INTERNATIONAL STANDARD

ISO 11933-4

First edition
2001-05-15

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

Reference number
ISO 11933-4:2001(E)

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Printed in Switzerland

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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

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

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

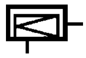
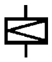
n is the number of particles downstream from the filter

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.

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

7.1.2 Open network

This type of network takes filtered ambient air from the room, passes it by direct transfer through the containment enclosure and, after filtration or the trapping of toxic and undesirable products exhausts it through the building or site stack or shaft. It is suitable for containment enclosures of class 4, 3 or 2 (see Table 3 and annex A).

NOTE The classification of containment enclosures is specified in ISO 10648-2.

7.1.3 Semi-open network

This type of network uses treated air, gas or a gaseous mixture directly from storage or a station, which is exhausted after the filtration or trapping of toxic and undesirable products, through the building or site stack or shaft.

This type of network is suitable for containment enclosures of class 3, 2, 1b or 1c (see Table 4 and annex A).

7.1.4 Closed network

This is a network using a gas or gaseous mixture that is recycled after filtration or the trapping of toxic or undesirable products or both.

The use of this network is justified by the obligation to keep products or materials under a determined atmosphere, the fact that re-use of ventilation fluid is considered the most inexpensive solution, and the possibility it gives to reduce gaseous effluents.

This type of network is suitable for containment enclosures of class 1a, 1b, 1c or 2 (see Table 5 and annex A).

NOTE 1 Depending on need, the same enclosure can have several operating modes (e.g. a containment enclosure of class 3 could be equipped to operate in an open or semi-open network).

NOTE 2 When pyrophoric or explosive products are used in a containment enclosure, the safety flow could induce additional risk. In this case, avoidance of the safety circuit for the containment enclosure is recommended.

7.1.5 Atmosphere

The internal atmosphere of a containment enclosure is determined by the type of operation for which it is intended, safety considerations, or both. The characteristics of the atmosphere will depend, too, on the physical aspects of the materials to be handled. Table 2 presents the characteristics of the internal atmosphere of the containment enclosure, with respect to the kind of network and nature of the gas.

The following considerations shall be taken into account for the containment enclosure atmosphere:

— nature (normal air, controlled atmosphere, vacuum vessel);

— purity (dry air with less than 200 ppm relative humidity, argon or helium with less than 100 ppm total impurity);

— internal pressure (for normal and emergency conditions);

— normal change rate and safety flow rate, when needed.

Annex A gives recommendations concerning the choice of atmosphere with respect to the classification of the containment enclosures according to ISO 10648-2.

7.1.6 Functional diagrams

Table 1 defines the meaning of the symbols used in the functional diagrams for the open, semi-open and closed enclosure networks of different classes shown in Tables 3 to 5.

Table 2 — Characteristics of the internal atmosphere

Characteristic	Nature of internal gas	Type of network		
		Open	Semi-open	Closed
Oxidant	Ambient air	X		
	Treated air	X	X	
Neutral	Nitrogen		X	X
	Argon		X	X
	Argon without impurity of oxygen, humidity		X	X
	Argon without impurity of oxygen, humidity, nitrogen		X	X
	Helium		X	X
Reducing	Mixture of nitrogen and hydrogen			X
	Mixture of argon and hydrogen			X

7.2 Permanency during filter exchange

7.2.1 Permanency of filtration

Where labile products are manipulated, and in order to avoid any deposit of contamination in the parts of the circuits located beside the HEPA filters, the safety authority can require permanency of the filtration instead of permanency of the nominal flow during filter exchange. In this case, the following shall be respected.

a) **Inlet with one HEPA-filter stage.** A second filter shall be installed, either in a series of the first filtering stage or in parallel with it. For cost reasons, and depending on the available space around the enclosure, it is recommended this second filter be installed outside the enclosure, in series with the first filter.

