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Nuclear facilities — Criteria for design and operation of confinement systems for nuclear worksite and for nuclear installations under decommissioning

Installations nucléaires — Critères pour la conception et l'exploitation des systèmes de confinement des chantiers nucléaires et des installations nucléaires en démantèlement

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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 ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, SC 2, *Radiological protection*.

Nuclear facilities — Criteria for design and operation of confinement systems for nuclear worksite and for nuclear installations under decommissioning

1 Scope

This document specifies the requirements applicable to the design and use of airborne confinement systems that ensure safety and radioprotection functions in nuclear worksites and in nuclear installations under decommissioning to protect from radioactive contamination produced: aerosol or gas.

The purpose of confinement systems is to protect the workers, members of the public and environment against the spread of radioactive contamination resulting from operations in nuclear worksites and from nuclear installations under decommissioning.

The confinement of nuclear worksites and of nuclear installations under decommissioning is characterized by the temporary and evolving (dynamic) nature of the operations to be performed. These operations often take place in area not specifically designed for this purpose.

This document applies to maintenance or upgrades at worksites which fit the above definition.

NOTE The requirements for the design and use of ventilation and confinement systems and for liquid confinement in nuclear reactors or in nuclear installations other than nuclear worksites and nuclear installations under decommissioning are developed in other ISO standards.

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 16170, *In situ test methods for high efficiency filter systems in industrial facilities*

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:

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

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

3.1
climatic shelter
shelter whose function is to provide suitable protection against the weather (sun, rain, wind, snow and extreme temperatures), usually structurally separated from radiological containment

3.2
aerosol
solid particles and liquid droplets of all dimensions in suspension in a gaseous fluid

3.3
barrier
structural element, which defines the physical limits of a volume with a particular radiological environment and which prevents or limits releases of radioactive substances from this volume

EXAMPLE Containment enclosure, shielded cell, filters.

3.4
discharge stack
duct (usually vertical) at the termination of a system, from which the air is discharged to the atmosphere

3.5
air conditioning
arrangement allowing the sustainment of a controlled atmosphere (temperature, humidity, pressure, dust levels, gas content, etc.) in a closed volume

3.6
confinement
arrangement allowing users to maintain separate environments inside and outside an enclosure, blocking the movement between them, of process materials and substances resulting from physical and chemical reactions which are potentially harmful to workers, the external environment, or to the handled products

Note 1 to entry: The word “confinement” is used in several IAEA documents to mean the function of confining radioactive or toxic products whereas “containment” is used to mean the physical barrier that achieves the objective of confinement, i.e. a confined area.

3.7
worksite containment
specific containment implemented to cover the temporary and evolving nature of worksite activities

3.8
dynamic confinement
action allowing, by maintaining a preferential air flow circulation, to limit back-flow between two areas or between the inside and outside of an enclosure, in order to prevent radioactive substances being released from a given physical volume

3.9
contamination
presence of radioactive substances on or in a material or a human body or any place where they are undesirable or could be harmful

3.10
containment enclosure
enclosure designed to prevent either the leakage of products contained in the pertinent internal environment into the external environment, or the penetration of substances from the external environment into the internal environment, or both simultaneously

3.11
gas cleaning
action of decreasing the content of undesirable constituents in a fluid

Note 1 to entry: Gas cleaning is sometimes called "scrubbing".

Note 2 to entry: Aerosol filtration and iodine trapping are examples of gas cleaning.

3.12
filter
device intended to trap particles suspended in gases and fluids or to trap gases themselves

3.13
high efficiency particle air filter
HEPA filter
aeorosol filter that corresponds to the classes H35, H40 or H45 according to ISO 29463-1

3.14
last filtration stage
LFS
last filtering stage implemented on the dynamic confinement release network protecting the environment

EXAMPLE HEPA filters for aerosols, iodine filters, etc.

3.15
Derived air concentration
DAC
amount of contamination in air, which, if 2 200 m^3 is inhaled, would result in the annual limit of intake (ALI)

Note 1 to entry: DAC is defined in ICRP 103 and expressed in Bq/m^3.

Note 2 to entry: The ALI is calculated using reference conversion factors given by ICRP (International Commission for Radiological Protection) for each radionuclide (ICRP 119).

3.16
airtight bag
ventilated airtight bag
flexible containment used to establish an enclosure around a contaminated item, allowing personnel to accomplish works or manipulations potentially via gloved sleeves without contacting the contaminated environment

Note 1 to entry: The airtight bag may include inlet and extract ventilation in order to achieve an air velocity in leakage points or negative pressure within the containment.

