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Characterisation principles for soils, buildings and infrastructures contaminated by radionuclides for remediation purposes

Principes de caractérisation des sols, bâtiments et infrastructures contaminés par des radionucléides, à des fins de réhabilitation

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Sub-committee SC 5, *Nuclear fuel cycle*.

Introduction

The remit of WG 13 covers all aspects of the decommissioning phase, and thus it interfaces with other Sub-Committees and Working Groups whose work intersects with this phase.

Figure 1 below indicates some of the topics that could be included in SC 5 and/or WG 13. It provides a view of how the scope of this ISO Standard links with both generic and more detailed topics.

This document contains both guidance and references to documents which may be useful in relation to this work area. Read in conjunction with the supporting references, it gives a generic approach to the topic. It also may have connections with many other blocks across the whole diagram (e.g. Decommissioning strategy, Waste Management, Site remediation, Dismantling/Demolition, Cost issues, Safety).

Moreover, it was not intended to establish this document as a stand-alone document. When a member country already has national tools in this field (e.g. regulatory requirements, national standards), these requirements and national standards are applicable in conjunction with this document.

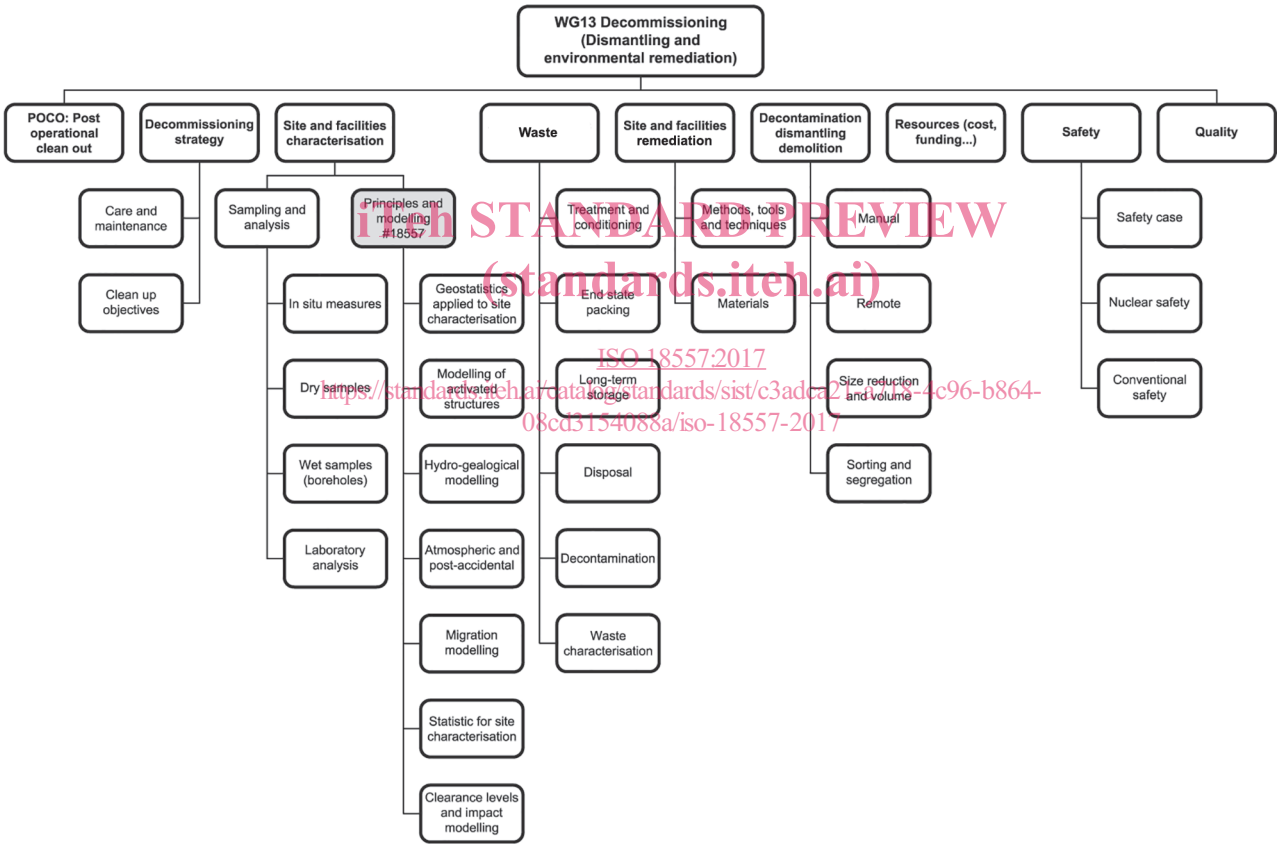

Figure 1 — Indicative chart of the topics included in WG 13, showing how this document is linked to other topics

This work stream structure can be used to clarify the scope of WG publications and to ensure that areas of joint interest between ISO teams and working groups are coordinated. The ISO shadow committee for a member body identifies proposals for further work and, if appropriate, submits them to the Working Group for international consideration as potential new work items. Figure 1 can be a useful prompt in this process. This document is part of an overall decommissioning and environmental remediation strategy including, for example, the monitoring and/or remediation of groundwater which might be addressed in a new work item.