b) **Inlet with two HEPA-filter stages.** This is equivalent to the configuration described in a) and fulfils the corresponding requirements.

c) **Outlet with two HEPA-filter stages.** A second extraction circuit in parallel with the first, equipped like it with two stages of HEPA filters, shall be installed to meet the obligation of permanency of filtration. This configuration allows for two extraction circuits: one that can be used as a “normal” circuit, and the another that can be kept on stand-by and used only for the replacement of a clogged filter located on the normal circuit.

d) **Outlet with single HEPA-filter stage.** When radioactive products are to be handled, two-stage HEPA filters only are recommended, with the configuration to c) corresponding.

7.2.2 Permanency of containment

The safety authority will generally require continuity of containment during filter exchange without interruption of the ventilation function. For this purpose, it is recommended that the technique of mounting filters in housings with a lateral outlet, in association with vinyl bags, be used. This allows replacement of the filtering media without breaking containment.

Table 3 — Open networks

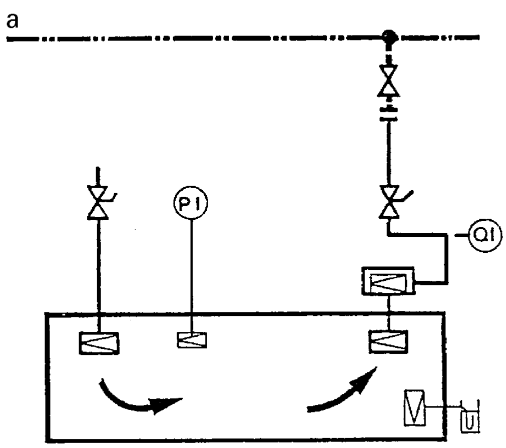
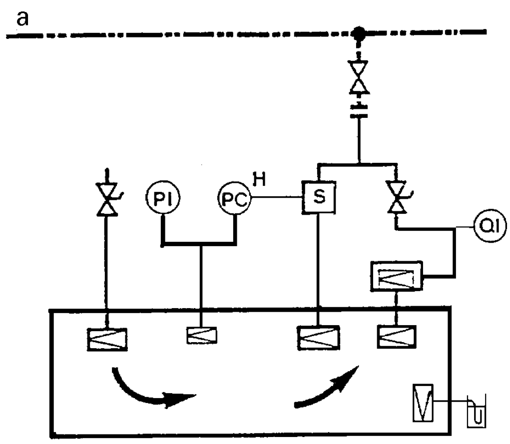
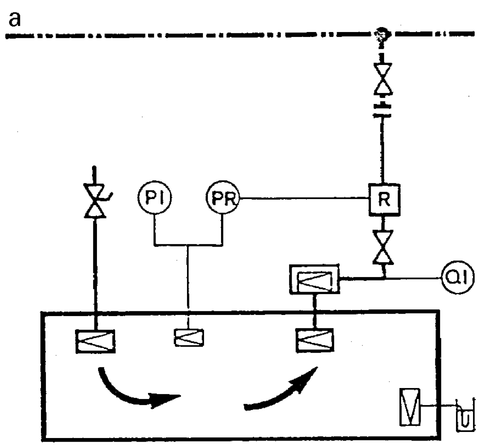
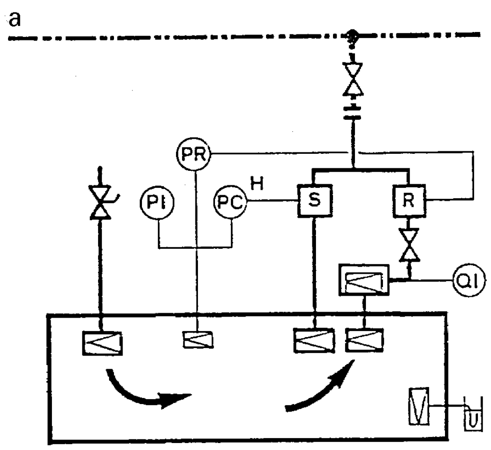
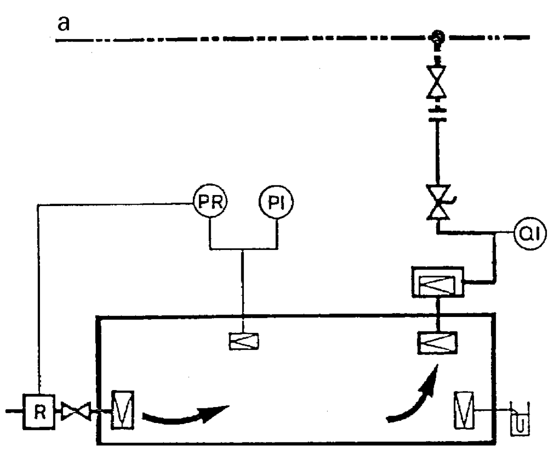
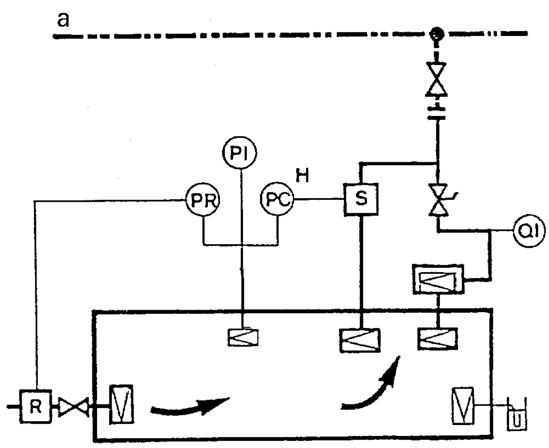
Class 4 containment enclosures		
	Without additional safety system	**With additional safety system**
WITHOUT REGULATION SYSTEM		
WITH REGULATION SYSTEM ON EXTRACTION (OUTLET)		
WITH REGULATION SYSTEM ON EXTRACTION (OUTLET)		

