) of radiological characterisation by nuclear industry sectors.



Both the regulators and owners responding to the questionnaire have a broad experience across the nuclear industry; with the regulators' experience generally being marginally broader. Overall the average responder's experience of radiological characterisation is around 15 years. The collective experience of those responding to the regulator questionnaire is approximately 300 years and for those responding to the owner questionnaire the collective experience is around 500 years [R5, I5]. More than 50% of the responders have experience of nuclear reactor plants and waste processing. Just less than half are experienced in interim waste storage. A lower percentage of responders (around 30%) had experience of fuel storage and uranium fuel fabrication. Around 20% of responders had experience of mixed oxide fuel fabrication and nuclear fuel reprocessing [Figure 1 – R4, I4].

The detailed responses to the technical sections of the questionnaire, which covered the national regulatory framework, practical aspects of initiating, planning, implementing, assessing and quality assuring radiological characterisation, are collated in the Annex. These results are discussed in Chapter 4 and the overall findings are summarised in Chapter 5.

CHAPTER 4. RESULTS AND DISCUSSION

This chapter presents an evaluation of the responses to technical aspects of characterisation covered in the questionnaire. It covers the national context in which characterisation takes place followed by the systematic characterisation process involving initiation, planning, implementing, assessing and quality assurance. The evaluation is based on the detailed survey results which are provided in the Annex.

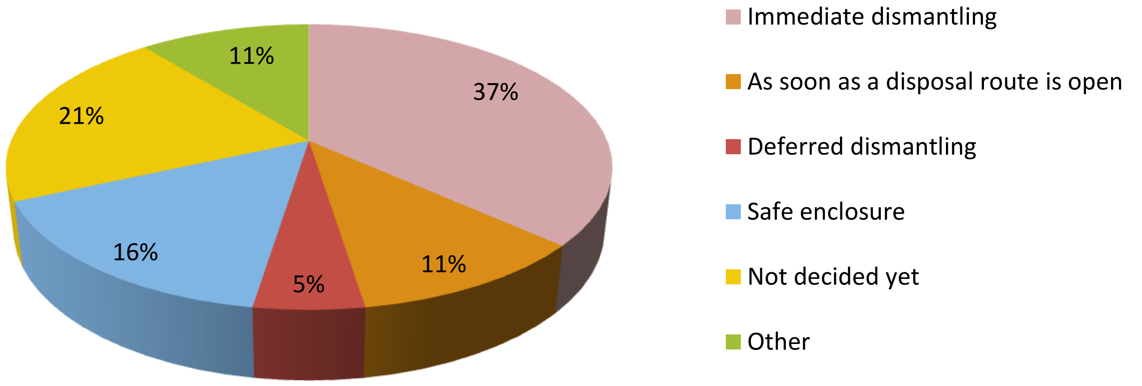
4.1 National context

Only the regulator responders were asked to provide responses on the national regulatory context in which characterisation takes place in their country.

Many responders favour prompt action, either immediate dismantling (37%) or as soon as a disposal route is open (11%). Deferred decommissioning is a less favoured approach with responses of 5% for deferred decommissioning and 16% for safe enclosure. A significant fraction of responders indicate that the decommissioning approach is either undecided or uses some other approach, however the more detailed comments in their responses generally indicate that these responders consider that their national decommissioning strategy reflects a preference for immediate dismantling but recognising there may be circumstances where this is not practicable [Figure 2 – R6].

Generally these findings appears to be in line with the latest International Atomic Energy Agency (IAEA) safety standards [ref: 3], which states that the preferred decommissioning strategy shall be immediate dismantling but recognising that there may be situations in which immediate dismantling is not a practicable strategy when all relevant factors are considered. The results also appear to reflect the latest IAEA standards which consider that "*entombment, in which all or part of the facility is encased in a structurally long lived material, is not considered a decommissioning strategy and is not an option in the case of planned permanent shutdown and should only be considered in exceptional circumstances (e.g. following a severe accident).*"

Figure 2: National Decommissioning Strategies

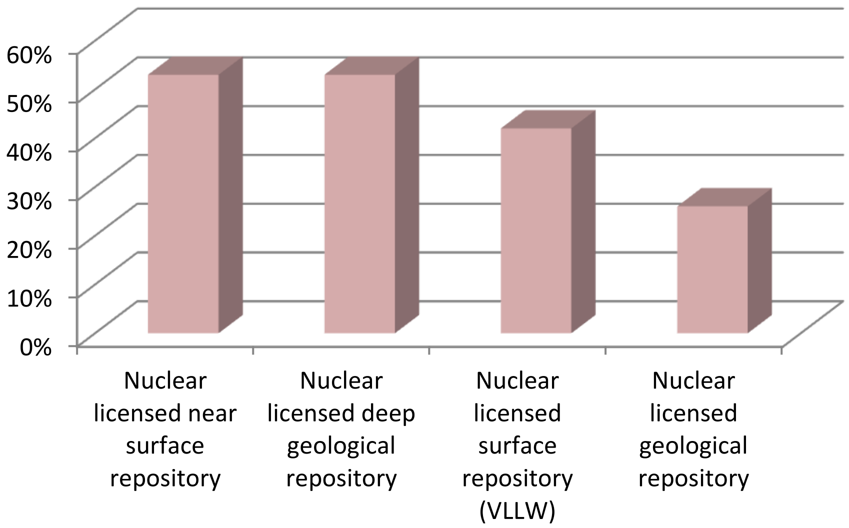


100% of responders report that interim waste storage facilities should be available either as a legal requirement or through a national programme [R7]. In the large majority of situations and for all categories of solid radioactive waste there are either local or centralised interim storage facilities, with a general shift towards more centralised national facilities as the waste category increases from low to high [R8]. Some responders note that where disposal routes are available, waste disposal should occur without delay and any interim waste storage should be minimised.

The responses (90%) show that clearance of materials for unrestricted use is a widespread international practice. About 60% state that clearance of metal for recycling outside the nuclear sector is an available option, with a lower percentage (42%) indicating that metals can be recycled within the nuclear sector. A majority of responders (63%) also highlight that clearance can be used to allow the disposal of waste to conventional waste disposal sites [R9].

The vast majority of responders indicated that licensed repositories are available or planned for the disposal of radioactive waste. About 40% of the responses show that surface repositories are available for VLLW, whilst some forms of repositories (surface, near surface or geological) are available, or planned, for all national programmes [Figure 3 – R10].

Figure 3: Percentage of responses regarding national repositories available or planned.



Primarily the national approach to regulating characterisation is through regulated principles combined with guidance documents (68% of responses). However, 21% of responders state that regulation is limited to guidance documents and 11% note that characterisation is not regulated. It is worth noting that no responders report that characterisation is regulated through processes defined in detail which are legally binding [R11].

The experience of characterisation, for the responding countries, is considered to be extensive or moderate (~80% of responses) split in to three categories: systems and components, buildings and site. The experience is reported as most extensive for systems and components [R12]. This probably reflects experience gained during the operational phase of the nuclear facilities. The responses also indicated that a lifecycle approach to characterisation is almost always considered for systems and components, buildings and site. However, this consideration appears to be fairly limited in most situations with only around a third of the responses considering that there is a detailed focus on lifecycle characterisation [R13].

The majority (about two thirds) of responders consider that the amount of resource qualified to perform radiological characterisation is sufficient. The sufficiency of qualified resources is assessed to be highest for systems and components (72%); then buildings (67%); followed by sites (61%). Approximately a third of the responses consider that qualified resources are insufficient [R14]. A similar pattern emerges regarding the sufficiency of accredited laboratories (e.g. accredited to the ISO17025 Ref: 4) available to perform radiological analyses. The sufficiency of qualified resources is assessed to be highest for gamma spectrometry (79%); followed by hazardous substances in radioactive samples (69%); alpha spectrometry (67%); and finally hard to measure radionuclides (61%). Once again, approximately a third of the responses consider that accredited laboratory capacity is insufficient [R15].

4.2 Initiation phase

The regulators and owners were asked to provide responses on the characterisation initiation phase. The questions were limited to exploring the development and documentation of characterisation objectives.

There is almost universal agreement between regulators and owners (>82%) that the characterisation objectives should be developed from the start of the characterisation process (i.e. the initiation phase). There is also clear agreement between regulators and owners on the importance of characterisation objectives, with about a third considering that the objectives should be documented in a high-level characterisation strategy and just over half believing that the objectives should be in the overall characterisation plan. A small percentage (6%) of the owners consider that the definition of characterisation objectives should not be necessary as they can be referenced to international standards/guidance, whilst 9% of responders are unsure where they should be documented [Figures 4 & 5 - R16, I15].

Figure 4: Regulator responses regarding where characterisation objectives should be defined during the characterisation initiation phase.