Since the discovery of radioactivity at the end of the 19th century, numerous laboratories and facilities have dealt with radioactive substances (notably radium). In addition, the development and considerable expansion of the nuclear industry, both civilian and defence, has generated many nuclear facilities built since the 1940s, resulting today in legacy sites.

More recently, nuclear operators and state organisations have intensively undertaken the dismantling and remediation of shutdown nuclear facilities. Remediation projects also concern former mining sites, other legacy sites and industrial sites having produced NORM (Naturally Occurring Radioactive Material) and TENORM (Technologically Enhanced NORM) waste, where the main issue is the large volume of waste involved. The aim is primarily to demonstrate that the entire nuclear cycle is well managed. A large number of issues need to be considered:

— The nuclear regulatory framework did not exist at the beginning and it has evolved over time (release procedures, health and safety, environmental considerations…). In addition, there is more and more stakeholder involvement today, and this needs to be considered at the early stages of any project.

— The availability of waste management facilities and disposal sites varies between countries and through time. The classification based on activity levels: e.g. very low level waste (VLLW), low level waste (LLW), intermediate level waste (ILW), high level waste (HLW) and nuclide half-lives (short-lived or long-lived radionuclides) impacts remediation projects. These factors sometimes result in the partial clean-up of sites, due to the absence of a final solution for waste disposal. Waste may also have had to be temporarily stored on site for economic reasons.

— Remediation costs and schedules are optimized and rationalized using a graded approach, as these projects are generally expensive and time consuming. They also need to be securely funded and planned.

— In order to optimize waste categories, volumes and costs, characterization is a crucial issue enabling the best knowledge of the radiological state of the site (soils, buildings and infrastructures) to be obtained before making project decisions.

Lessons learned from the first sites to be remediated have demonstrated that poor characterization (based on incomplete historical information and too limited a number of data points or samples) strongly impacts the success of a remediation project, with inappropriate choices having been made (over-estimation of volumes and over-categorization of waste, unexpected contamination).

As a consequence, it is now recognized that accurate characterization is the key to successful dismantling and remediation projects. There are many characterization steps necessary throughout a project, each with specific objectives.

The main potential improvement concerns the sampling effort, sample representativeness and assessment of activity levels assessments. Combined with data analysis and processing, all the uncertainties involved are combined to deliver a result with a corresponding confidence interval. Therefore the characterization strategy and programme should be set well before the actual measurements, to ensure efficiency.

The preparation of any nuclear facility's remediation programme requires knowledge of its operational history. This covers the entire period from design, licensing and through to final shutdown, in order to establish the nature and location of potential or known radioactive contamination, together with possible associated chemical products, with the appropriate accuracy. The overall remediation strategy requires an estimation of the quantity and the volume of waste to be produced, and an assessment of its level of contamination. This enables appropriate optimized waste management.

In addition, a final characterization is compulsory for sites to be released and/or re-used in order to demonstrate compliance with remediation objectives (clearance levels, if any, or a release threshold set by, or agreed with, the regulatory body).

This document outlines the principles of characterization for remediation purposes of soils, buildings and infrastructures contaminated by radionuclides and possible associated chemical pollutants.

As the preparation of a sampling plan is an iterative process, decision-taking steps will be defined throughout this document taking into account constraints imposed by operations, budgets and regulations, while respecting the ALARA and ALARP principles.

The application of this methodology will aid the user to obtain the information necessary for compiling the files associated with remediation operations, as required by the regulatory authorities. It is applicable to each of the steps necessary for the remediation of sites, depending on the objectives (release into the public domain, re-use). It can enable an assessment to be established for contaminated soils, or in preparing to carry out post-remediation checks (even including the facility's civil engineering structures), in order to confirm that the remediation objectives have been met.

With regards to the recommendations of the International Atomic Energy Agency (IAEA), a graded approach should be considered for the characterization of soils, buildings and infrastructures for remediation purposes. The characterization strategy, programme and planning should be commensurate with the complexity of the remediation problem and with the established end state. A graded approach can limit occupational exposure for workers, as well as saving time and money [ref. IAEA = DeSa project (Evaluation and Demonstration of Safety for Decommissioning of Facilities Using Radioactive Material)].

