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Components for containment enclosures —

Part 4: Ventilation and gas-cleaning systems such as filters, traps, safety and regulation valves, control and protection devices

Composants pour enceintes de confinement —

Partie 4: Systèmes de ventilation et d'épuration tels que filtres, pièges, vannes de régulation et de sécurité, organes de contrôle et de protection

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 11933 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11933-4 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

ISO 11933 consists of the following parts, under the general title *Components for containment enclosures*:

— *Part 1: Glove/bag ports, bungs for glove/bag ports, enclosure rings and interchangeable units*

— *Part 2: Gloves, welded bags, gaiters for remote-handling tongs and for manipulators*

— *Part 3: Transfer systems such as plain doors, airlock chambers, double door transfer systems, leaktight connections for waste drums*

— *Part 4: Ventilation and gas-cleaning systems such as filters, traps, safety and regulation valves, control and protection devices*

— *Part 5: Penetrations for electrical and fluid circuits*

Annex A forms a normative part of this part of ISO 11933. Annex B is for information only.

Introduction

A great number of components or systems used for ventilation and gas-cleaning in containment enclosures are presently offered on the market. These components or systems can:

— have different geometrical dimensions;

— differ by their design criteria;

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

— be attached to the wall by different methods;

— use different mounting techniques for their corresponding leak tightness.

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 standard.

As a consequence, the aim of this part of ISO 11933 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;

— make possible interchangeability between existing devices;

— demonstrate consistency among the various parts of the same system such as a ventilation basic element or gas-cleaning associated element.

Components for containment enclosures —

Part 4:
Ventilation and gas-cleaning systems such as filters, traps, safety and regulation valves, control and protection devices

1 Scope

This part of ISO 11933 specifies the design criteria and the characteristics of various components used for ventilation and gas-cleaning in containment enclosures. These components are either directly fixed to the containment enclosure wall, or used in the environment of a shielded or unshielded containment enclosure or line of such enclosures. They can be used alone or in conjunction with other mechanical components, including those specified in ISO 11933-1 and ISO 11933-3.

This part of ISO 11933 is applicable to:

— filtering devices, including high-efficiency particulate air (HEPA) filters and iodine traps;

— safety valves and pressure regulators;

— systems ensuring the mechanical protection of containment enclosures;

— control and pressure-measurement devices.

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 normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 11933. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 11933 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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*.

3 Terms, definitions and symbols

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

3.1
activated carbon
carbon of vegetable or mineral origin, submitted to special activation treatment to create highly specific surfaces, and to impregnation treatment to enable it to adsorb specific chemical forms of iodine, used in adsorbent material for trapping volatile components of radioactive iodine (see iodine trap)

3.2
ventilation flow rate
F
volume of fluid passing through the containment enclosure per time unit, whose temperature and pressure[1)] are considered at that time

3.3
safety flow rate
Q_s
volume of fluid passing through the containment enclosure per time unit, which, by an occasional or accidental opening, permits an air velocity sufficient to either limit the back-scattering of contaminant products (radioactive or other) or avoid pollution from handled products

3.4
gas cleaning
action taken to decrease the content of the given constituents of a fluid

EXAMPLE Filtration of aerosols, trapping of iodine.

3.5
tightness
characteristics of a containment enclosure that prevent fluids, gases or dusts from passing from the external through to the internal environment, or from the internal to the external environment, or both

NOTE In practice, tightness is defined by the leak rate (see ISO 10648-2), under a defined pressure, of an undesirable element through a wall of the enclosure.

3.6
filtration
separation by a filter of the solid or liquid particles of a gaseous flow when in suspension

3.7
filter
device that removes specific particulate contaminants, liquid or solid, from the atmosphere passing through it

3.8
pressure drop
loss of total pressure due to air or gas passing through a duct or filter, etc.

3.9
trapping
action taken to lower by chemical reaction or adsorption the concentration of undesirable volatile components from a gaseous flow

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1) Unless otherwise mentioned, the unit of pressure used in this part of ISO 11933 is the decapascal (daPa) or pascal (Pa): 1 daPa = 1 mm WG.