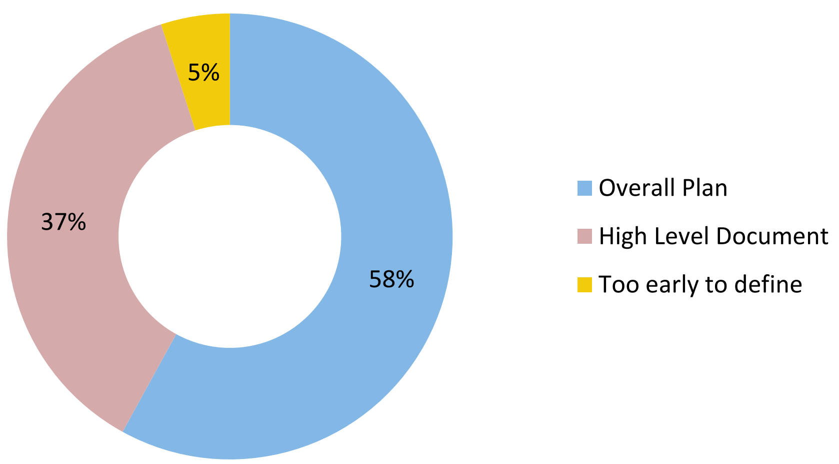
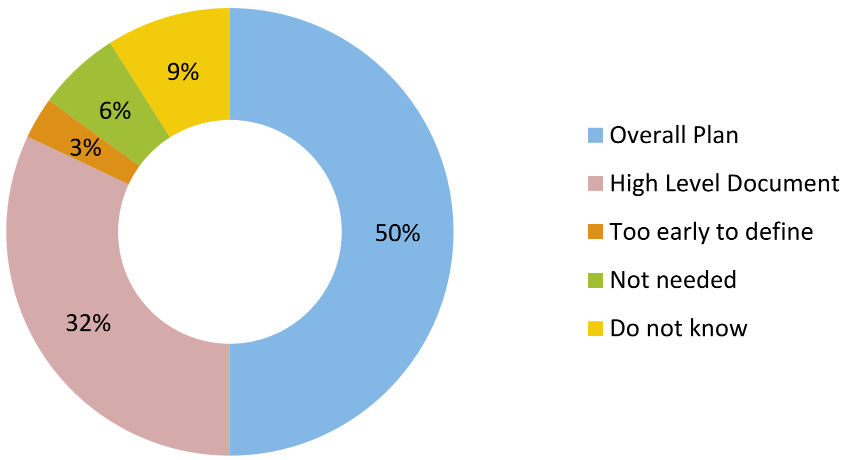


Figure 5: Owner responses regarding where characterisation objectives should be defined during the characterisation initiation phase.



Responders were asked to assess the importance (high; medium or low) of a range of radiological characterisation objectives during planning for dismantling and/or during the actual dismantling. Generally, there was a very close agreement between regulators and owners regarding the relative importance of characterisation objectives during the planning of dismantling, with many factors considered important.

Regulator and owner views diverge slightly regarding the factors that are considered important during the dismantling phase. The owners focus on hazard and waste management as the most important factors, whilst the regulators also continue to place importance on waste planning and safety analyses [R17, I16].

4.3 Planning phase

Only the owners were asked to provide responses on the planning phase of characterisation.

All owners agreed that a systematic characterisation plan (sampling, measurement and analyses) should be developed. The majority (62%) consider that a detailed plan is needed whereas 24% consider that a higher level plan containing the principles and programme is appropriate and the remainder (14%) feel that the level of detailed of the plan should be considered on a case by case basis [I16]. Some owners noted that regulators generally recommend a detailed plan, but only a few require their preparation and use.

When taking a systematic planning approach to characterisation (such as the data quality objectives methodology (ref: 2), owners were asked to provide information on which experts are most important to support the different phases of the planning process. The individual responses show significant variation probably indicating that different organisations have to operate within their own site or national frameworks. However, a general conclusion is that there needs to be close co-operation between the teams responsible for planning the decommissioning and dismantling, planning the characterisation and managing the waste. More specifically, the planning team and the dismantling expert are judged to be the most important resource, supported by the waste management organisation. This is the case for all of the planning stages, with the exception of specifying performance/acceptance criteria. For the specifying performance/acceptance criteria stage the waste management and repository organisations are seen as most important [Table 2 – I18]. These results suggest that the core experts who have overall accountability for planning radiological characterisation to support decommissioning are taking responsibility for the work and acting as the intelligent customer, even when they are contracting support services such as measurement and analysis expertise.

Table 2: The importance of experts to support the stages of the radiological characterisation planning process.

Characterisation Planning Stage	Planning team	Dismantling expert	WM organisation	Independent expert	Measurement staff/ contractor	Laboratory	Repository organisation
1: State the problem	57%	47%	40%	17%	13%	10%	20%
2: Identify the goals of the study or project	53%	33%	37%	17%	13%	7%	13%
3: Identify information inputs	43%	47%	30%	17%	23%	10%	13%
4: Define the boundaries of the study	47%	43%	33%	13%	13%	7%	7%
5: Develop an analytical approach to address the problem	33%	43%	27%	20%	30%	20%	10%
6: Specify performance or acceptance criteria	30%	30%	47%	23%	23%	20%	33%
7: Develop the plan for obtaining data and results	57%	37%	30%	23%	27%	27%	10%

Generally, owners consider that existing information from all available sources should be used to support characterisation assessments. The information is of most benefit during the planning phase (prior to dismantling). Generally owners rank the operational history and facility documentation as most useful with characterisation results from previous activities, interviews with operating personnel and radiological inventory data also being important [Table 3 - I19].

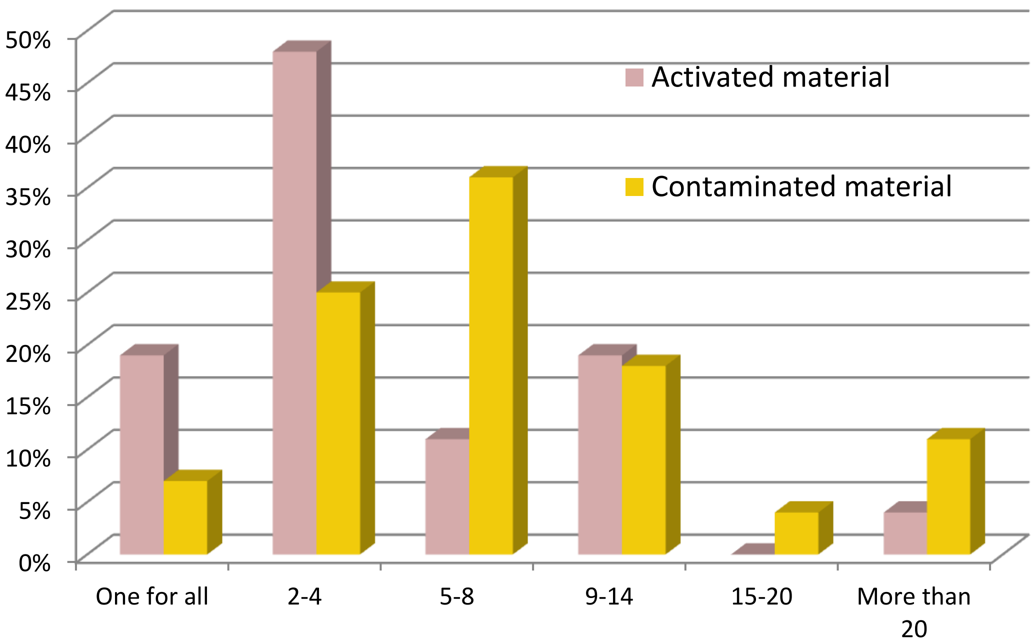
Table 3: Owners' views on the relative importance of existing information to support characterisation prior to and during dismantling.

	Prior to dismantling	During dismantling
Facility documentation	95%	64%
Operational history	96%	64%
Past Characterisation results	85%	64%
Interviews of former staff	83%	45%
Use of literature	68%	38%
Data from similar facilities	64%	34%

Radiological inventory calculations	85%	64%
Radiological impact calculations	78%	71%

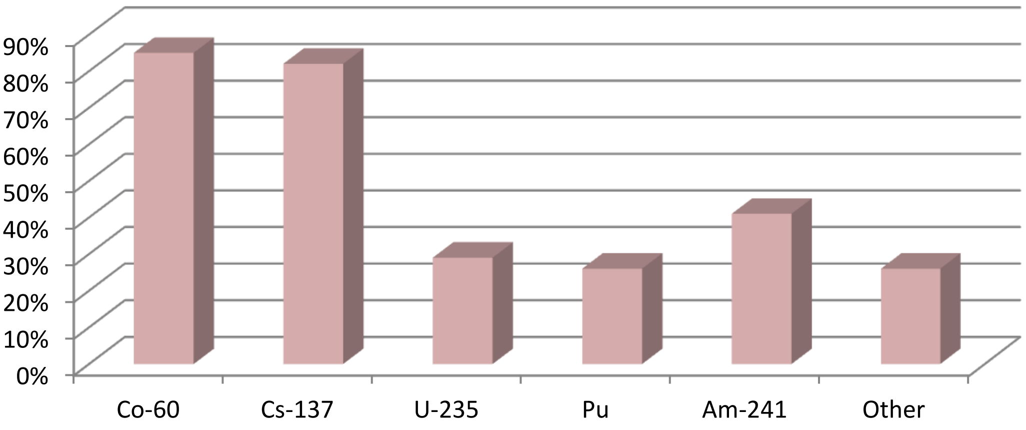
It is often impractical to perform characterisation measurements or analysis on all samples for all potential radiological and chemical contaminants that could be present. However, determination of the detailed contaminant composition for representative measurements or samples can be used to establish relationships (scaling factors) between easy and hard to measure contaminants [Ref: 5 and Ref: 6]. This is known as the vector or fingerprint method. Widespread measurements or analysis of the easy to measure contaminants can then be used to infer the concentrations of hard to measure contaminants in all the measurements/samples. Overall, the owners consider that vectors/fingerprints must be developed on a case by case basis. Some facilities can have a single vector but in many cases, even where there has not been significant processing of contaminated materials or waste, there can be significant variation of contamination within facilities and with depth in the facility fabric. It typically appears that a few (2-4) vectors may be used to support the characterisation of activated materials, whilst the number of vectors used to support the characterisation of contaminated materials may typically be higher. One respondent also noted the need for additional targeted radionuclide vectors where there is a physicochemical reason for the fingerprint to be altered [Figure 6 - I20].

