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Components for containment enclosures —

Part 5: Penetrations for electrical and fluid circuits

Composants pour enceintes de confinement —

Partie 5: Traversées de parois pour circuits électriques et circuits de fluides

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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 document 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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This document was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

This second edition cancels and replaces the first edition (ISO 11933-5:2001), which has been technically revised.

The main changes are as follows:

— editorial and technical changes throughout the document.

A list of all parts in the ISO 11933 series can be found on the ISO website.

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

A great number of components or systems used in the electrical and fluid circuits of containment enclosures are presently offered on the market. These components or systems can

— have different geometrical dimensions,

— require holes of different diameters for installation on the containment enclosure wall,

— be attached to the wall by different methods, and

— use different sealing systems for limiting leaktightness.

These components or systems are generally not mutually compatible, but nevertheless often have the same performance level; therefore, it was not possible to select only one component or system as the International Standard.

As a consequence, the aim of this document is to present general principles of design and operation, and to fully describe the most common components or systems in use, in order to

— avoid new, parallel components or systems based on identical principles and differing only in details or geometrical dimensions, and

— make possible interchangeability between existing devices.

Components for containment enclosures —

Part 5:
Penetrations for electrical and fluid circuits

1 Scope

This document specifies selection criteria for, and describes the design characteristics of, the various electrical- and fluid-circuit penetration components mounted on leaktight or shielded containment enclosures.

This document is applicable to

— electrical components, including connectors, fixed or removable wall penetrations, distribution boxes and lighting devices, and

— fluid components, including fixed or removable wall penetrations, fittings and junctions, and control devices for process or effluent circuits.

NOTE The elements constituting the framework of containment enclosures (e.g. metallic walls, framework and transparent panels) are dealt with in ISO 10648-1.

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 10648-1, *Containment enclosures — Part 1: Design principles*

ISO 10648-2, *Containment enclosures — Part 2: Classification according to leak tightness and associated checking methods*

ISO 11933-1, *Components for containment enclosures — Part 1: Glove/bag ports, bungs for glove/bag ports, enclosure rings and interchangeable units*

ISO 11933-2, *Components for containment enclosures — Part 2: Gloves, welded bags, gaiters for remote - handling tongs and for manipulators*

ISO 11933-4, *Components for containment enclosures — Part 4: Ventilation and gas-cleaning systems such as filters, traps, safety and regulation valves, control and protection devices*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10648-1, ISO 10648-2 and ISO 11933-4, and the following apply.

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

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

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

3.1
cabinet
floor-mounted enclosure, totally closed by one or more doors, which houses low-voltage electricity supply equipment

3.2
small distribution box
enclosure for housing small electrical equipment (e.g. relay terminals, circuit-breakers, indicator lights, controls)

3.3
large distribution box
enclosure of larger dimensions than the *small distribution box* (3.2), for housing both small and large electrical components

3.4
connector
electrical (or optical) connector composed of two plug-in elements

Note 1 to entry: Depending on use, the plug-in elements can be removable *concave plug* (3.8) and wall-penetration plug receptacle, removable *convex plug* (3.7) and wall-penetration socket, removable *concave plug* (3.8) and plug receptacle attached to power-consuming equipment; or removable convex and concave plugs.

3.5
plug receptacle
fixed receptacle, generally on an appliance, providing electrical continuity for one or more conductors when connected to a *concave plug* (3.8), downstream element in a *connector assembly* (3.6)

3.6
connector assembly
assembly of standardized or specially designed electrical-connection components such as a socket or plug, serving a specific function in a containment enclosure

3.7
convex plug
removable plug with convex pins that provides electrical continuity for one or more conductors; downstream element in a *connector assembly* (3.6)

3.8
concave plug
removable plug whose contacts are recesses (concave) and which provides electrical continuity for one or more conductors; upstream element in a *connector assembly* (3.6)

3.9
socket
fixed body (e.g. wall penetration, supply box) that provides electrical continuity for one or more conductors when connected to the *convex* (3.7) or *concave plug* (3.8)

3.10
control console
fixed or mobile unit panel housing process controls, monitoring devices and instruments

3.11
power-consuming equipment
device or mechanism which, receiving a supply of electricity, outlets another form of energy (e.g. mechanical, chemical, heat, light)

3.12
high-voltage distribution cabinet
cabinet (3.1) or set of *cabinets* (3.1) that can be assembled housing high-voltage electricity supply equipment

3.13
plug board
small, fixed enclosure equipped with several power points fed by the same power supply

3.14
wall penetration
system allowing an electrical circuit or fluid to pass through the wall of a containment enclosure

Note 1 to entry: For the purposes of this document, it is necessary to distinguish between a wall penetration that allows the passage of an electrical current or signal, and a fluid wall penetration, which allows the passage of fluids and gases.

