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Nuclear criticality safety — Solid waste excluding irradiated and non-irradiated nuclear fuel

Sûreté-criticité — Déchets solides à l'exclusion du combustible nucléaire irradié et non irradié

Reference number
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Contents

Page

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*, Subcommittee SC 5, *Nuclear installations, processes and technologies*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Nuclear criticality safety considerations can play a significant role in the production, management, transport and disposal of waste containing fissile nuclides. Such waste can present particular challenges from a nuclear criticality safety perspective.

— The fissile content of waste can vary significantly. Most waste has a relatively low fissile content; however, there is the potential for waste to contain some items with significantly higher fissile inventory or for fissile nuclides to move and/or increase in local concentration. Typically, there are also large variations associated with the moderators, absorbers and scattering materials which make up the waste matrix.

— The uncertainties associated with the quantity, distribution, concentration and elemental fractions of fissile nuclides associated with a waste material can be large. Typically, there is also significant uncertainty associated with the moderators, absorbers and scattering materials that may comprise the waste matrix.

— Very large volumes of waste requiring criticality assessment can arise. Often the average fissile concentration can be low, but the total fissile mass can be significant.

— The physical and chemical form of waste can be very diverse, with a wide variety of potential effects on nuclear criticality safety (e.g. moderation, neutron poisons, neutron reflectors, etc.).

— The timescales that require nuclear criticality safety to be demonstrated for waste may be very long (and could be as large as hundreds of thousands of years or more when considering final disposal). Over such timescales, there is the potential for key parameters to change - for example, nuclide proportions as a result of radioactive decay, chemical changes in the waste matrix, re-distribution of fissile nuclides and moderators, separation of poisons. There is the potential for significant variability in the distribution of fissile nuclides within the waste volume at the time of disposal.

— There is often a requirement to transport waste within the public domain, which can be subject to differing limits and constraints when compared with where the waste was produced.

The purpose of this document is to support nuclear criticality safety throughout the waste life cycle while taking into account the potential to have a significant negative impact on other important areas such as:

— Radiological safety: For example dose control, risk of nuclear material ingestion/inhalation, the potential for contaminated wounds when handling waste, etc. If the nuclear criticality safety limits are set with little consideration of the other areas, resulting in large criticality safety margins, there is the potential for reworking waste to ensure compliance, incurring unnecessary radiological risk.

— Environmental considerations: For example additional handling, processing and storage leading to additional discharges, use of services such as electricity and water, generation of additional contaminated and non-contaminated packaging materials, generation of increased waste volumes.

— Conventional safety: For example additional risks of acute or chronic physical injuries.

— Cost: For example excessive or disproportionate costs which might be better spent reducing risk elsewhere. Final disposal space (e.g. deep geological disposal or shallow/ surface disposal) is an expensive, finite resource – with costs being directly linked to the volume of waste produced. Cost may also arise from, for example, the numbers of packages produced and the number of package movements required.

— Delay: For example potential for excessive delay due to development of overly complicated engineered solutions or safety arguments.

The criticality safety specific requirements and guidance within this document are to be applied with an awareness of this wider context to ensure that an appropriate balance between the criticality safety considerations and these other important factors is achieved.

Nuclear criticality safety — Solid waste excluding irradiated and non-irradiated nuclear fuel

1 Scope

This document provides specific requirements and guidance on the nuclear criticality safety of waste containing fissile nuclides, generated during normal operations. This document is intended to be used along-side and in addition to ISO 1709.

This document applies specifically to the nuclear criticality safety of solid nuclear wastes. It also applies to residual quantities of liquids and/or slurries which are either intimately associated with the solid nuclear waste materials or arise as a result of processing or handling the waste.

This document does not apply to bulk or process liquids (including higher concentration process solutions) or irradiated or un-irradiated fuel elements.

NOTE The term fuel element is sometimes applied to fuel assembly, fuel bundle, fuel cluster, fuel rod, fuel plate, etc. All these terms are based on one or more fuel elements. A cylindrical fuel rod (sometimes referred to as a fuel pin) for a light-water-reactor is an example of a fuel element.

All stages of the waste life cycle are within the scope of the document. This document can also be applied to the transport of solid nuclear waste outside the boundaries of nuclear establishments.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1709, *Nuclear energy — Fissile materials — Principles of criticality safety in storing, handling and processing*

ISO 12749-3, *Nuclear energy, nuclear technologies and radiation protection — Vocabulary — Part 3: Nuclear fuel cycle*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1709, ISO 12749-3 and the following apply.

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

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

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

3.1
waste
<nuclear criticality safety> any kind of solid material containing or contaminated with fissile nuclides for which no further use is foreseen, not including irradiated or un-irradiated fuel elements

Note 1 to entry: This also includes:

a) solids containing or contaminated with fissile nuclides for which no further use is foreseen, but for which further work to prepare the waste for final disposal is programmed, e.g. volume reduction;

b) residual quantities of liquid or slurry type wastes which are either intimately associated with the solid nuclear wastes, or generated as a result of processing or handling the waste.