Table 3 (*continued*)

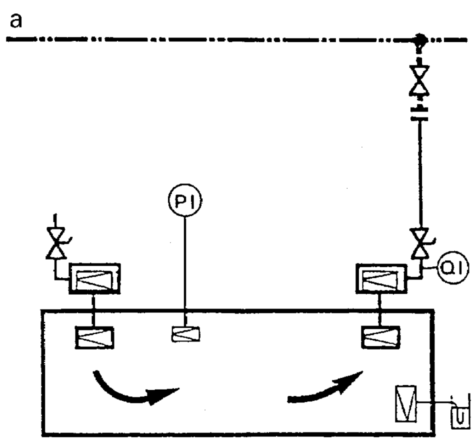
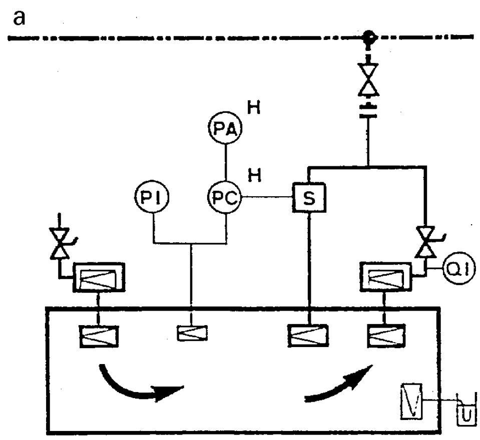
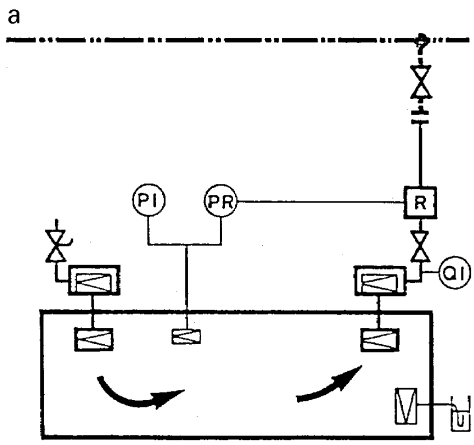
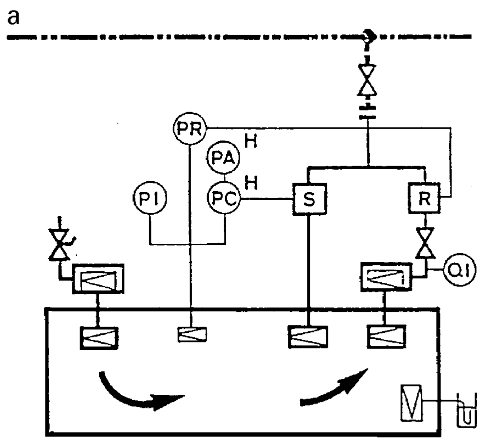
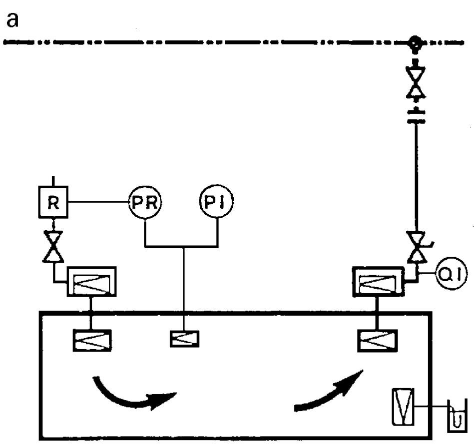
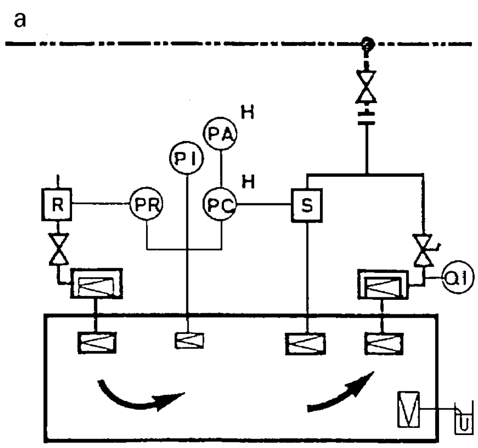
Class 3 or 2 containment enclosures		
	Without additional safety system	**With additional safety system**
WITHOUT REGULATION SYSTEM		
WITH REGULATION SYSTEM ON EXTRACTION (OUTLET)		
WITH REGULATION SYSTEM ON EXTRACTION (OUTLET)		

Table 3 (*continued*)

The total safety flow is the sum of flows coming from the normal extraction circuit (the HEPA extraction filter being considered clogged) and from the additional safety circuit. This additional safety circuit is only necessary when the required safety flow rate cannot be obtained by the normal extraction circuit, even if the filter on this line is clogged. The extraction circuit shall be dimensioned accordingly. Depending on the results of a safety analysis, a second HEPA filter on the additional safety circuit may be necessary. For containment enclosures of class 4, the second HEPA filter on the extraction is optional, however it is recommended if radioactive products are to be handled. The safety analysis can lead to it becoming compulsory. For containment enclosures of classes 3 and 2, the second HEPA filter on the admission is optional, but is recommended if radioactive products have to be handled. The filters outside the enclosure shall be, if possible, located inside a gas-tight housing in order to ensure the containment continuity during the replacement. Any housing that cannot ensure this shall be excluded for that function. Compliance with control standards determines the position of isolation valves: upstream from the filters for admission; downstream from the filters for extraction. The underpressure of the general extraction network shall be about 150 daPa at the connection point of the enclosure network. If needed, the containment enclosures may be fitted with a protection device. If requested, they may be separated from the general extraction network by an isolation valve.
[a] General extraction network.