Figure 6: Owners' views on the number of vectors used to support characterisation of activated and contaminated materials.



Owners report that Cobalt-60 and Caesium-137 are the preferred radionuclides for use in correlation of radionuclide vectors, but there are many other circumstances where other nuclides need to be used, with Americium-241 being the most common. To a lesser extent Uranium-235 and Plutonium isotopes are also reported to be used. One responder reports that the radionuclide composition in concrete associated with activation requires knowledge of aggregate composition and that Europium isotopes have been used in this respect [Figure 7 - I21].

Figure 7: Owners' preferred radionuclides for use in correlation of radionuclide vectors.



There is a general consensus that physical and chemical characteristics should be used in a characterisation programme, i.e. programmes should provide a complete picture of contamination and not just have a radiological focus. Examples of such physical and chemical characteristics included moisture content, rheology, asbestos, PCBs, VOCs and heavy metals. The use of vectors/fingerprints to support such characterisation work is also used. For example, the measurement of benzo[a]pyrene (Bap) is used to indicate the concentration of coal tar. The inclusion of physical and chemical species appears to be increasing as the scope of contaminants covered in waste acceptance criteria expands [I22].

Owners generally consider that reducing uncertainty about waste and identification of waste classification are the highest priorities for characterisation, both of which support securing waste route availability. Determining the waste volume or inventory is considered less of a priority. This is the same in both the planning and implementation phases [I23].

Owners were asked about the extent to which the decommissioning strategy and elements of the waste management strategy (treatment, storage, clearance and disposal) affect the characterisation programme. Generally, owners consider that all of these strategies should be reflected in the characterisation programme because the characterisation outputs can affect them all, particularly during the planning phase. The waste treatment and disposal strategies are seen as slightly more important in planning and material clearance strategy as slightly more important during actual dismantling [I24].

Nearly all owners consider that an internal dedicated review process is the correct approach to ensure that characterisation gives statistically robust and representative results. More than half also recognise that review by external experts has an important role to play. Benchmarking and networking are considered to be useful but not essential with less than half of the owners considering that these are important [I25].

4.4 Implementation phase

Only the owners were asked to provide responses on the implementation phase of characterisation.

Owners consider that the most significant characterisation efforts should be put into characterisation of areas known to be contaminated, both prior to and during dismantling, with proportionately less effort expended as the risk of contamination diminishes. The responses suggest that slightly lower effort is expended on characterisation of areas affected by neutron activation. However, this may reflect that some respondents do not deal with neutron activated materials [Table 4 - I26].

Table 4: Owner's views on the relatively importance for how characterisation effort should be deployed to areas with different radiological status.

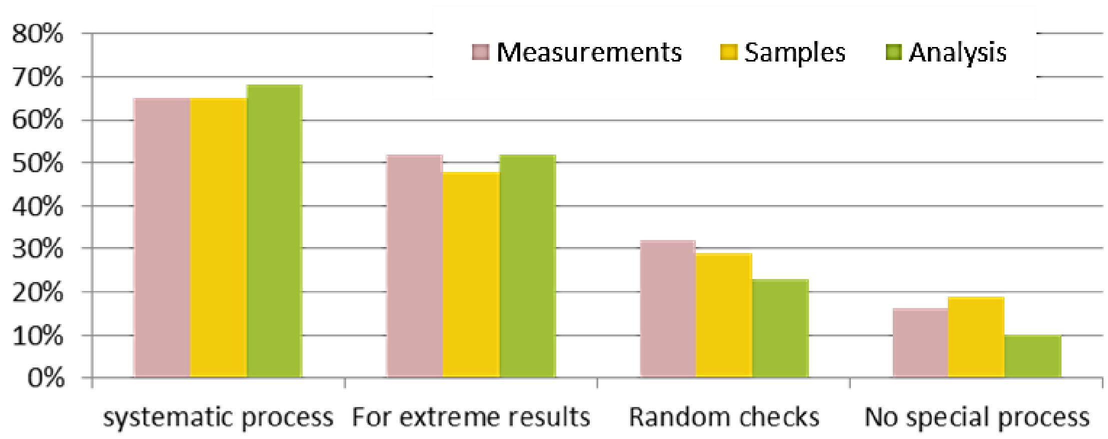
	Prior to dismantling	During dismantling
Areas with very low risk for contamination	40%	49%
Areas with low risk for contamination	58%	62%
Areas with risk for contamination	74%	82%
Contaminated areas	83%	86%
Highly contaminated areas	83%	85%
Areas affected by neutron activation	75%	69%

The large majority of owners (74%) consider that the choice of the sampling/measurement locations should be tailored on a case by case basis, using specific information about the materials or waste to inform the distribution of sampling or measurements. Only a small percentage of owners (26%) are in favour of the use of a prescribed system based on a random distribution or a regular mesh [I27]. Over half of the owners also consider that the approach to the choice of the sampling/measurement locations to identify contamination at depth should be made on a case by case basis. For the collection of a sample, a significant fraction (35%) favour the use of drilling, with a smaller percentage (13%) preferring scabbling (surface removal) [I29].

Owners were asked about which techniques for measurement and sampling/analysis are most important to characterisation of materials and waste prior to and during dismantling. The overall results indicate that characterisation mainly relies on: dose rate or gamma measurements; sampling followed by gamma, alpha and beta analysis; and the use of in-situ handheld beta measurements and volume gamma counter. It is interesting that the relative importance of the various characterisation techniques are judged to be similar both prior to and during dismantling. For example, in-situ gamma measurements would appear to be a technique particularly suited to characterisation prior to dismantling to allow wide coverage. Such techniques also support waste led dismantling, i.e. allowing dismantling to be undertaken in a manner that allows the sorting and segregation of waste and the application of the waste management hierarchy. Overall it should be noted that the results cover characterisation undertaken for a variety of purposes, across a wide range of international projects, and this probably explains the small differences that are seen in the importance of the various characterisation techniques. [I28].

A clear majority (approximately two thirds) of owners are in favour of a systematic predefined process when it comes to how measurements, sampling and analyses should be repeated/checked to verify results. About half believe that such verification should be undertaken for extreme results, whilst about one third think that random checks should be performed. From this we conclude that there should be a systematic verification process which checks results on both a random basis and when extreme results are identified [Figure 8 - I30-32].

Figure 8: Owners responses on the need for a systematic process to verify measurements, samples and analysis and whether such verification should be undertaken randomly and/or in response to extreme results.

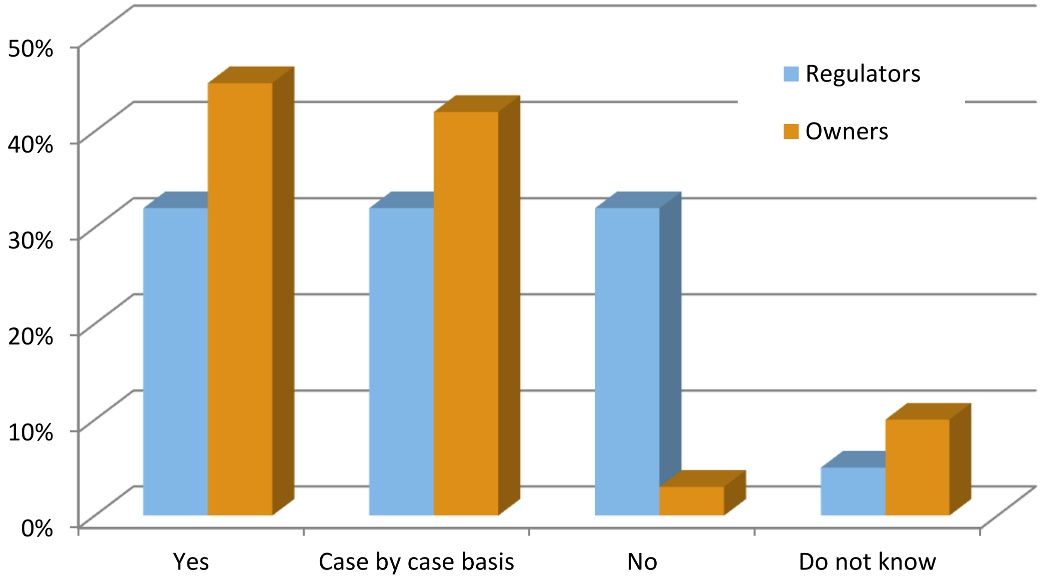


4.5 Data assessment phase

The regulators and owners were asked to provide responses on the data assessment phase. The questions explored the use of data assessment plans, data assessment and reporting methods, areas of uncertainty and which experts undertake such assessment.

Regulators and owners are evenly split between the required use of a systematic plan for data assessment and use of a case by case approach [Figure 9 - R18, I33].