3.15
valve
system allowing the flow of a fluid in a pipe to be established or cut off, or the rate of the flow to be controlled

4 Selecting a component

4.1 General requirements

Components used in the transmission of electrical energy, liquids and gases to, from or within a shielded or unshielded containment enclosure are generally chosen from the manufacturer's catalogue. However, special nuclear-safety applications can require the modification of such "off-the-shelf" products.

Such "off-the-shelf" components may be considered suitable for most applications, but only provided they comply with the requirements in this document. Where specifically nuclear demands need to be met (e.g. resistance to high levels of radiation, seismic or specific leaktightness for maintaining a vacuum), the materials and components shall be specially adapted or "nuclearized".

The components used for special applications related to nuclear safety, such as those involving processes or remote handling, those in use behind shielding walls (see ISO 7212[1] and ISO 9404[2]) or subject to repeated use, or those used in the fabrication or operation of special effluent circuits, shall be developed as needed.

4.2 Risk assessment and safety analysis

4.2.1 Principle and parameters

The actual use of a component shall be compatible with the general purpose of the containment enclosure on which it is mounted.

Before the selection of a material or component, a systematic risk assessment and safety analysis shall be conducted in order to establish adequate and consistent parameters for design and fabrication.

The first step in the risk assessment shall be a review of all the operational constraints imposed by the process implemented in the containment enclosure having an influence on the component. Important design and safety criteria (considering items in AGS-G001[3]), such as normal and abnormal operating conditions, seismic requirements, internal atmosphere characteristics, ventilation, illumination, electrical grounding and shock prevention, and ergonomic arrangements, shall be addressed by the analysis. The risk of fire, explosion and violent chemical reaction, and other possible hazards, shall be assessed.

4.2.2 Atmosphere

The internal atmosphere of a containment enclosure is determined by the type of operation for which it is intended, safety considerations or by both these. The characteristics of the atmosphere depend, too, on the physical aspects of the materials to be handled.

The following shall be taken into account:

— nature (e.g. normal or dry air, controlled atmosphere, vacuum vessel);

— purity of the controlled atmosphere;

— internal pressure (for normal and emergency conditions);

— normal and safety air-change rates.

4.2.3 Heat radiation

The internal temperature of a containment enclosure shall be maintained at a level that is acceptable for the normal functioning of the component. The main sources of heat in the enclosure are lighting devices, chemical reactions, mechanical or chemical operations, heating devices, ovens and radioactivity. Additional cooling systems could be necessary.

4.2.4 Corrosion

Degradation of the containment enclosure and its components can result from the chemical aggressiveness of the products handled inside the enclosure or induced by secondary reactions during the process. When selecting materials for components, care shall be taken as to the possibility of corrosion of

— sealing material, especially when constituted of natural rubber or elastomer,

— electrical cables,

— wall penetrations (for electrical or fluid purposes) including insulator materials, highly sensitive to corrosive action, and

— filter elements, constituted of different types of materials (filtering media, luting, envelope).

4.2.5 Leaktightness

Electrical and fluid penetrations contribute to the containment enclosure's static leaktightness. Thus, a penetration component's individual leaktightness shall be in accordance with the specified leaktightness of the entire containment enclosure on which it is mounted.

In general, the individual leaktightness of an electrical or fluid penetration is not verified. Instead, a final leak rate measurement is made on the containment enclosure fully fitted with all its components. During this test, conformity with the specified leak rate is verified, and in case of failure, a check is made for possible mounting or assembly faults, with those identified being corrected (they are usually caused by inappropriate sealing around the penetrations).

Where special leaktight electrical and fluid penetrations are specified, a dedicated test assembly can be designed for testing their leaktightness.

4.2.6 Fire

In containment enclosures, as in nuclear installations as a whole, fire presents an important risk for the spread of contamination, and therefore shall be carefully assessed (considered in AGS-G010[4]).