Table 4 — Semi-open networks

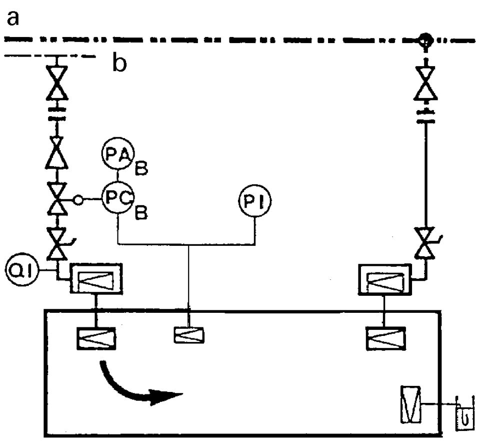
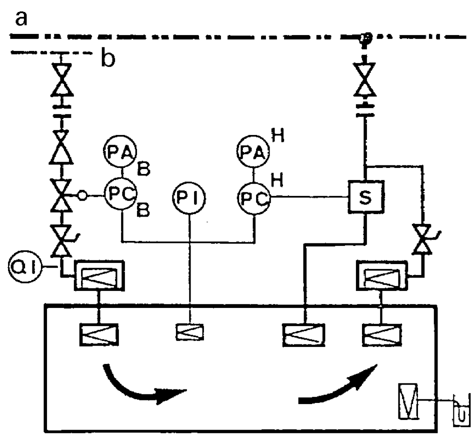
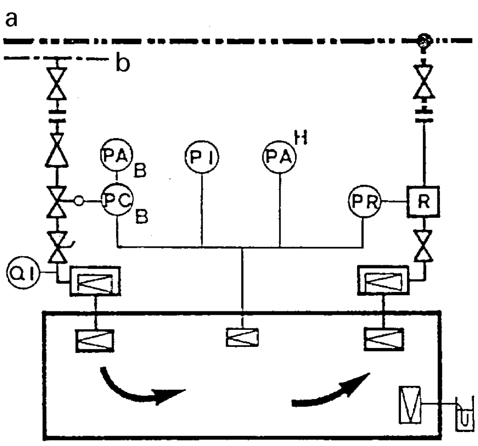
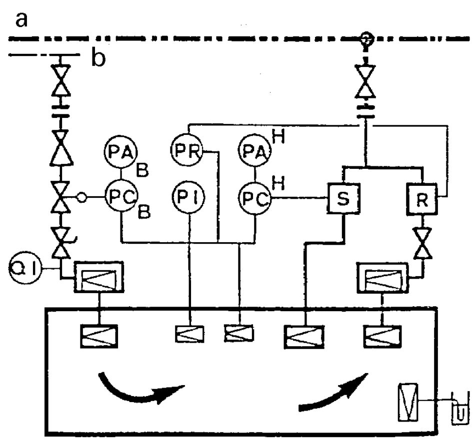
<table>
<tr><th colspan="3">Class 3 or 2 containment enclosures</th></tr>
<tr><th></th><th>Without additional safety system</th><th>With additional safety system</th></tr>
<tr><td>WITHOUT REGULATION SYSTEM</td><td></td><td></td></tr>
<tr><td>WITH REGULATION SYSTEM ON EXTRACTION (OUTLET)</td><td></td><td></td></tr>
<tr><td>WITH REGULATION SYSTEM ON EXTRACTION (OUTLET)</td><td colspan="2">In semi-open networks, the systems with inlet regulation shall be designed as a function of the characteristics of the chosen devices.</td></tr>
</table>

Table 4 (*continued*)