3.17
spark arrestor
device fitted upstream of the main filters to minimize transport of particles and the deterioration of main filters, by capture of incandescent large particles

3.18
prefilter
filter fitted upstream of the main air filters to minimize the dust burden on the latter, by removal of large particles

3.19
negative pressure
depression
pressure difference between the pressure of a given volume, which is maintained lower than the pressure in a reference volume or the external ambient pressure

3.20
confinement system
system constituted by a coherent set of physical barriers and/or dynamic systems intended to confine radioactive substances

3.21
ventilation system
totality of network components such as ducts, fans, filter units and other equipment, that ensures ventilation and gas cleaning functions

3.22
air-change rate
ratio between the ventilation air flow rate of a containment enclosure or a compartment and the volume of this containment enclosure or compartment, during normal operating conditions

3.23
ventilation
organization of air flow patterns within an installation

4 Functions ensured by the confinement

The confinement of nuclear worksite and nuclear installations under decommissioning (sometimes in complement with the existing confinement of the installation) enables the improved safety of the workers, members of the public and provides protection of the environment. It plays the role of:

— **Safety and radioprotection**, by contributing to limit the contamination impact on the workers, members of the public and the environment.

— **Protection of equipment and rooms**, maintaining the level of cleanliness to avoid any radiological releases of contamination.

Confinement system ensures the following main functions:

— **Confinement**, by acting in a static and/or dynamic manner. The role of this function is to control the release and spread of radioactive products, in aerosol or gas form, in environment, and to protect workers, in particular those that do not have respiratory protection from existing volume radioactivity or volume radioactivity generated by activities.

— **Cleaning** the atmosphere of the enclosure or room, by renewing the volumes of air within it, in order to minimise the risks associated with the corresponding atmosphere (for example, the elimination of any gas that can lead to an explosion hazard, fume gas evacuation, etc.).

— **Purification** (or gas cleaning) by conveying the collected gases including any dust, aerosols and volatile components, to defined and controlled points for collection, processing and elimination if possible (by using filters, traps, etc.).

— **Radiological cleanliness** maintaining the level of the atmospheric and surface contamination of equipment and rooms, as low as possible

The dynamic confinement system may also contribute to the following functions:

— **Surveillance** of the releases, in particular when the static containment faces the environment by orientating the airflows to the contamination sensors to the exhaust points.

— **Conditioning** of the atmosphere of considered volumes to ensure ambient conditions continually compatible with the proper functioning of the equipment.

5 Principles for radioactive substances confinement

5.1 General principles

Confinement systems shall ensure the safety and radioprotection functions defined in Clause 4, in all normal operating conditions of nuclear worksites and nuclear installations under decommissioning. They shall also ensure that these functions continue during abnormal operating conditions, or accident situations that are to be defined case by case depending on the safety analysis.

Before beginning any confinement design, a risk assessment shall be made so that actual targets are adequately defined. 5.2 provides an outline of the risk assessment process.

5.2 Risk assessment procedure

The design of an appropriate confinement system requires preliminary analysis, taking into account:

— radiological hazards generated by materials and operations leading to the need to confine the rooms or work areas where hazardous substances are handled, including:

  — permissible levels of surface or airborne contamination inside the room or rooms where are contained confined enclosures;

  — requirements for airborne contamination monitoring;

— verification of discharge authorization limits in respect of actual discharges through existing ventilation systems or ventilation systems to be set up;

— risks associated with the facility to which the confined enclosures and ventilation systems can be exposed and that can be considered plausible on the installation (e.g. load drop, fire, flood, external explosion, earthquakes, wind and extreme temperatures, etc.);

— human activities deployed nearby facilities (collocated operations);

— possible temporary unavailability of fluids or energy necessary for the proper functioning of the confinement system (electricity, compressed air, neutral gases, cooling water, etc.);

— non-radiological hazards associated with equipment and operations implemented in confined enclosures (e.g. sudden break of containment due to mechanical failure, sudden change in pressure, over pressure risks, explosion, fire, corrosion, condensation, load drop), which consequences may be resuspension of radioactivity. As an example, when the worksite confinement is used in the fire safety demonstration, special analyses are needed for cases where fire extinguishers are likely to create a breach in the confinement, e.g. by pressurizing the static confinement because of their potential impact on dynamic confinement or for glove boxes for which water cannot be used when they are criticality risks.

For each consideration, a risk assessment is to be carried out using the safety analysis methodology where the risk is defined as the combination of the consequences of the event and its estimated frequency. This may consist of a deterministic approach, based on incidental or accidental conservative situations.

Other factors to consider in the design of confinement systems are:

— to reduce the amount of waste produced and radioactive release (liquid and gaseous) to a level as low as reasonably achievable, for the protection of the environment;

— to minimize the level of contamination in the rooms or work areas as far as reasonably achievable, in particular by implementing dynamic confinement as close as possible to the source;

— the impact on the existing installation of modifications of ventilation network, enclosure, containment enclosure layout, etc.;

— physical and radiological state of the existing installation (e.g. for static confinement, cable, drains);

— incidental or accidental situations;

— appropriate work conditions that should be provided to workers;

— robustness of confinement system (e.g. fan redundancy), if considering worksite containment with high permanent volumic activity.