3.10
iodine trap
activated carbon trap
scrubbing device, usually carbon-base activated (see activated carbon), for trapping the volatile components of radioactive iodine in air or ventilation gases

3.11
prefilter
a filtering unit installed ahead of a filter to protect it from rapid clogging caused by high dust concentration or other environmental conditions

3.12
regulation
action taken to permanently compare the value of a measured parameter with its set value, so that an automatic correction can be carried out

3.13
air/gas complete change rate
R_n
ratio between the ventilation flow rate, F, during normal operating conditions and the volume, V, of the containment enclosure, so that

$$R_n = \frac{F}{V} \ (\text{h}^{-1})$$

3.14
ventilation
organization of air and other gas flows within a facility and at the borders of its environment

3.15
filter housing
closed envelope placed around a filter of a containment enclosure to protect it against shock and thus allow its replacement without breaking containment

NOTE All filter housings of a containment enclosure are fitted with a removable cover.

3.16
filter casing
rigid element surrounding a filter element that together with it forms the filter or filter cartridge

NOTE Filter casings may be open, closed or perforated.

3.17
filter element
part of a filter having rigid cell sides and containing the filtering medium

NOTE The leak tightness between the rigid cell sides and the filtering medium is realized by luting, while the filter element is generally mounted inside a housing that allows connection with ventilation ducts.

3.18
filtering medium
material with porous or fibrous structure used as a filtering barrier

3.19
isolation device
device for starting or stopping the fluid flow inside a duct, which can be used in an adjustment function (see adjustment device)

3.20
protection device
device used to protect the containment enclosures against the risk of excessively high or low pressures (explosion or implosion)

NOTE These devices can be hydraulic or mechanical, and include the following types: mechanical valve, bursting membrane, rupture disc, hydraulic valve and hydraulic protection, oil protection, protection chamber and safety valve.

3.21
adjustment device
device allowing adjustment (generally manual) of a parameter to a pre-determined value

NOTE By design, such units do not perform an insulation function. Included in this category of device are all types of cocks and valves, as well as throttles and incliners.

3.22
regulation device
device used for permanently comparing the value of a measured parameter with its set value, enabling automatic correction to be carried out and, specifically, containment-enclosure or ventilation-network depression regulation

3.23
safety device
yes/no-mode device used to maintain safety flow rate in case of inadvertent containment-breaking (e.g. wrenching of a glove)

3.24
efficiency
E
ratio, expressed as a percentage, of the particle concentration arrested by the filter to the particle concentration fed to the filter (expressed in %), and calculated as:

$$E = \left(\frac{N - n}{N} \right) \times 100$$

where

N is the number of particles upstream from the filter

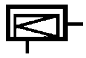
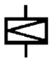
n is the number of particles downstream from the filter

3.25
average arrestance
A_{m}
ratio, expressed as a percentage, of the weight of synthetic dust arrested by the filter to the weight of the dust fed to the filter

3.26
penetration
P
ratio, expressed as a percentage, of the particle concentration downstream from the filter to that upstream from the filter

3.27
decontamination factor
DF
term used by some sectors of industry, and especially the nuclear industry, to describe the efficiency of a filter: normally expressed as a whole number (DF = 100/penetration)

Table 1 — Functional diagram symbols and their meanings

	Small HEPA filter		Protective device	PC H	High pressure alarm (e.g. 5 daPa)
	Flange		HEPA filter under housing	PC B	Low pressure alarm (e.g. 80 daPa)
	HEPA filter		Pressure reducing valve	Aa	Analysis and alarm
	Motorized valve		Isolation valve	PR	Regulated pressure
	Non-return valve		Regulation device	PC	All-or-nothing controlled pressure
	Adjustment valve		Yes/no device ensuring safety flow rate	PI	Indicated pressure
				PA	Alarm pressure
				QI	Indicated flow rate

4 Functions of ventilation and gas-cleaning systems

4.1 Purpose

The role of ventilation in containment enclosures is to ensure:

— the enhancement of safety, by helping keep personnel and environment free from contamination;

— the protection of materials and handled products, indirectly contributing to safety, by keeping the internal atmosphere (temperature, humidity, physical/chemical composition) in a status compatible with their proposed use.

Ventilation or gas-cleaning systems serve the functions described in 4.2, 4.3 and 4.4, but possess the limitations mentioned in 4.5.

4.2 Containment

The ventilation systems act dynamically in order to set a negative pressure gradient between different containment enclosures of a set and between the enclosure and the room atmosphere. This pressure difference, creating an aspiration, prevents the diffusion of the contamination through imperfections in the leak tightness of the static containment. The systems also provide an air flow of a rate sufficient to mitigate the intentional or accidental breaking of the static containment formed by walls and filters.

4.3 Gas cleaning and dilution

The ventilation systems participate in the air cleaning and dilution (or renewal) of the internal atmosphere by flushing gas through the containment enclosure in order to remove contamination and keep the enclosure atmosphere in a satisfactory state.