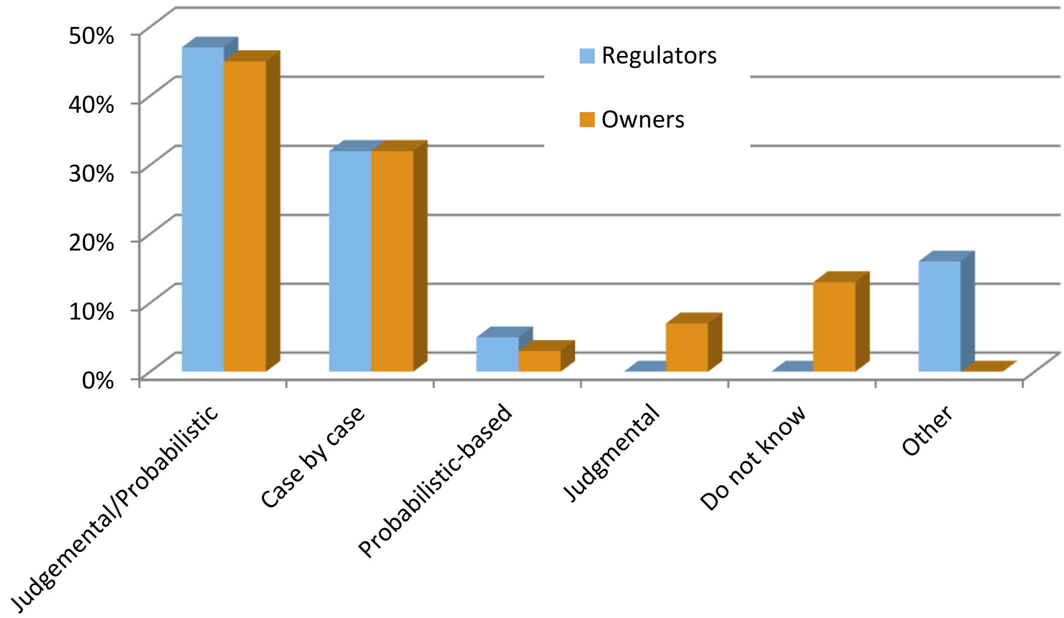
Figure 9: Regulator responses on whether systematic data assessment plans are prescribed and owner responses on whether systematic data assessment plans should be used.



Owners were asked about which experts are most important to the data assessment process. Laboratory and measurement staff and quality assurance and independent experts are seen as most important to the data verification and validation process. The dismantling experts and quality assurance and independent experts are considered to be most important when reviewing the data quality objectives and sample design. Whilst when drawing conclusions from the characterisation data, the planning team, dismantling experts and waste management organisation are believed to be most important. Interestingly, experts from the repository organisation are generally to be seen as least important [I34].

Regulators and owners are in equal agreement that the material and waste characterisation data should be evaluated using a combination of judgemental and probabilistic approaches, with selection of the appropriate methodology on a case by case basis [Figure 10 - R19, I35].

Figure 10: Regulator and owner responses on approaches to evaluation of characterisation data.



The use of graphical modelling for evaluation and presentation of results is largely adopted by owners and regulators, although many regulators only consider recommending its use on a case by case basis [R20, I36].

When considering the impact of uncertainties on the evaluation of material and waste characterisation data, both regulators and owners see sampling and measurement representativeness as the most important factor. There is also agreement that the next most important factors are variations in activity distribution and nuclide composition. Measurement and sampling staff understanding was also seen as important (though more so by the regulators) along with the impact of shielding and background. All other factors were considered to have a lesser, but still significant, impact by both communities, except for instrument and analysis method uncertainty where the regulators saw these to be of least significance and less significance than the owners [R21, I37].

4.6 Quality assurance

The regulator and owners were asked to provide responses on characterisation quality assurance. The questions explored quality assurance plans, the most important measures used to assure quality, sample and records retention, independent review and duplication of in-situ measurements and laboratory analysis.

Regulators (79%) and owners (61%) largely agree that characterisation campaigns should have a dedicated quality assurance plan. None of the regulators and only a very low percentage of owners (7%) believe that quality assurance plans can be just covered by reference to standards and guidance. The remaining minority of responders (regulators and owners) believe that quality assurance plans are only needed for large or complex characterisation campaigns or if a plan had been requested [R22, I38].

The overwhelming majority of both regulators (95%) and owners (77%) expect the development of the quality assurance plan during the initiation or planning phases. Several responders commented that it is good practice to implement the quality assurance plan at the start of the project and then update it at each phase [R23, I39].

Regarding the measures for quality assurance and maintenance of quality throughout the characterisation process (before dismantling), regulators and owners consider the use of specific characterisation documentation to be the main measure, but they also agree that review and independent evaluation of characterisation plans; use of accredited laboratories and review of representative sampling are also important [R24a,I40a].

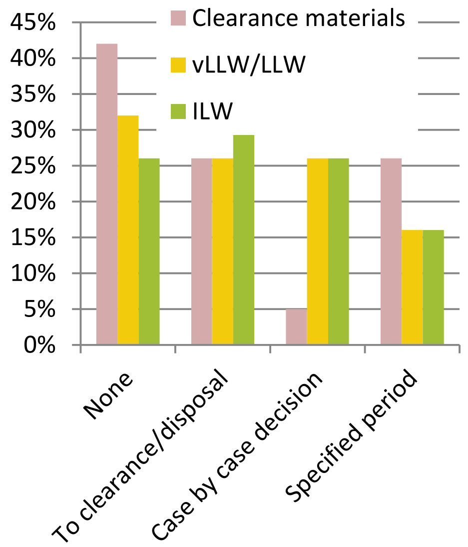
During dismantling, the importance of those factors continued, except for the evaluation of characterisation plans. For both regulators and owners, the use of independent control measures and evaluation of results by external experts also increase in significance.

All of the other measures put forward for consideration in the questionnaires are seen as having some, but lesser value for quality maintenance [R24b, I40b].

The approach taken to retention of samples of materials or waste for future reference appears to depend on the availability of final waste route in each country and primarily relates to recommendations rather than requirements. It appears that practice may even vary within a single country, due to different approaches for individual states or counties. A variety of sample retention approaches are employed with sample storage: up to clearance/disposal; based on case by case decisions; for a specified number of years; or samples not stored at all with only sample results being retained. The responses are similar for the different categories of material and waste (material for clearance, LLW/LLW and ILW). These results may indicate that it is worth considering whether international guidance would be useful in this area to support more consistent practice [Figure 11 - R25-30, I41-43].

For the retention of characterisation documentation and results, there are very similar mixed responses to those provided regarding sample retention. These results similarly, indicate that there is no consistent approach for long term keeping of the characterisation strategy, results, evaluation and quality assurance information. This might indicate that international guidance would be useful in this area to support more consistent practice. It is striking, however, that no owners report that the retention of characterisation documentation is done on a case by case basis, suggesting that all have a clear document retention process in place. In addition, both regulator and owner responses indicate that the most common retention is for a specified number of years. This may be a result of regulatory requirements in some cases, but also probably reflects the greater attention given to records management (as opposed to sample retention) and the availability of international guidance (Ref: 7 & Ref: 8) [Figure 12 - R:Q31-36, I44-46].

Figure 11: Regulator (left) and owner (right) responses on sample retention (storage) for different categories of materials and waste.



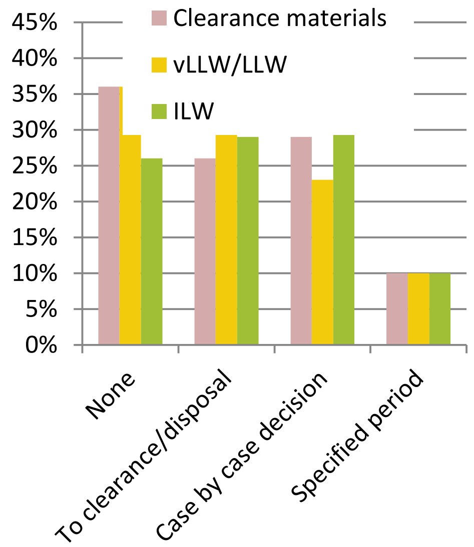
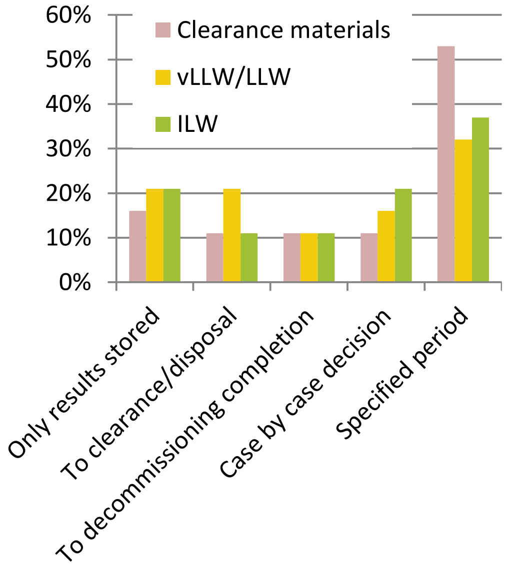
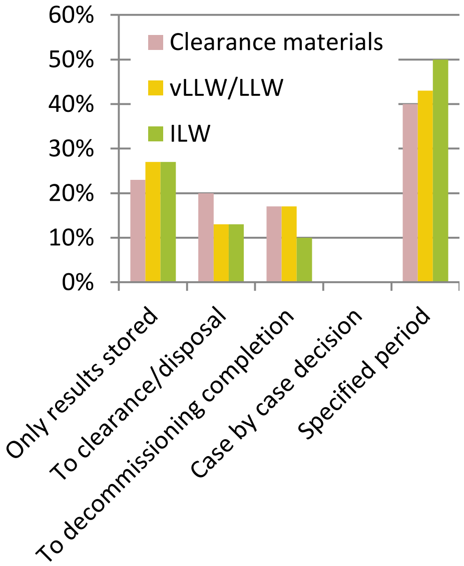


Figure 12: Regulator (left) and owner (right) responses on the retention of characterisation documentation and results for the different categories of material/waste.