The containment enclosures ventilated with a semi-open network may intake either ambient or dry air, gas from a station, or neutral gas. The total safety flow is the sum of flows coming from the normal extraction circuit (the HEPA extraction filter being considered clogged) and from the additional safety circuit. This additional safety circuit is only necessary when the required safety flow rate cannot be obtained by the normal extraction circuit, even if the filter on the line is clogged. The extraction circuit shall be dimensioned accordingly. Depending on the results of a safety analysis, a second HEPA filter on the additional safety circuit may be necessary. This filter on admission is optional, but it is recommended if radioactive products are to be handled. The safety analysis can lead to it becoming compulsory. The filters outside the enclosure shall be, if possible, located inside a gas-tight housing, in order to ensure containment continuity during their replacement. Any housing that cannot ensure this shall be excluded for that function. Compliance with control standards determines the position of isolation valves: upstream from the filters for admission; downstream from the filters for extraction. The underpressure of the general extraction network shall be about 150 daPa at the connection point of the enclosure network. If needed, the containment enclosures may be fitted with a protection device. If requested, they may be separated from the general extraction network by an isolation valve.
[a] General extraction network. [b] Medium pressure circuit, dry air or neutral gas.

Table 5 — Closed networks

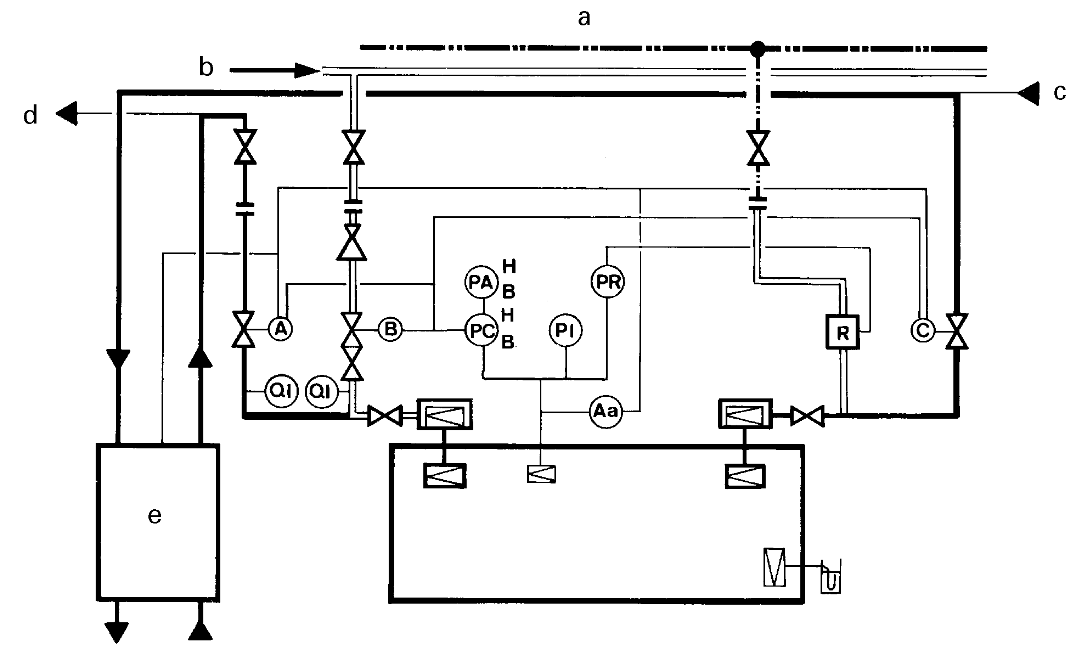
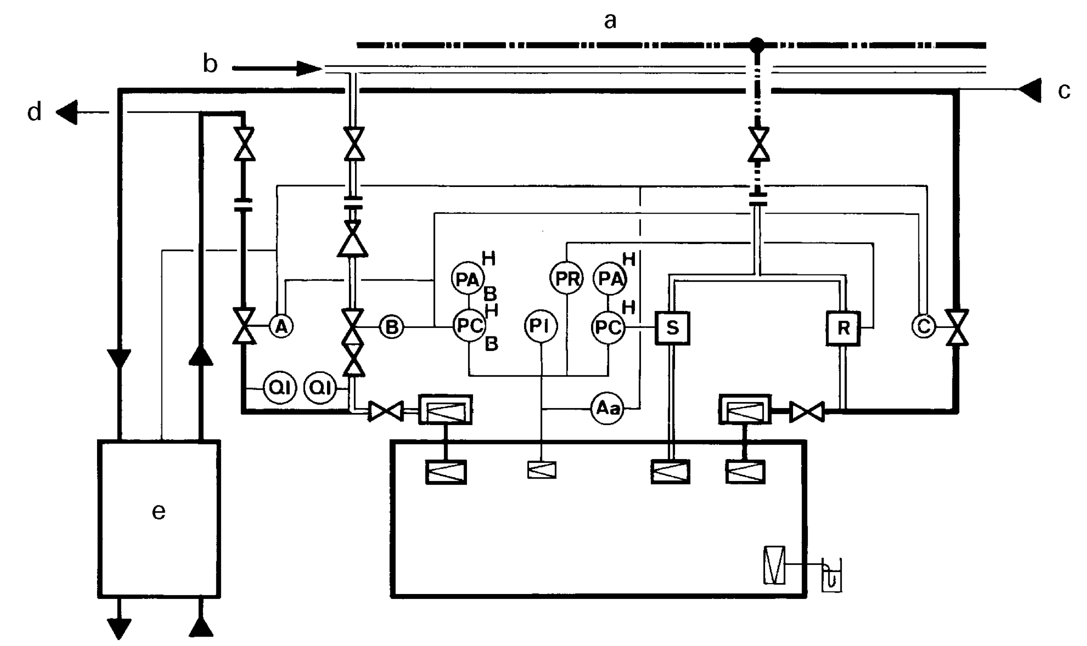
Class 1b or 1a containment	
Without additional safety flow	
With additional safety flow	