Characterisation principles for soils, buildings and infrastructures contaminated by radionuclides for remediation purposes

1 Scope

This document presents guidelines for sampling strategies and characterization processes to assess the contamination of soils, buildings and infrastructures, prior to remediation and/or to check that the remediation objectives have been met (final release surveys). The principles presented need to be appropriately graded as regards the specific situations concerned (size, level of contamination…). *It can be used in conjunction with each country's key documentation.*

This document deals with characterization in relation to site remediation. It applies to sites contaminated after normal operation of older nuclear facilities. It could also apply to site remediation after a major accident, and in this case the input data will be linked to the accident involved.

The document complements existing standards, notably concerning sampling, sample preservation and their transport, treatment and laboratory measurements, but also those related to *in situ* chemical and radiological measurements. *References in the Bibliography contain links to appropriate documentation and techniques as required by individual member countries.*

The document does not apply to the following issues: execution of clean-up works, sampling and characterization of waste (conditioned or unconditioned) or to waste packages.

It does not apply to groundwater characterization (saturated zone).

Given the case-by-case nature of site remediation and decommissioning, the principles and guidance communicated in this document are intended as general guidance only, not prescriptive requirements.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
characterization
determination of the nature, concentration and spatial extent of radiological and chemical contents present in a specified place

Note 1 to entry: See also radiological and chemical survey.

3.2
clean-up work
actions taken to reduce the exposure to radiological and chemical substances from existing contamination through actions applied to the contamination itself (the source) or to the exposure pathways to humans and the environment

Note 1 to entry: See also *remediation* (3.22).

3.3
clearance level
release threshold
value, or a set of values, established by a regulatory body and expressed in terms of activity concentration and/or total activity, at or below which a source of radiation may be released from regulatory control

3.4
contaminant
radioactive or chemical substance or agent present in a medium which due to its properties, amount or concentration may have impacts on the environment and human health

3.5
contamination
presence of radioactive or chemical substance or agent in any medium where it is not desired, and which due to its properties, amount or concentration may have impacts on the environment and human health

3.6
cost-benefit analysis

decision aiding tool using a systematic evaluation of the positive effects (benefits) and negative effects (disbenefits) of undertaking an action, integrating technical, time-schedule, management, financial, societal, environmental issues.

3.7

data quality assessment
DQA
process performed once the collected data have been properly verified and validated

Note 1 to entry: In DQA, assessment means evaluation of quality of data that is meaningful only when it relates to the intended use of the data.

3.8
data quality objective
DQO
process used to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study

3.9
destructive analysis
DA
analysis of radioactive and chemical materials using methods which involve the destruction of a sample, e.g. chemical and radiochemical analysis, ICP-MS, alpha spectrometry

3.10
difficult to measure radionuclides DTM
nuclides that cannot be easily measured through their gamma radiation or beta emissions; usually comprise alpha-emitting nuclides without strong gamma lines or pure beta emitters

Note 1 to entry: Examples include ^{3}H, ^{14}C, ^{36}Cl, ^{90}Sr, ^{99}Tc, ^{129}I, ^{238}Pu.

3.11
easy to measure radionuclides
ETM
gamma emitting nuclides whose radioactivity can be readily measured directly by non-destructive analysis means

3.12
fingerprint
nuclide vector
used to infer and quantify the presence of other key nuclides

Note 1 to entry: Applying correlation factors enables estimations of *difficult to measure nuclides* (3.10).

Note 2 to entry: It is a method which involves measurements of *easy to measure radionuclides* (3.11) (usually gamma emitters, e.g. ^{137}Cs, ^{60}Co) to quantify *difficult to measure nuclides* (3.10).

3.13
geostatistics
statistical methodology based on the use of spatial correlations between couples of measured values, which produces interpolation maps by the kriging technique

Note 1 to entry: The added value of geostatistics lies in the quantification of the result uncertainty and its more advanced techniques (non linear, non stationary, multivariate…).

3.14
graded approach
application of safety requirements that is commensurate with the characteristics of the practice or source and with the magnitude and likelihood of the exposures

Note 1 to entry: The use of a *graded approach* is intended to ensure that the necessary levels of analysis, documentation and actions are commensurate with, for example, the magnitudes of any radiological hazards and non-radiological hazards, the nature and the particular characteristics of a *facility or site*, and the stage in its *lifetime*.