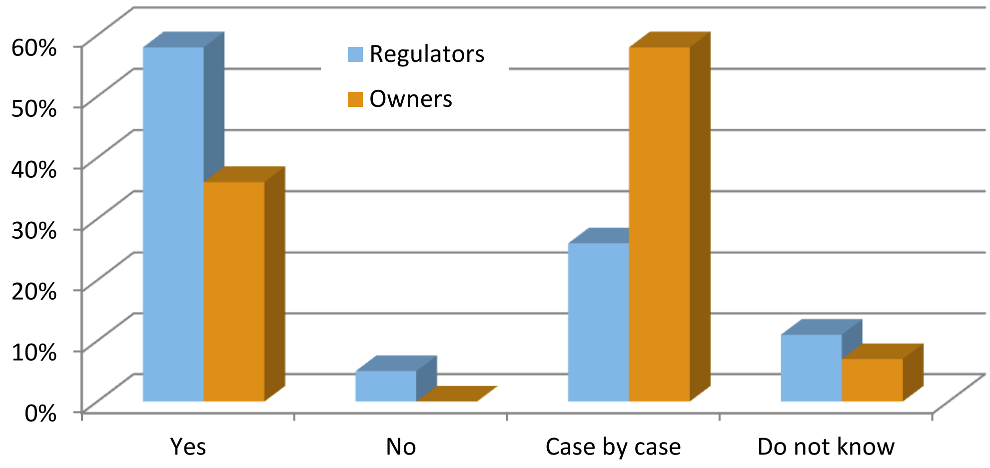




The majority of owners clearly use or want a centralised system to manage characterisation information. Regulators, whilst also favouring use of a centralised system, are also very interested in retention of paper records. Other options such as a local software solution receive lower interest particularly from owners [R37, I47].

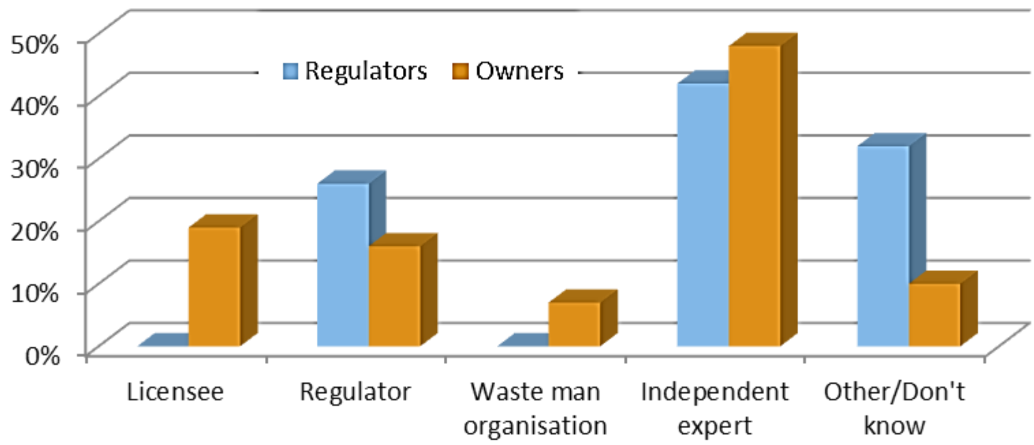
There is overwhelming agreement from both regulators and owners that independent review of results and evaluation should be undertaken. Regulators favour mandatory independent review whilst owners are more supportive of this requirement being considered on a case by case basis [Figure 13 - R38, I48].

Figure 13: Regulator and owners responses on whether independent review of characterisation results and evaluation should be undertaken.



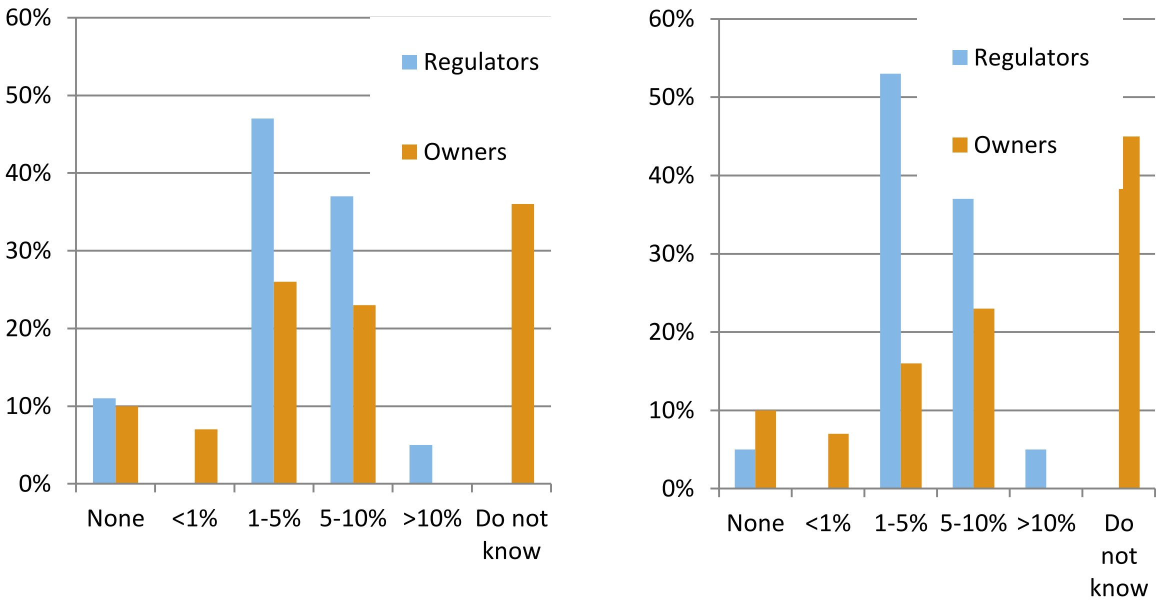
Regarding who should undertake the independent review the largest proportion of both regulators and owners favour a review by independent experts. A minority of responders believed that others (e.g. licensee, regulator, waste organisation) should be considered [Figure 14 - R39, I49].

Figure 14: Regulator and owners responses on who should undertake the independent review of characterisation results and evaluation.



The large majority of regulators and owners consider that duplicate analysis of samples by a second laboratory should be undertaken for a limited amount of samples (between 1% and 10%). With the responses indicating that a value of around 5% would attract the greatest support. It is worth noting that one third of the owners who responded to the questionnaire don't know, which may suggest this as an area where some guidance on good practice would be beneficial [R40, I50]. Responses are similar regarding the percentage of in-situ measurements which should be repeated for evaluation purposes. Again, a value of around 5% would appear to attract the greatest support. Interestingly, the proportion of owners who responded that they did not know is high (46%). This reinforces the proposal that guidance would be of assistance to the industry in this area [Figure 15 - R41, I51].

Figure 15: Responses on need for duplicate analysis of samples by a second laboratory (left) and need for repeat in-situ measurements (right).



CHAPTER 5. CONCLUSIONS

The work of the WPDD Task Group on Radiological Characterisation and Decommissioning to develop the status on selection and tailoring of strategies for optimisation of nuclear facility characterisation from a waste and materials end-state perspective has been explored through a major international survey of characterisation experts. 53 survey responses from characterisation experts from 13 countries, including 10 European countries, Canada, Japan and the United States have been evaluated. The key learning points from this evaluation are summarised below, covering the national context in which characterisation takes place followed by the systematic characterisation process involving initiation, planning, implementing, assessing and quality assurance.

National Context

- Immediate dismantling is the preferred decommissioning strategy, over deferred decommissioning, but recognising that it may not always be practicable.
- Interim waste storage facilities are available to support decommissioning but, where disposal routes are available, this should occur without delay and any interim waste storage should be minimised.
- Radiological clearance is a widespread international practice allowing unrestricted use of materials/waste, including metal recycling and conventional waste disposal.
- Waste repositories are planned or available for most national programmes.
- Regulation of characterisation is primarily undertaken through regulated principles combined with guidance documents.
- Characterisation experience is considered to be fairly extensive but there is considerable scope to embed greater consideration of a lifecycle approach to radiological characterisation.

Initiation Phase

- Characterisation objectives should be developed from the start of the process (i.e. at the initiation phase) and set out preferably in a detailed characterisation plan, or otherwise in a high-level characterisation strategy.
- During decommissioning planning the most important characterisation objectives are those that contribute towards the development of the decommissioning and waste management (prevention/minimisation, storage, treatment and disposal) plans, as well as cost estimation and safety analyses.
- Once dismantling is taking place the primary objectives of radiological characterisation become hazard and waste management.

Planning Phase

- A detailed and systematic characterisation (sampling, measurement and analyses) plan should be developed.
- When planning characterisation, the planning team and the dismantling expert are judged to be the most important supported by the waste management organisation.
- Operational history and facility documentation are seen as most useful to support characterisation assessments, with characterisation results from previous activities, interviews with operating personnel and radiological inventory data also being important. These are all needed at the planning stage.
- Vectors/fingerprints of a material or waste are commonly used to estimate hard to measure contaminants using measurements of easy to measure contaminants multiplied by the relevant scaling factors. However, vectors/fingerprints must be developed on a case by case basis and great care is needed in their use as there can be significant temporal (e.g. due to decay and/or radionuclide migration) or spatial variations (e.g. with depth within concrete) in the contaminant concentrations across facilities and within waste streams.
- Cobalt-60 and Ceasium-137 are the preferred radionuclides for use in correlation of radionuclide vectors/fingerprints, however Americium-241, Uranium-235 and isotopes of plutonium are used to a lesser extent.
- Consideration of physical and chemical vectors should form an integral part of a characterisation programme.
- Reducing uncertainty about waste and identification of waste classification are generally the highest priorities for characterisation, both of which support securing waste route availability.
- The characterisation programme should be developed and maintained through consideration of the decommissioning strategy and waste management strategy (including treatment, storage, clearance and disposal) both prior to and during dismantling.
- An internal dedicated review process is essential to ensure that characterisation gives statistically robust and representative results. Review by external experts is also important, whilst benchmarking and networking are useful.