Table 5 (*continued*)

The installation without additional safety flow allows for three operating modes: — normal operation in a closed network through the purifying station (circuit indicated in bold line: closed loop); — emergency operation, where, in the case of a stop of the loop, an emergency supply is provided by the gas reserve, and exhaust is towards the general extraction network in semi-open mode (double line); — reduced operation, when the enclosure pressure is outside normal operating limits, starting an additional admission, extraction or both these. The installation with additional safety flow further allows for the safety operating mode, where the safety device is tripped in case of glove stripping. The total safety flow is the sum of flows coming from the normal extraction circuit (the HEPA extraction filter being considered clogged) and from the additional safety circuit. This additional safety circuit is only necessary when the required safety flow rate cannot be obtained by the normal extraction circuit, even if the filter on the line is clogged. The extraction circuit shall be dimensioned accordingly. The total safety flow shall be the subject of a special study, which shall include the protection of the purifying station. Depending on the results of this safety analysis, a second HEPA filter on the additional safety circuit could become necessary. The filters outside the enclosure shall be, if possible, located inside a gas-tight housing, in order to ensure containment continuity during the replacement. Any housing that cannot ensure this shall be excluded for that function. Compliance with control standards determines the position of isolation valves: upstream from the filters for admission; downstream from the filters for extraction. The underpressure of the general extraction network shall be about 150 daPa at the connection point of the enclosure network. The purifying station shall be designed to ensure its own regeneration. Taking into account the low flows concerned, the regulation and safety devices shall have very good leak tightness characteristics (leak rate compatible with the tightness class of the enclosure). If needed, the containment enclosures may be fitted with a protection device. If requested, they may be separated from the general extraction network by an isolation valve. NOTE In case of threshold overrun on the enclosure pressure, the purification is stopped and the neutral gas circuit is opened.
[a] General extraction network. [b] Medium pressure circuit, neutral gas. [c] From other enclosures. [d] To other enclosures. [e] Purifying station.