The total fire load of the containment enclosure (the sum of the material constituting its frame, components mounted on its walls, and products or equipment handled or installed in it) shall be limited by selection of construction materials and components on the basis of their fire behaviour, minimizing the presence of combustible materials in the enclosure.

An incombustible gas (e.g. nitrogen or argon) should be used to avoid the risk of ignition of gases, flammable liquids, and pyrophoric solids.

Flame-retarding electric cables are recommended.

Equipment with high static electricity risk shall be grounded.

Electrical and fluid components presenting a high degree of fire resistance should be selected.

Ventilation networks (see ISO 11933-4) should be set up so that the propagation of any fire is limited (e.g. construction using fire-resistant materials, installation of fire-cutting valves).

These design and construction provisions can be enhanced by the addition of appropriate fire-detection devices with alarm-report and fire-extinguishing means. Where needed, additional preventive measures such as the use of explosion-proof electrical equipment and safety electric-light fixtures, and the installation of guards, casing or screens, are recommended.

4.2.7 Mechanical risk

A risk is present when fluid circuit or connectors with pressure are installed on the containment enclosure; this risk shall be taken into account, especially when auto-eject connectors releasing.

4.2.8 Electrical risk

Electrical equipment shall comply with the relevant safety standards or regulations. In addition, all particular operating conditions (e.g. irradiation, temperature, corrosion, resistance to decontamination agents, explosive atmosphere) shall be taken into consideration in its selection.

Every containment or shielded enclosure equipped partially or fully with metallic components (i.e. remote manipulator) shall be grounded.

4.2.9 Contamination and irradiation

In many installations, internal radioactive hazards can pose a risk even under normal operating conditions, leading to the degradation of certain containment enclosure components.

Radioactive contamination can be deposited in locations where decontamination is difficult (e.g. near the sealing of parts of enclosure panels or penetration devices, usually made of elastomer material), thus contributing to the degradation of organic materials.

Irradiation from sources of high-level radiation can negatively affect the materials constituting the internal equipment, a particular concern in the case of electrical components.

In addition, for gaseous radioactive sources, such as tritium, that are likely to be adsorbed on surfaces, and later desorbed from these surfaces under a different chemical form, specific material for penetrations should be selected such as to limit gas interaction (permeation and adsorption) on the material (e.g. metal alloy or stainless steel should be preferred to organic materials).

4.2.10 Chemical risk

The chemical risk depends on the nature and quantity of the products handled or stored inside the containment enclosure. This risk shall be taken into account in respect of corrosion effects on liquid-effluent circuits, extraction from ventilation networks and introduction circuits for process needs.

Appropriate construction materials shall be chosen; leak sensors could be installed, if required.

4.2.11 Other risks

All other risks related to the use of the containment enclosure and its electrical and fluid components shall be considered with a view to preventing any normal or accidental events resulting from their operation, such as mechanical assault, excessively high pressure or under pressure, moisture, seismic risk, criticality risk, vibration, flood and condensation. Special attention shall be given to the following:

— The possibility of interference between different enclosures through common transfer networks such as effluent or ventilation circuits, pneumatic transfer systems, and the introduction of process fluids or reagents.

— The furnishing of actuating fluids for electrical or fluid-transfer systems (e.g. electricity, compressed gases, vapour or hot water, cold water, special gases). The safety analysis shall determine whether or not there is a need for permanency in relation to these auxiliary fluids.

4.3 Shielded penetration requirements

4.3.1 General

The particularities of electrical or optical penetrations and fluid circuit in shielded containment enclosure are radiation protection, seismic safety and remote-handling.

4.3.2 Radiation protection (external exposure)

Considering of gamma, neutron or other radiation from sources of high-level radiation, special penetration structure could be applied with shield wall, ceiling and floor (e.g. curved tube, staged blocks).

4.3.3 Seismic safety

For some nuclear safety related penetrations, seismic safety should be considered or designed, ensuring the integrity or function during or after the earthquake (see IEC/IEEE 60980-344[5], IAEA Specific Safety Guide (No SSG-67)[6] and IAEA-TECDOC-1347[7]).

4.3.4 Remote-handling

The location, view, manipulator-accessibility and handling force of Remote-handling electrical or fluid connectors in shielded enclosures shall be considered (see ISO 17874-1[8], widely-used remote-handling device: master-slave manipulator, see ISO 17874-2[9], as well as IAEA Document "Manual on safety aspects of the design and equipment of Hot Laboratories"[10]).