Implementation Phase

- The most significant characterisation efforts are put into the characterisation of areas known to be contaminated both prior to and during dismantling.
- The choice of the sampling/measurement locations, to characterise at both the surface and at depth, should be tailored on a case by case basis, using specific information about the materials or waste.
- Characterisation, prior to and during dismantling, mainly relies on: dose rate or gamma measurements; sampling followed by gamma, alpha and beta analysis; and the use of in-situ handheld beta measurements and volume gamma counter.
- There should be a systematic verification process which checks results on a random basis and when extreme results are identified.

Data Assessment Phase

- Views are evenly split between the required use of a systematic plan for data assessment and use of a case by case approach.

- Material and waste characterisation data should be evaluated using a combination of judgemental and probabilistic approaches, with selection of the appropriate methodology on a case by case basis.
- Use of graphical modelling for evaluation and presentation of results is largely adopted by owners and regulators.
- When considering the impact of uncertainties on the evaluation of material and waste, characterisation sampling / measurement representativeness is the most important factor followed by variations in activity distribution and nuclide composition (heterogeneity).
- Laboratory, measurement and quality assurance/independent experts are seen as most important to the data verification and validation process.
- When implementing the data quality assessment process, waste management and quality assurance/independent experts are seen as the most important resources.

Quality Assurance

- Characterisation campaigns should have dedicated quality assurance plan developed early on in the characterisation process (during the initiation or planning phases).
- The most important quality assurance measure is developing and following specific documented characterisation arrangements. Other important measures are: review and independent evaluation of characterisation plans; use of accredited laboratories and review of representative sampling. The regulators consider independent control measures and reviews by external experts to be particularly important during the characterisation implementation phase.
- There is wide variation in retention times for samples and characterisation records across all categories of radioactive waste. International guidance may be beneficial in this area.
- Characterisation records are best held on a centralised electronic system but where there is any doubt about the ability to preserve such records, duplicate records in a different form (e.g. paper) should be retained.
- Independent review of characterisation results and evaluation should be undertaken by independent experts.
- Duplication of in-situ measurements and analysis by a second laboratory should be conducted for approximately 5% of measurements/analysis.

The second phase of the task group’s work involves other activities, including the collation of case study information. A final report of the entire second phase of the work will be produced providing an overall status report on selection and tailoring of strategies for optimisation of nuclear facility characterisation from a waste and materials end-state perspective.

6. REFERENCES

1. NEA (2013), "*Radiological Characterisation for Decommissioning of Nuclear Installations*" NEA/RWM/WPDD (2013)2, OECD, Paris.

2. USEPA (2006), "*Guidance on Systematic Planning Using the Data Quality Objectives*", EPA QA/G-4.

3. IAEA (2014), "*Decommissioning of Facilities*", IAEA Safety Series. General Safety Requirements Part 6, IAEA, Vienna.

4. ISO (2005), General requirements for the competence of testing and calibration laboratories, ISO17025, ISO, Paris.

5. IAEA (2009), *"Determination and use of Scaling Factors for Waste Characterization in Nuclear Power Plants"*, Technical reports No. NW-T-1.18, IAEA, Vienna.

6. ISO (2007), *"Scaling factor method to determine the radioactivity of low- and intermediate-level radioactive waste packages generated at nuclear power plants"*, ISO21238, ISO, Paris.

7. ISO (2001), "*Information and documentation -- Records management -- Part 1: General"*, ISO15489-1, ISO, Paris.

8. ISO (2011), "*Information and documentation — Management systems for records — Fundamentals and vocabulary" and "Information and documentation — Management systems for records — Requirements", ISO*30300 and ISO30301, ISO, Paris.

ANNEXES

1. GENERAL INFORMATION

Text responses are labelled R# or I#, where: ''R'' corresponds to a question on the regulator questionnaire; ''I'' corresponds to a question on the owners questionnaire; and ''#'' is the question number.

For consistency purposes all the tables in the annex use a scale of 0-100% and responses are colour shaded according to their value (yellow 0-24%; purple 25-49%; blue 50-74%; gold 75-100%). Where responders could choose only a single answer to a question, the collated responses have been converted into percentages. In these cases the sum of the responses in the table equals approximately 100% (noting percentages have been rounded to the nearest percentage). Where responders could choose multiple answers to a question each possible response has been transposed into a percentage within the 0-100% range.

2. RESPONDER'S EXPERIENCE

Introduction

Questions were asked about the responder experience including what type of organisation the responder represents, type(s) of facilities in which the responder has experience of characterisation programmes and number of years of experience in radioactive waste and materials characterisation related matters.

The entire section has been responded by the regulators and owners.

Questions and answers

Country in which the responder work:

	Regulators	Owners
Belgium	1	1
Canada		1
Denmark		1
France	1	7
Germany	6	2
Italy	1	1
Japan	1	1
Norway	1	1
Poland	1	
Spain	1	1
Sweden	2	8
UK	3	9
USA	1	1

R2,I2

Type of organisation the responder represents:

Regulator version	Response
Regulator	79%
Specialist consultant	11%
Other	11%

R3

Owner version	Response
Nuclear power plant	29%
Other nuclear facility	29%
Waste disposal organisation	6%
Waste processor	3%
Specialist consultant	9%
Other	24%

I3

Responders experience of waste and material characterisation for the following types of nuclear facilities:

	Regulators	Owners
Power reactor	79%	65%
Research reactor	68%	56%
Waste treatment	63%	62%
Waste interim storage	53%	38%
U fuel fabrication	32%	24%
Fuel storage	32%	27%
Other type:	21%	21%
MOX fuel fabrication	16%	6%
Reprocessing	16%	29%

R4,I4

Number of years of experience of responder in radioactive waste and materials characterisation:

	Regulators	Owners
<5	11%	12%
5-10	26%	27%
10-20	26%	32%
>20	37%	29%

R5,I5

3. NATIONAL CONTEXT

Introduction

The entire section was responded on by the regulator group only.

Questions and answers

National decommissioning strategy:

Answer Options	Response
Immediate dismantling	37%
Safe enclosure	16%
As soon as a disposal route is open	11%
Deferred dismantling	5%
Not decided yet	21%
Other	11%

R6

Whether intermediate storage facilities are or will be available (by law/national programme). If so the responder was asked to define whether those are to be local or centralised/national as well as for which waste forms (VLLW/LLW, ILW, HLW):

Yes	100%
No	0%

R7

	For VLLW/LLW	For ILW	For HLW (Fuel)
Local	81%	88%	69%
Centralised/national	64%	71%	93%

R8

Material and waste disposition alternatives available/forecasted to be available by national programme:

Clearance of material for unrestricted use	90%
Conditional clearance for disposal on conventional disposal site	63%
Conditional clearance of metals for recycling outside nuclear sector	63%
Recycling of metals within nuclear sector	42%
Presently not defined	50%
Do not know	5%

R9

Disposition alternatives for radioactive waste available/forecasted to be available by national programme:

Nuclear licensed near surface repository	53%
Nuclear licensed deep geological repository	53%
Nuclear licensed surface repository (VLLW)	42%
Nuclear licensed geological repository	26%
Presently not defined	5%
Do not know	0%

R10

The process of characterisation is regulated nationally through:

Defined process in detail, legally binding	0%
Regulated principles (legally binding) combined with guidance documents	68%
Only guidance documents	21%
Not regulated	11%

R11

National experience of characterisation:

	Extensive	Moderate	Limited
Systems and components	71%	12%	18%
Buildings	53%	32%	16%
Sites (soil etc.)	50%	33%	17%

R12

Waste disposal and clearance considerations (i.e. full life cycle approach) is in focus during characterisation:

	In focus	Considered	Not in focus
Systems and components	39%	61%	0%
Buildings	39%	61%	0%
Sites (soil etc.)	26%	68%	5%

R13

The amount of resources qualified to perform radiological characterisation of systems and components, buildings and sites (soil etc.):

	Sufficient	Non-sufficient
Systems and components	72%	28%
Buildings	67%	33%
Sites (soil etc.)	61%	39%

R14

The number of accredited laboratories nationally that can perform the required analyses and measurements of samples:

	Sufficient	**Non-sufficient**
For gamma measurements	79%	21%
For alpha measurements	67%	33%
For hard to measure nuclides	61%	39%
For hazardous substances in radioactive samples (PCB, Hg etc.)	69%	31%

R15

4. INITIATION PHASE

Introduction

The process of planning the characterisation, implementing the characterisation and assessing the characterisation results prior to making a decision is called the data life cycle.

The data life cycle comprises three steps: planning, implementation, and assessment. During the planning phase, a systematic planning procedure like the Data Quality Objectives (DQO) process is recommended to be used to define quantitative and qualitative criteria for determining when, where, and how many samples to collect and a desired level of confidence. This information, along with the sampling methods, analytical procedures, and appropriate quality assurance (QA) and quality control (QC) procedures are documented.

During the implementation phase data are then collected following the documented specifications. Data Quality Assessment (DQA) completes the data life cycle by providing the assessment needed to determine if the planning objectives were achieved.

During the assessment phase, the data are validated and verified to ensure that the sampling and analysis protocols specified in the characterisation plan (or equivalent document) were followed, and that the measurement systems performed in accordance with the criteria specified in the characterisation plan (or equivalent document). DQA then proceeds using the validated data set to undertake a data assessment in order to make a decision in line with the project objectives.