The risk assessment procedure is needed to define the requirements for the worksite confinement provisions and to give appropriate health physics coverage to the workers prior to the start of the activities: e.g. process provisions/rinsing/cleaning of systems to be removed or decommissioned, additional local shielding, access control.

Performing such adequate analysis optimizes confinement provisions.

There are several safety topics to be considered in the analysis, and in particular ALARA (as low as reasonably achievable) principle for worker radiations exposure, waste, etc.

5.3 General requirements

The basic principle with regard to the prevention of the spread of the radioactive material is:

— in normal situations, to limit the release of radioactive material outside the facility to levels that are as low as reasonably achievable, through dedicated monitored pathways, but also to reduce the level of contamination inside the nuclear worksite or the nuclear installation under decommissioning;

— in accidental situations, to limit the radiological consequences for the environment and the workers to acceptable levels.

The application of this principle leads to the provision of different confinement systems between the environment and the radioactive substances. Each confinement system and the associated devices are designed to suit the risks they are intended to control. The goal is to maintain, in any case, the functionality of at least one stage of effective containment and filtration between the contaminated areas and the environment under all circumstances, including some accidental situations, (such as a fall from a contaminated sample component) and in all cases to limit to the radiological consequences for workers and the environment to acceptable levels.

The application of this principle requires knowing precisely the following:

— nature, spectra and quantities of radioactive material (contamination and activation) at the equipment to be modified/dismantled and particularly in areas of cutting or volume reduction;

— the state of the installation (e.g. building's architecture and ventilation system of buildings and processes);

— tools and processes used for maintenance/dismantling/cleaning and resuspension factors related to activities to be realized;

— the sequence and procedures of operations to be performed to derive scenarios of accidental situations and their associated probability level.

For these input, a conservative approach in the confinement design may also be accepted.

5.4 Confinement system

5.4.1 General

The objective of "confinement system(s)" is to limit the spread of radioactive substances in accessible work areas to levels that are as low as reasonably achievable and to prevent the spread of radioactive substances into the environment. Usually a double containment is in place, however according to radiological issues and to existing configurations, the implementation of three levels of containment or a single containment may be an optimal configuration.

Two main configurations can be met, other configurations shall be considered on a case by case study:

— case of a worksite containment located in an existing "confinement system" (usually an "historic" nuclear ventilation system, but can also be set up for the needs of a particular worksite);

— case of a worksite containment located beyond any "confinement system".

5.4.2 Case of a worksite containment located in an existing "confinement system"

The goal of "**worksite containment**" is to avoid, as much as possible, the release of radioactive materials from containment in areas accessible to unauthorized or unprotected persons (radiologically).

It includes walls of containment, if necessary associated ventilation systems: ventilation ducts, filters installed in ducts or on-through, etc.

The design of the worksite containment shall reflect the maximum amount of dispersible radioactive substances within the containment and the possible consequences of risks caused by industrial process(es).

In this case, the goal of **second confinement system** (existing “historic” confinement or new one to set up if necessary), is to prevent the release of radioactive contamination outside the building in the event of failure of worksite containment. It provides protection of the environment and members of the public to an acceptable level. It comprises the walls of the confinement system and the ventilation and air conditioning system associated.

A "**complementary containment**" located as close as possible to the activities generating the spread of radioactive materials may be necessary depending on the radiological issue (airtight bag, ventilated airtight bag, dynamic exhaust close to the source).

5.4.3 Case of a worksite containment located beyond any "confinement system"

The goal of "**worksite containment**" is to control the release of radioactive contamination outside this worksite containment. It provides protection of the environment and members of the public.

It includes walls of containment, if necessary associated ventilation systems: ventilation ducts, filters installed in ducts or on -through, etc.

The containment design shall take into account the maximum amount of dispersible radioactive substances within the containment and the possible consequences of risks caused by industrial process(es).

A "**complementary containment**" located as close as possible to the activities generating the spread of radioactive material may be necessary. It shall be implemented according to the safety requirements. It is generally recommended in installations with high risk of spreading radioactive material or in which high radiotoxicity materials are manipulated (e.g., alpha particle emitters).

Depending on the level of airborne contamination and weather conditions, it may be necessary to implement a containment and/or a climatic shelter encompassing the worksite containment.

5.4.4 Summary of different natures and levels of confinement

Table 1 below describes the different types of confinement that may be used. Figure 1 provides an explanatory block diagram of their implementation.