4.4 Other requirements

In addition to the requirements specific to radioactive environments, all other requirements given in national or international regulations relating to the materials, components and systems used in the electrical and fluid circuits of containment enclosures shall be met: in particular, electrical requirements and electromagnetic compatibility (ECM) rules.

5 Electrical components

5.1 Design and installation

5.1.1 General

As well as complying with the general requirements of this document and the provisions of other international and national technical regulations, the design of electrical equipment for containment enclosures shall take into account the following technical aspects of construction, use, maintenance and dismantling. These various aspects are closely interrelated, and their respective provisions shall determine the installation and layout of the components used in electrical circuits in containment enclosures.

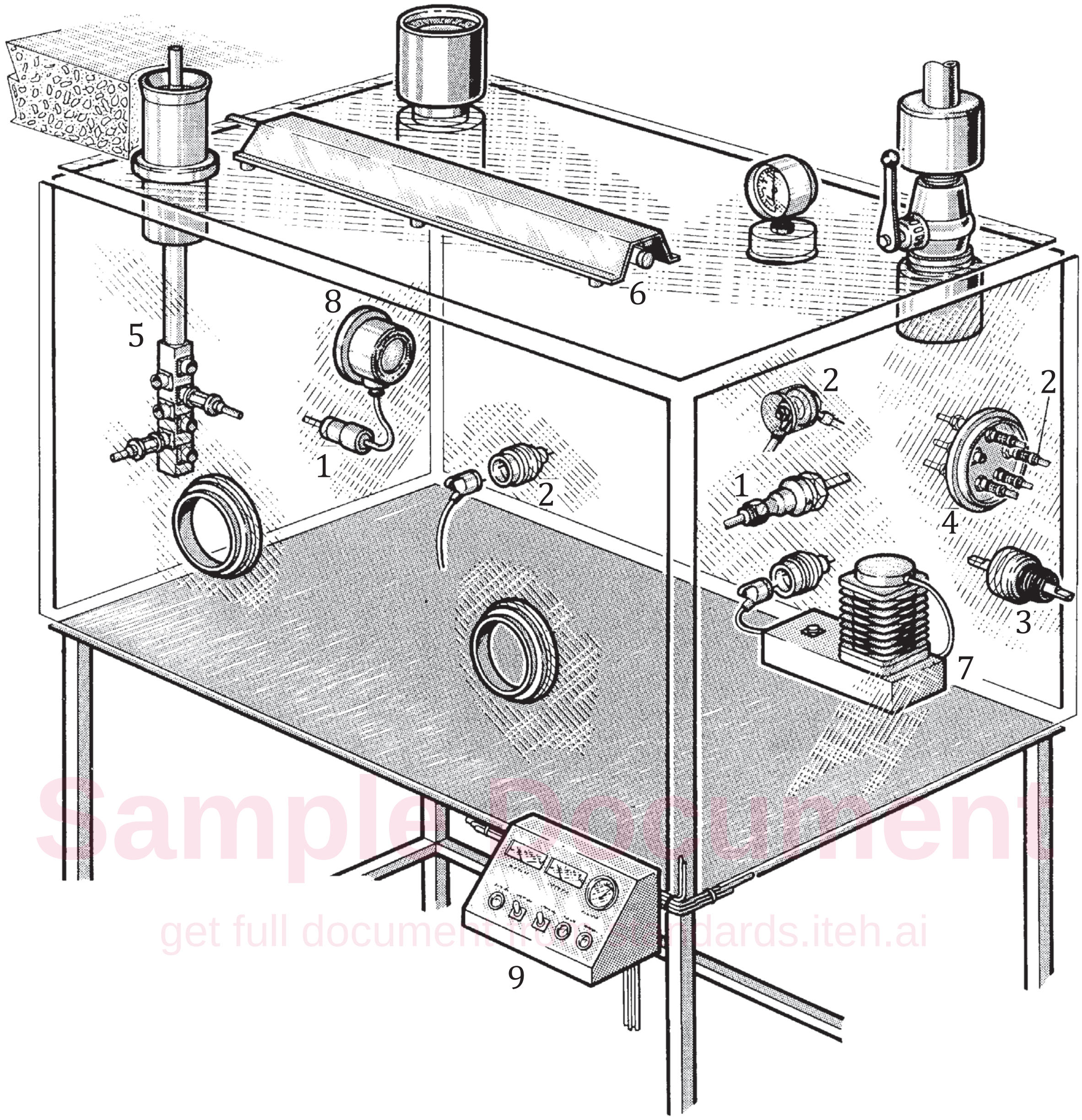
Electrical equipment should always be designed and installed with a view to subsequent maintenance or dismantling operations. Otherwise, for example, loosening nuts on a device installed in a contaminated enclosure using remote-handling equipment and a hand-held spanner could prove difficult or even impossible. Figure 1 shows a containment enclosure fully equipped with typical electrical components.