4.4 Filtration and trapping

Components associated with ventilation systems such as filters and traps enable the assembly, at specific and controlled locations, of dust, aerosols and volatile components for collection, treatment or disposal.

4.5 System limitations

The components and systems described in this part of ISO 11933 do not normally ensure the cooling of the equipment, but partially or totally cool only the containment's internal atmosphere. When needed, each piece of internal equipment shall have its own cooling system. Similarly, the systems do not provide sufficient protection against fire, explosion or similar hazards. The total control of such hazards can be ensured by appropriate process-ventilation systems (see 5.3).

5 Safety and protection principles and requirements

5.1 General

The following design and operational requirements related to safety (5.2), the protection of materials and handled products (5.3) and fire protection (5.4) are aimed at ensuring that ventilation and gas-cleaning components and systems perform with maximum efficiency.

5.2 Safety

To avoid networks becoming a source of exposure or contamination, the ventilation and gas-cleaning shall:

— contain contamination as close as possible to its source;

— trap contamination as completely as possible.

Ventilation and gas-cleaning components and systems shall be designed to:

— limit the consequences of any accumulation of dangerous material;

— help in monitoring the facility;

— prevent breaking of the containment, particularly during filter replacement or the occasional, or accidental, opening of the containment enclosure and its network.

5.3 Protection of material and handled products

The characteristics of the atmosphere (see 7.1.2) shall be kept within the normal operating range of each process. Where there is a risk of accident or production disturbance due to excessive modification of these characteristics, a control device shall be available to halt the process run.

5.4 Fire protection

5.4.1 General

The design of a ventilation or gas-cleaning system for containment enclosures shall take into account the risk of fire associated with the processes and operations conducted within the containment enclosure. Its design shall ensure that any outbreak of fire within a containment enclosure is limited either to the enclosure's static containment or to the premises containing the first envelope; or that a fire's spreading and the consequent release of radioactive contamination into the local work environment are prevented or severely limited.

Enclosure ventilation networks are part of the overall ventilation system protecting workers, the general public and the exterior environment. Protection against fire hazard cannot be separated from the protection of the system and its environment (the containment enclosure, general ventilation network, the building and overall installation premises).

Fire protection consists of prevention (5.4.2), detection (5.4.3) and intervention (5.4.4).

5.4.2 Prevention

In order to reduce or suppress the risk of fire, the ventilation of containment enclosures can be realized using an inert gas and a semi-open or closed network (see clause 6). Air flow rate is also to be taken into account, notably in respect of:

— the presence of a heat source, whose calories shall be extracted continuously;

— the production or use of gases or vapours that can react with air to produce corrosive, inflammable or explosive mixtures.

In order to avoid the propagation and extension of a fire, the ventilation system shall be designed to remain in operation and maintain it functions for as long as possible. In order that this can be achieved:

— the materials used in the construction of the ventilation networks shall be chosen according to their positive fire behaviour;

— the possibility of the release of corrosive, toxic or radiotoxic products shall be evaluated;

— the location, thermal isolation and arrangement of the ventilation networks shall be studied in order to avoid propagation due to conduction or radiance effects;

— the geometry of the ventilation ducts, their cross-section, the nature of their internal covering and the velocity of the transported air should be designed in such a way as to prevent any deposits of flammable dust, debris or particles on their internal parts.

When open networks are used, fire prevention shall be enhanced by the selection of fire-proof or fire-resistant materials of construction that minimize the total fire loading per unit area. More generally, the same requirement for reducing the total fire loading shall apply to the design of the containment enclosure itself. This includes the material constituting the structure of the containment enclosure, the equipment, process material and end products handled or stored in the enclosure.

If these precautions are considered insufficient, and if any possible fire could not be stopped by static means, the containment enclosure and its associated ventilation networks can be considered to be vulnerable. Fire prevention measures is then to be applied to the local work environment instead of the containment enclosure and its associated networks.

5.4.3 Detection

Where necessary, a suitable fire detection system shall be installed in order to detect fires as rapidly as possible and permit immediate intervention with automatic or manual fire-extinguishing equipment.

5.4.4 Intervention

When a fire is detected in a containment enclosure, the ventilation may either be maintained or stopped, depending on the evolution of the fire, fire-resistance of the containment walls, filtration barriers, type of extinguisher available and means of protection applicable to the local work environment.

The impact of maintaining, stopping, or restarting ventilation networks in the event of a fire shall be analysed at the design stage. To this end, a safety analysis shall be implemented and the results of the analysis recorded and registered in the operating procedures.