3.15
health impact assessment
combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population

3.16
infrastructures
all ancillary equipment and facilities providing necessary support to the operation of a nuclear facility or site: e.g. sewage network, roads. but also heavy equipment which might be disposed of as waste or re-used after clean-up, such as bridge and portal cranes

3.17
in situ measurement
field measurement
measurement where the detection instrument is taken to the material: it is a non-destructive measurement

3.18
judgement assessment
measurements performed at locations selected using expert judgment based for instance on unusual appearance, location relative to known contaminated areas, high potential for residual radioactivity, general supplemental information.

3.19
mapping
representation of 2D or 3D objects

Note 1 to entry: Background layers consist of aerial or satellite images as well as vectorial maps. Measured data are represented in the form of a map (points, colourscale, size, symbol…). It also integrates 2D and 3D grid results (e.g. isocontours, slices, selection).

3.20
non-destructive analysis
NDA
number of analytical techniques that allow measurement of specific properties without physical destruction of the media/item

Note 1 to entry: Generally used for *in situ* measurements.

3.21
radionuclide
RN
nucleus (of an atom) that possesses properties of spontaneous disintegration (radioactivity)

Note 1 to entry: Nuclei are distinguished by their mass number and atomic number.

3.22
remediation
measures taken for contaminant removal, containment or monitored non-intervention at a contaminated site to reduce exposure to radiation, and for improvement in the environmental and/or economic value of the contaminated site

Note 1 to entry: to entry**:** Remediation of a site does not necessarily imply a restoration of the site to pristine condition.

3.23
remediation objectives
generic term for any objective, including those related to technical (for example residual contamination concentrations, engineering performance), administrative and legal requirements

Note 1 to entry: to entry**:** The future site end-use assumption forms the basis of remediation objectives and is used in developing the strategy for the decommissioning and remediation activities.

3.24
sample
set of individual physical portions or measurements drawn from a population whose properties are studied to gain information about the entire population

Note 1 to entry: to entry**:** The manner the sample is selected should be described in the *sampling plan* (3.27).

3.25
laboratory sample
sample intended for laboratory inspection or analysis

Note 1 to entry: When the laboratory sample is further prepared (reduced) by subdividing, mixing, grinding, or by combinations of these operations, the result is the test sample. When no preparation of the laboratory sample is required, the laboratory sample is the test sample. A test portion is removed from the test sample for the performance of the test or for analysis.

Note 2 to entry: The laboratory sample is the final sample from the point of view of sample collection but it is the Initial sample from the point of view of the laboratory.

Note 3 to entry: Several laboratory samples may be prepared and sent to different laboratories or to the same laboratory for different purposes.

3.26
sampling
act of taking or constituting (and preparing) a sample, in the aim of investigating a whole population

Note 1 to entry: For the purpose of soil investigation, “sampling” also relates to the selection of locations for in situ testing carried out in the field without removal of material.

3.27
sampling plan
detailed outline of which measurements will be taken, typically detailing at what times, on which material, in what manner, and by whom

Note 1 to entry: Sampling plans are designed in such a way that the resulting data will contain a representative sample of the parameters of interest and enable all questions, as stated in the goals, to be answered.

Note 2 to entry: The steps involved in developing a sampling plan are typically:

a) Identify the parameters to be measured, the range of possible values, and the required resolution.

b) Design a sampling scheme that details how and when samples will be taken.

c) Select sample sizes.

d) Design data storage formats.

e) Assign roles and responsibilities.

Note 3 to entry: This includes which surveys will be done, which samples will be taken, and how they will be collected, prepared and measured (e.g. sampling point, time of collection, depth of sampling, and other variables necessary to carry out a measurement of a specific sampling location in time and space).

Note 4 to entry: The plan may specify, for example, that the sampling is systematic and in two stages. In combination with the specification of the type of sampling, the sampling plan in this example also may specify the number of increments to be taken from a lot, the number of composite samples (or gross samples) per lot, the number of test samples per composite sample, and the number of measurements/tests per test sample.

3.28
probabilistic sampling
sampling conducted according to the statistical principles of sampling, to ensure that each particle or element in the population submitted to sampling has an equal chance of being part of the sample

Note 1 to entry: Probabilistic sampling results in boundary conditions for the type of sampling equipment used, the method of sampling (where, when, how) and the minimum size of increments and (composite) samples.

3.29
site
any installation, facility, or discrete physically separate parcel of land, or any building or infrastructure or portion thereof, that is being considered for survey and investigation and if necessary, remediation

Note 1 to entry: It includes soils, buildings and infrastructures (excluding surface and groundwater).

3.30
radiological survey
chemical survey
type of survey that includes facility or site sampling, monitoring, and analysis activities to determine the extent and nature of *contamination* (3.5)

Note 1 to entry: Characterization surveys provide the basis for acquiring necessary technical information to develop, analyse, and select appropriate cleanup techniques.

Note 2 to entry: See also *characterization* (3.1).