The entire section has been responded by the regulators and owners.

Questions and nswers

In the view of Best Practice, should the characterisation objectives be outlined in a specific document such as a characterisation Strategy/Characterisation Plan in the Initiation Phase?

	Regulators	Owners
Yes – in detail as part of an overall plan	58%	50%
Yes – a high-level document (only objectives and main principles)	37%	32%
No – too early - objectives are to be defined at a later stage (please state when and in what documentation)	5%	3%
No, not needed. A reference to international standards and recommendations is enough	0%	6%
Do not know	0%	9%

R16,I15

What are the objectives of the characterisation activities before/during dismantling? Please mark the objectives considered as important and rank them High / Medium / Low in the table below for the phases of a decommissioning project.

Before dismantling (planning phase)	Regulators	Owners
Generate input to decommissioning plan	88%	89%
Planning of specific projects	70%	83%
Determination of relevant radionuclides and nuclide vectors (scaling factors / fingerprints)	81%	88%
Validation of nuclide vectors / scaling factors / fingerprints	53%	67%
Overview of hazardous substances (asbestos, PCB etc.)	75%	84%
Input to cost estimations	85%	85%
Environmental impact assessment	86%	84%
Asset management (physical state of systems and components)	68%	67%
Safety analyses	80%	91%

Management of radiological hazards for workers	75%	85%
Planning for radioactive waste minimisation i.e. avoidance, minimisation, reuse, recycle	86%	81%
Planning for radioactive waste treatment	84%	81%
Planning for radioactive waste storage (raw or conditioned waste)	88%	79%
Planning to determine the waste disposal routes (existing or planned)	88%	80%
Estimate waste inventory (activity, mass, volume etc.) and its categorisation	84%	83%
Gather information for qualification of waste for disposal	62%	68%
Reporting to national radwaste inventory	55%	63%
Planning of waste treatment (decontamination, compaction, melting etc.)	79%	79%

During actual dismantling	Regulators	Owners
Generate input to decommissioning plan	65%	57%
Planning of specific projects	85%	67%
Determination of relevant radionuclides and nuclide vectors (scaling factors / fingerprints)	84%	68%
Validation of nuclide vectors / scaling factors / fingerprints	100%	81%
Overview of hazardous substances (asbestos, PCB etc.)	73%	81%
Input to cost estimations	53%	56%
Environmental impact assessment	72%	56%
Asset management (physical state of systems and components)	73%	53%
Safety analyses	83%	71%
Management of radiological hazards for workers	98%	87%
Planning for radioactive waste minimisation i.e. avoidance, minimisation, reuse, recycle	81%	77%
Planning for radioactive waste treatment	74%	75%
Planning for radioactive waste storage (raw or conditioned waste)	67%	72%
Planning to determine the waste disposal routes (existing or planned)	75%	61%
Estimate waste inventory (activity, mass, volume etc.) and its categorisation	79%	75%
Gather information for qualification of waste for disposal	88%	77%
Reporting to national radwaste inventory	70%	71%
Planning of waste treatment (decontamination, compaction, melting etc.)	81%	71%

R17,I16

Remark: The responses have been weighted with a factor 5 for “High”, 3 for “Medium” and 1 for “Low”. 100% represents 5 (High) by all responders.

5. PLANNING PHASE

Introduction

The planning phase is important for a successful characterisation project. This can be structured in different ways. For this questionnaire the DQO process as defined by USEPA was used as the basis for the questions.

The DQO process aims to develop performance and acceptance criteria (or data quality objectives) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.

The entire section has been responded by the owner group only.

Questions and answers

Should a systematic (sampling, measurement and analyses) plan be developed and used?

Yes - detailed	62%
Yes – principles and program content only	24%
No	0%
On case by case basis	15%
Do not know	0%

I17

For material and waste related characterisation projects please mark who is involved with an "x" and the most important role with "xx".

	Planning team	Dismantling expert	WM organisation	QA representative/ Independent expert	Measurement staff/ contractor	Laboratory	Repository organisation
1: State the problem	57%	47%	40%	17%	13%	10 %	20 %
2: Identify the goals of the study or project	53%	33%	37%	17%	13%	7%	13 %
3: Identify information inputs	43%	47%	30%	17%	23%	10 %	13 %
4: Define the boundaries of the study	47%	43%	33%	13%	13%	7%	7%
5: Develop an analytical approach to address the problem	33%	43%	27%	20%	30%	20 %	10 %
6: Specify performance or acceptance criteria	30%	30%	47%	23%	23%	20 %	33 %
7: Develop the plan for obtaining data and results	57%	37%	30%	23%	27%	27 %	10 %

I18

Remark: The responses have been weighted with a factor 3 for "XX" and 1 for "X" and summed up and divided with the number of responses. 100% represents "XX" by all responders.

From a waste and materials perspective, which input information should the characterisation assessment rely on? Please mark the different input parameters with High / Medium / Low.

	Prior to dismantling	**During dismantling**
Facility documentation (drawings, instructions etc.)	95%	64%
Operational history	96%	64%
Characterisation results from previous activities	85%	64%
Interviews of former operating personnel	83%	45%
Use of bibliographic data (literature)	68%	38%
Data from similar facilities	64%	34%
Radiological inventory calculations	85%	64%
Radiological impact calculations (dispersion and shielding calculations)	78%	71%

I19

Remark: The responses have been weighted with a factor 5 for “High”, 3 for “Medium” and 1 for “Low”. 100% represents 5 (High) by all responders.

Estimated number of nuclide vectors required/to be developed?

	Activated material	Contaminated material
One for all	19%	7%
2-4	48%	25%
5-8	11%	36%
9-14	19%	18%
15-20	0%	4%
More than 20	4%	11%

I20

Which key radionuclides should be used as the correlation basis for radionuclide vectors (fingerprints)?

Co-60	85%
Cs-137	82%
U-235	29%
Pu	26%
Am-241	41%
Other	26%

I21

Should a characterisation program also cover physical and chemical vectors

	Physical	Chemical
Yes	56%	68%
No	6%	9%
Do not know	38%	24%

I22

How should the characterisation be prioritised? Rate High/Medium/Low

	Prior to dismantling	**During dismantling**
To confirm classification/categorisation of areas/waste	90%	79%
Focus on areas with high inventory	74%	69%
Focus on areas with large volumes of waste	64%	69%
Based on uncertainty (to gather more information in certain areas)	81%	77%
To secure waste route availability	78%	69%

I23

Remark: The responses have been weighted with a factor 5 for "High", 3 for "Medium" and 1 for "Low". 100% represents 5 (High) by all responders.

To what extent should the strategies/programmes listed below affect the characterisation programme Please rate it High / Medium / Low in the table below for the phases of a decommissioning project.

	Prior to dismantling	**During dismantling**
Dismantling/ demolition strategy	74%	71%
Waste treatment strategy	81%	69%
Material clearance	66%	76%
Waste storage strategy	75%	59%
Waste disposal program	78%	66%

I24

Remark: The responses have been weighted with a factor 5 for "High", 3 for "Medium" and 1 for "Low". 100% represents 5 (High) by all responders.

What approach(es) should be taken to ensure that the characterisation approach gives statistically robust and representative results?

Review by external expert	62%
Internal dedicated review process	94%
Networking/benchmarking with other organisations	41%
Other	18%

I25

6. IMPLEMENTATION PHASE

Introduction

A nuclear facility can be divided into a number of categories. A number of different approaches are available as developed over the years. Certain differences apply but also a lot of similarities.

Facilities were considered to be divided into the following categories: Areas with extremely low risk for contamination (=clean, clearance not required), Areas with low risk for contamination (should be clean but contamination may occur), Areas with risk for contamination (could be clean but also contaminated), Contaminated areas (require contamination to be subject for clearance if at all possible), Highly contaminated areas (dose rate is an issue), Areas affected by neutron activation (mainly RPV and internals)

The entire section has been responded by the owner group only.

Questions and answers

What are the objectives of the characterisation activities before/during the dismantling?

	Prior to dismantling	During dismantling
Areas with extremely low risk for contamination	40%	49%
Areas with low risk for contamination	58%	62%
Areas with risk for contamination	74%	82%
Contaminated areas	83%	86%
Highly contaminated areas	83%	85%
Areas affected by neutron activation	75%	69%

I26

Remark: The responses have been weighted with a factor 5 for "High", 3 for "Medium" and 1 for "Low". 100% represents 5 (High) by all responders.

How should the sampling/measurement location be set out?

Random	10%
Regular mesh	16%
Based on distribution hypothesis	29%
Other	45%

I27

If converted into measurements – what type of measurements are important to build the basis of the characterisation report?

	Prior to dismantling	During dismantling
Loose contamination (smear test or wipe test)	70%	73%
Dose rate measurements	85%	83%
CPS – Alpha (in-situ handheld instruments)	70%	81%
CPS - Beta (in-situ handheld instruments)	73%	85%
In-situ gamma scan (gamma camera etc.)	54%	52%
In-situ gamma measurements	73%	75%
Volume (box etc.) gamma counter	47%	68%

Material samples - nuclide specific activity gamma emitting nuclides	77%	85%
Material samples - nuclide specific activity alpha emitting nuclides	68%	75%
Material samples - nuclide specific activity low beta emitting nuclides	66%	71%

I28

What measures should be taken to identify contamination depth?

Core drilling	19%
Step-wise core drilling	16%
Scrabbling (removal of surface)	13%
Other	52%

I29

How should Sampling be repeated/checked to verify results? More than one alternative can be marked.