5.1.2 Materials used in fabrication

The choice of materials used in the fabrication of a component shall take into account the actual stresses, strains and risks to which it is subjected. Depending on the operating requirements and intervention options, radiation- resistant materials shall be used, or components protected from existing irradiation either by location away from the source of irradiation or shielding.

5.1.3 Work stations

Work stations shall be designed to combine efficient working methods with operator comfort. The layout of controls, handling devices and signals shall take into account their frequency of use and relative importance. The choice of lighting and colours, both inside the enclosure and in the general surroundings, shall facilitate good perception of shapes and appreciation of distances, without dazzle or undesirable reflections.



Key

1	continuous wall penetration
2	non-continuous wall penetration
3	rotating penetration
4	ejectable plug (for electrical circuit with or without remote connections)
5	ejectable holder
6	fluorescent light
7	electric motor
8	explosion detector
9	control console

Figure 1 — Containment enclosure fully equipped with electrical components

5.1.4 Equipment location and operation

Depending on its nature and method of use, the main item of equipment (e.g. oven, polishing device) shall be located in the operator's work place, and may be fixed or semi-mobile. Account shall be take of vibrations emanating from the machine itself and any movement of the machine caused by external vibrations. A machine used infrequently should be used in the most accessible part of the enclosure, and stored in a less accessible area when not in use.

Specific support structures (whether or not articulated) may be provided, but apparently easy solutions should not be adopted automatically, since these almost invariably entail mechanical problems.

Ancillary equipment (lighting, detection devices) should be located in a suitable position, causing minimum interference with the use of the enclosure.

If, as in most cases, permanent access to equipment is not required, it is still may be necessary for equipment to be checked, maintained and replaced. Unused areas (front panel) may be used for this purpose, provided there is a means of moving the equipment into the handling area whenever necessary (e.g. articulated support bracket) or there are additional facilities (glove boxes, which are generally equipped with protective covers).

To ensure the protection, ease of replacement and durability of the material, the equipment should be connected using the components described in this document.

5.1.5 Operator safety

Operator safety shall be ensured by protecting bare electrical contacts or other live exposed parts when these are liable to come into contact with the tongs or remote-handling devices. Moving parts should be equipped with covers, while remaining visible where necessary.

Under normal conditions, liquid splashing on electrical equipment shall be avoided and all possible steps shall be taken to prevent such splashing in the event of an accident.

Where there is a risk of flooding, electrical components shall be protected by being lifted out of the way or enclosed in a leaktight container. The necessary emergency equipment shall be provided (e.g. detectors, alarms).

5.1.6 Maintenance and intervention

The types of intervention in relation to electrical components may range from routine, minor, optional or mandatory maintenance and operational checks to the correction of minor faults or major failures involving the replacement of items of equipment. Some factors from the design stage onwards are essential, such as the accessibility of the component, i.e. whether to fit it inside or outside the enclosure, as well as the effects of ageing and possible contamination related to its location.

For components fitted inside the enclosure, repairs may be carried out on the spot or the equipment transferred to a workshop where suitable handling and other equipment is available.

Prior to any intervention, the equipment shall be electrically isolated.

If it is necessary to remove components from an enclosure, adequate means of achieving this shall be provided. The devices used during removal shall be capable of passing through the operating holes as bag ports in ISO 11933-1, doors and of being contained in transfer equipment as welded bag in ISO 11933-2, container, waste drum.

5.1.7 Decontamination and dismantling

Decontamination is the final phase in a component's working and maintenance life and should be planned for at the time of construction. As only correctly functioning equipment may be used, maintenance operations can also involve dismantling and replacement.

Contamination of components can be reduced to a minimum by locating equipment in a low-contamination area, inside or outside the enclosure, or by protecting it from radiation. Covers, however, rarely afford total protection, but merely slow down the contamination process; the accumulated contaminated products are frequently relatively inaccessible.