3.1.1
waste life cycle
<nuclear criticality safety> all phases in the life of the waste

Note 1 to entry: These phases can include, but are not limited to:

— pre-generation: the planning, design or operational stage of a process or facility before any waste is produced;

— generation: the processes that lead to generation of waste;

— initial handling: the initial handling of waste, prior to movement to a storage location or interim waste processing;

— local or interim storage: storage of waste for a short period when compared with the longer-term fate of the waste;

— interim waste processing: operations undertaken to further process the waste, prior to final disposal;

— transportation: the deliberate physical movement of waste to either some interim waste processing location, interim storage facility, or the location of final disposal;

— final disposal: emplacement of waste in an appropriate facility without the intention of retrieval (note that the term disposal implies that retrieval is not intended; it does not mean that retrieval is not possible).

Note 2 to entry: Typically, final disposal is split into two phases:

— operational: when the facility is being filled with waste and/or waste movements are taking place;

— post-closure: after the last addition of waste material, no more waste movements. Materials are in a long-term, quiescent state.

3.1.2
waste matrix
non-radioactive materials within waste in which radioactive substances are dispersed, including (but not exclusive to) any encapsulation or immobilisation material

Note 1 to entry: There is no expectation that the dispersal of the radioactive substances is homogeneous throughout the waste matrix.

[SOURCE: ISO 19017:2015, 2.23, modified — added “including (but not exclusive to) any encapsulation material”.]

3.2
nuclear criticality safety strategy for waste
high level plan as to how the nuclear criticality safety of the waste will be managed throughout the waste life cycle

4 Nuclear criticality safety strategy for waste

4.1 General

This document requires that a nuclear criticality safety strategy for waste is developed to make all relevant stakeholders aware of how nuclear criticality safety of solid waste are managed over the waste life cycle. This clause specifies requirements and recommendations for preparing, defining and maintaining a nuclear criticality safety strategy for waste.

4.2 Developing the strategy

A nuclear criticality safety strategy for waste shall be developed and documented.

Developing a nuclear criticality safety strategy as early as practicable will reduce the potential redesign or rework of nuclear criticality safety assessment and controls at a later stage. Documentation of the strategy allows for it to be reviewed; it also forms part of the audit trail as the waste is managed over its entire waste life cycle potentially including multiple owners, handling and processing stages and significant periods of time.

The nuclear criticality safety strategy for waste should be developed at the facility/plant design stage before any waste is created so risk and waste volume reduction options can be considered.

In the instances of existing wastes, which may have been created without a formal nuclear criticality safety strategy for waste, the earliest practicable stage can be regarded as the current stage at the time of application of this document.

4.3 Consulting with stakeholders

The nuclear criticality safety strategy for waste should be developed in consultation with all relevant recognized stakeholders.

If the strategy is developed without the input of all relevant recognized stakeholders, there is the potential that the strategy may not be optimised or will have to be revised at a later stage. However, identifying all relevant stakeholders can be difficult and depends on, amongst other things, the stage the project is at when the nuclear criticality safety strategy is developed. Therefore, it is appropriate to reflect this potential uncertainty in the wording of this recommendation.

Relevant stakeholders could include, but are not necessarily limited to:

— organisations who will handle, process, store, transport or dispose of the waste over the waste life cycle;

— the relevant regulatory body or bodies.

4.4 Strategizing over the waste life cycle

The nuclear criticality safety strategy for waste shall take into account nuclear criticality safety throughout the planned waste life cycle.

If the nuclear criticality safety strategy does not consider the entire planned waste life cycle, there is the potential for incurring higher criticality risk at a future stage, or higher non-criticality risk/costs, for example by having to repackage waste.

It is important that the strategy does not just consider local arrangements but, for example, considers transport and/or final disposal requirements (where applicable). Transportation in the public domain can lead to different regulatory limits than for within a nuclear facility (for example the IAEA criteria, see Reference [1]). Final disposal limits may also be different than would be adequate for local arrangements.

4.5 Radioactive waste characterization

The nuclear criticality safety strategy for waste shall allow for radioactive waste characterization that is proportionate to the criticality hazard of the waste across the full waste life cycle.

Radioactive waste characterization reduces uncertainties and allows for a more realistic assessment. This can reduce costs and allow better comparison between nuclear criticality safety and other important considerations. If proportionate radioactive waste characterization is not built into the strategy, it might be necessary to carry out radioactive waste characterization in conditions that were not originally planned for. It is important for the radioactive waste characterization strategy to consider the full waste life cycle, as, for example, a compound or nuclide which might not be relevant to nuclear criticality safety at an early stage in the waste life cycle could be relevant for final disposal.