Systematic process (part of sampling/measurement plan)	65%
If extreme results	48%
Random checks	29%
When found needed, no special process	19%
Other	13%

I30

How should measurements be repeated/checked to verify results? More than one alternative can be marked.

Systematic process (part of sampling/measurement plan)	65%
If extreme results	52%
Random checks	32%
When found needed, no special process	16%
Other	13%

I31

How should analyses be repeated?

Systematic process (part of sampling/measurement plan)	68%
If extreme results	52%
Random checks	23%
When found needed, no special process	10%
Other	13%

I32

7. DATA ASSESSMENT PHASE

Introduction

Evaluation is of importance to make decisions based on characterisation data. The assessment phase in a data life cycle approach consists of three phases: data verification, data validation, and evaluation of data using the data quality assessment (DQA). The DQA is the scientific and statistical evaluation of data to determine if data obtained are of the right type, quality and quantity to support their intended use.

The entire section has been responded by the regulators and owners, unless otherwise stated.

Questions and answers

Owners: Should systematic assessment plans be used?

Regulators: Do you as regulator representative prescribe/propose systematic Assessment plans?

	Regulators	Owners
Yes	32%	45%
Not mandatory but on case by case basis	32%	42%
No	32%	3%
Do not know	5%	10%

R18,I33

For material and waste related characterisation projects please mark who is involved with an "X". Mark the most important role with "XX" (owners only).

	Planning team	Dismantling expert	WM organisation	QA representative/ Independent expert	Measurement staff/contractor	Laboratory	Repository organisation
Data verification	19%	29%	28%	36%	38%	38%	6%
Data validation	25%	28%	25%	33%	29%	42%	9%
Data evaluation using DQA process	29%	32%	32%	29%	32%	23%	9%
Step 1: Review DQOs and sampling design	28%	33%	26%	39%	28%	16%	4%
Step 2: Conduct preliminary data review	23%	23%	26%	29%	28%	19%	3%
Step 3: Select statistical test	22%	22%	22%	28%	20%	19%	6%
Step 4: Verify the assumptions	25%	32%	32%	28%	14%	12%	9%
Step 5: Draw conclusions from the data	36%	46%	36%	26%	16%	13%	13%

I34

Remark: The responses have been weighted with a factor 3 for “Most important” (XX) and 1 for “Should be involved” (X). 100% represents most important role by all responders. The 10 highest are marked red and the 10 lowest blue.

How should the material and waste characterisation data be evaluated?

	Regulators	Owners
Combination of judgemental and probabilistic	47%	45%
Approach selected on case by case basis	32%	32%
Probabilistic-based	5%	3%
Judgemental	0%	7%
Do not know /other	16%	13%

R19,I35

Do you request or recommend graphical modelling for evaluation and presentation of results?

	Regulators	Owners
yes - request	11%	32%
yes - recommend	42%	68%
maybe - on case by case basis	42%	0%
no	5%	0%

R20,I36

What impact will the following uncertainties have on the evaluation of material and waste characterisation?

	Regulators	Owners
Sampling/measurement representativeness	98%	100%
Sample composition (for analyses)	72%	77%
Shielding and impact of background (for measurements)	69%	72%
Activity distribution variations	91%	85%
Nuclide composition variations	84%	82%
Instrument uncertainty	53%	62%
Analyse method uncertainty	53%	68%
Measurement/sampling staff motivation/attitude	67%	66%
Measurement/sampling staff understanding	81%	68%

R21,I37

Remark: The responses have been weighted with a factor 5 for “High”, 3 for “Medium” and 1 for “Low”. 100% represents 5 (High) by all responders.

8. QUALITY ASSURANCE PHASE

Introduction

The entire section has been responded by the regulators and owners, unless otherwise stated.

Questions and answers

Should a characterisation campaign have a dedicated Quality Assurance Plan?

	Regulators	Owners
yes, always	79%	61%
for large campaigns only	5%	7%
complex campaigns only	5%	16%
if requested	11%	10%
no – not needed, covered by standards	0%	7%

R22,I38

When should it be developed?

	Regulators	Owners
When setting objectives (initiation phase)	37%	29%
During planning phase	58%	48%
In parallel with implementation phase (when practical challenges are known)	5%	16%
Do not know	0%	7%

R23,I39

Which measures for quality assurance should be applied, and how should the quality be maintained throughout the materials and waste characterisation process? Please tick the 5 most appropriate choices in the following table with an "X". Mark the most important one with "XX".

Before dismantling (planning phase)	Regulators	Owners
Use of specific documentation of the characterisation design (For example a Characterisation Plan that incorporates the characterisation objectives and design)	57%	67%
Evaluation of plans for characterisation by independent experts/technical peer	30%	27%
Review of sampling and measurement plans	27%	27%
Use of defined in-situ monitoring and sampling procedures	13%	27%
Internal audit of in-situ monitoring and sampling	3%	17%
Independent audit of in-situ monitoring and sampling	10%	10%
Data entered into a database for access in later stages of decommissioning	17%	27%
Use of accredited laboratories	23%	30%
Internal audits of laboratories	7%	20%
Independent control measurements	7%	13%
Review of representativeness of sampling	23%	33%
Evaluation of characterisation results by external experts	20%	13%

R24a,I40a

Remark: The responses have been weighted with a factor 3 for "XX" and 1 for "X" and summed up and divided with the number of responses. 100% represents "XX" by all responders.

During dismantling	Regulators	Owners
Use of specific documentation of the characterisation design (For example a Characterisation Plan that incorporates the characterisation objectives and design)	30%	50%
Evaluation of plans for characterisation by independent experts/technical peer	13%	23%
Review of sampling and measurement plans	23%	37%
Use of defined in-situ monitoring and sampling procedures	23%	33%
Internal audit of in-situ monitoring and sampling	17%	20%
Independent audit of in-situ monitoring and sampling	10%	17%
Data entered into a database for access in later stages of decommissioning	17%	30%
Use of accredited laboratories	27%	33%
Internal audits of laboratories	10%	20%
Independent control measurements	37%	27%
Review of representativeness of sampling	37%	33%
Evaluation of characterisation results by external experts	37%	23%

R24b,I40b

For Material for Clearance: how long must/should material samples from characterisation have to be kept for reference?

	Regulators	Owners
Only results will be stored	42%	36%
Up to clearance	26%	26%
Case by case decision	5%	29%
A specified number of years (please specify)	26%	10%

R25,I41

Referring to the previous question (regulators only): This is a

recommendation	63%
requirement	37%

R26

For VLLW/LLW: How long must/should material samples from characterisation have to be kept for reference?

	Regulators	Owners
Only results will be stored	32%	36%
Up to final disposal	26%	32%
Case by case decision	26%	23%
A specified number of years (please specify)	16%	10%

R27,I42

Referring to the previous question (regulators only): This is a

recommendation	63%
requirement	37%

R28

For ILW: how long must/should material samples from characterisation have to be kept for reference?

	Regulators	Owners
Only results will be stored	26%	26%
Up to final disposal	32%	29%
Case by case decision	26%	36%
A specified number of years (please specify)	16%	10%

R29,I43

Referring to the previous question (regulators only): This is a

recommendation	63%
requirement	37%

R30

For Material for Clearance: how long must/should the characterisation strategy, results, evaluation and quality information be kept for reference?

	Regulators	Owners
Only results will be stored	16%	23%
Up to clearance	11%	20%
Till completion of the decommissioning project	11%	17%
Case by case decision	11%	0%
A specified number of years	53%	40%

R31,I44

Referring to the previous question (regulators only): This is a

recommendation	63%
requirement	37%

R32

For VLLW/LLW: how long must/should the characterisation strategy, results, evaluation and quality information be kept for reference?

	Regulators	Owners
Only results will be stored	21%	27%
Up to (final) disposal	21%	13%
Till completion of the decommissioning project	11%	17%
Case by case decision	16%	0%
A specified number of years (please specify)	32%	43%

R33,I45

Referring to the previous question (regulators only): This is a

recommendation	63%
requirement	37%

R34

For ILW: how long must/should the characterisation strategy, results, evaluation and quality information be kept for reference?

	Regulators	Owners
Only results will be stored	21%	27%
Up to clearance	11%	13%
Till completion of the decommissioning project	11%	10%
Case by case decision	21%	0%
A specified number of years (please specify)	37%	50%

R35,I46

Referring to the previous question (regulators only): This is a

recommendation	63%
requirement	37%

R36

What systems/principles for storage of characterisation information should be used?

	Regulators	Owners
Centralised system	58%	65%
Local software solution (Excel, Word etc.)	26%	13%
Paper report	47%	10%
Other (please specify)	21%	13%

R37,I47

Should there be an independent review of the results and evaluation?

	Regulators	Owners
Yes	58%	36%
No	5%	0%
Case by case basis (when needed)	26%	58%
Do not know	11%	7%

R38,I48

Who should do the independent review?

	Regulators	Owners
Licensee	0%	19%
Regulator	26%	16%
Waste management organisation	0%	7%
Independent expert	42%	48%
Other/Do not know	32%	10%

R39,I49

How many percent of samples should be analysed by at least a second laboratory for evaluation purpose?

	Regulators	Owners
None	11%	10%
<1%	0%	7%
1-5%	47%	26%
5-10%	37%	23%
>10%	5%	0%
Do not know	0%	36%

R40,I50

How many percent of in-situ measurements should be repeated for evaluation purposes?

	Regulators	Owners
None	5%	10%
<1%	0%	7%
1-5%	53%	16%
5-10%	37%	23%
>10%	5%	0%
Do not know	0%	45%

R41,I51