NOTE The means of intervention depend on the type of fire.

6 Basic data relevant to ventilation and gas cleaning

6.1 General

The ventilation of a containment enclosure is necessarily carried out through a network called the enclosure network. This is most often connected to what is referred to as a general extraction network, which acts as the collector for the enclosure network and whose function is distinct from ambient ventilation (cell or laboratory).

The following fundamental data related to the enclosure (6.2) and general extraction networks (6.3) shall be taken into account and corresponding recommendations and requirements acted upon wherever possible.

6.2 Enclosure network

6.2.1 Normal operating flow rate

The normal operating flow rate is the rate extracted from the containment enclosure, and the most relevant value related to the enclosure network, Q_n, is defined as the air or gas volume extracted per time unit, expressed in cubic metres per hour (m^3/h or $m^3 \cdot h^{-1}$).

6.2.2 Air- or gas-change rate

Depending on the nature of contained products and work carried out, the recommended air/gas-change rate (R_n) values are:

— between 3 and 10 complete changes per hour for regular enclosures ventilated with ambient air;

— between 1 and 3 complete changes per hour for enclosures ventilated with dry air or neutral gas.

These recommended values can be modified by other considerations such as perturbation due to glove movements, variation of volume in the containment enclosure, and changes in the level of impurities in the neutral atmosphere, or in accordance with local safety regulations.

EXAMPLE Local safety regulations exist for enclosures containing tritium: $30 < R_n < 40$; for low level of impurities: $10 < R_n < 20$; for oxide powder, with dry air: $3 < R_n < 5$; for oxide powder, with neutral gas: $R_n < 1$.

6.2.3 Number of filtering stages and choice of trapping devices

The number of filtering stages required to protect the extraction network and work environment will depend on the containment enclosure class (see Annex A), while the choice of a trapping device will be specific to the nature of gases released by the process. In certain cases, in order to increase the lifetime of the HEPA filters, a prefilter should be installed upstream from the enclosure extraction filter to protect the latter against rapid clogging due to particles and dust, or the deposit of flammable components. This prefilter is usually less efficient than the filter it protects in filtering the finest particles present in the aerosol. If needed, a safety study shall be made to dimension such components. (See annex B.)

6.2.4 Underpressure

For the handling of radioactive or toxic products, the enclosure is required to be at a negative pressure in relation to the room. This underpressure, the only one of such values easily monitored, is expressed in pascals (Pa) or decapascals (daPa), and generally ranges from 20 daPa to 50 daPa below room pressure. Its measurement enables a hierarchy of pressure to be maintained when different enclosures are connected.

6.2.5 Safety flow rate

Either to protect the operators or materials and handled products, a safety study shall be performed that will set the value of the safety flow rate, Q_s, and thus that of the resultant velocity of the air flow.

Normal velocities shall be no less than 0,5 m/s, to avoid the spread of contamination. However, velocities of up to 1,5 m/s may be used, depending on the nature of the material being handled, for example, ^{238}Pu, tritium [2].

Velocities higher than 1,5 m/s can cause unusual turbulent flow eddies in the containment system that could negate the desired containment.

6.3 General extraction network

6.3.1 Underpressure

The total underpressure of the network is applied to the connection point of the fan. The following shall be taken into account in respect of the flow rates specified in 6.3.2:

— the underpressure of the containment enclosures;

— a clogging reserve of the filtration device (the recommended values are 5 daPa for the admission circuit and from 5 daPa to 50 daPa for the extraction circuit);

— the pressure drops of the filtration stages of the network and of served enclosures;

— the pressure drops of the downstream fan network and of accessories.

6.3.2 Operating flow rates

The following shall be taken into account when evaluating the capacity of the network to operate in different working conditions:

— the sum of the instant unit flow rates of the containment enclosures;

— the considered safety flow rates (the total flow rate is defined by the probability of simultaneous trip of the elementary safety flows);

— the need for the flow to continue in all network components in the event of a single component failure.

7 Design

7.1 Types of enclosure network

7.1.1 General

Depending on the potential risk of the handled products, the following parameters shall be determined and then used for deciding on whether an open, semi-open or closed network is required:

— characteristics of atmosphere and kind of enclosure;

— ventilation function to be performed;

— ventilation system specific to each enclosure;

— minimum equipment needed for ventilation;

— need to regulate inlet or outlet flow;

— need to maintain safety flow.

2) Safety flow-rate values are generally given in national regulations.