7.3 Location of extraction filters on shielded enclosures

On the normal extraction circuit, and in order to avoid any exposure due to deposit of radioactive particles on the filtering media, the first stage of the HEPA filter should be installed inside the shielded enclosure. Depending on the condition of use and the available space around the enclosure, the second stage of the HEPA filter may be installed either outside or inside the shielded enclosure.

On the safety circuit, generally only one filtering stage is needed. This first HEPA-filter stage should be installed inside the shielded enclosure.

7.4 Reservation for flow rate measurement

Each enclosure shall have a point of flow-rate measurement on the global extraction: normal flow added to the safety flow. This point of measurement may, for example, be closed with a welded nut or a screw. The measurement device shall have a section smaller than the duct section so that the flow will not be disturbed. The installation of the measurement device shall be leaktight.

7.5 Dimensioning of purification stations

In order to maintain the required purity of the containment enclosure's internal atmosphere, the following parameters shall be checked:

— the external purification-station flow rate,

— the pressure inside the containment enclosure,

— the purity of the air or gas filling the containment enclosure.

The quantities of impurities present in the internal atmosphere shall be chosen in accordance with the process requirements and operational procedures in use at the work place.

Special attention shall be given to checking the leak tightness of the different components of the network (containment enclosure, framework, panels, seals, circuit penetrations, ducts related to the purification station, connections, etc.), and on the maintenance of this leak tightness during the lifetime.

8 Dimensioning of ventilation and gas-cleaning systems

8.1 Principle

It is necessary to dimension the ventilation and gas-cleaning components or systems in order to conform with the required parameters, to ensure both normal and accidental configurations, and to keep the ventilation regime as stable as possible (or varying within acceptable limits) in respect of those operating configurations. The components or systems are the following:

— air production and treatment systems,

— filters (see 8.2 and clause 12),

— activated-carbon/iodine traps (see 8.3 and clause 12),

— linking, or connection, devices (see 8.4),

— control devices (see 8.5 and clause 13),

— fans (see 8.6),

— regulation devices (see clause 9),

— safety and protection devices (see clauses 10 and 11).

8.2 Filters

8.2.1 General requirements

The filters installed on the enclosure or on the network shall be of the HEPA type. Their efficiency is defined by several quantities, the most representative of which is the decontamination factor (DF). This quantity is equal to the ratio of the concentration of incident particles to the concentration of emergent particles. The other most useful quantities are efficiency and penetration.

For the purposes of the nuclear industry, the usual decontamination factors, measured on a test bench for each unit filter at its nominal flow rate, shall be, at minimum:

— 5 000 for the test with soda fluorescein (standard NF X 44-011), with an efficiency of 99,98 % and a penetration of 0,02 %;

— 10 000 for the test with sodium chloride [Eurovent (European committee of aeraulic equipment manufacturers) document 4/4], with an efficiency of 99,99 % and a penetration of 0,01 %.

NOTE Other technical specifications for ventilation filters are given in Annex B.

8.2.2 Enclosure filters

8.2.2.1 Admission filters

To dimension the admission filters, it is necessary to know:

— the flow rate and the negative pressure of the enclosure with respect to the room,

— the pressure drop of the filter element and of the casing,

— the clogging reserve.

The flow rate to be considered is the normal flow rate of the enclosure. This is a function of the enclosure volume and necessary hourly air change rate. Taking into account the usual considered values, the flow rate for a 1 m^3 containment enclosure would range from 3 m^3/h to 10 m^3/h.

The underpressure is set by the designer, according to the safety or the design requirements (namely hierarchy of underpressure). The pressure drop shall take into account not only the pressure drop of the new or partially clogged filter element, but also that of casings or boxes, elbows and adapters. This pressure drop is equal to the underpressure of the enclosure for the set flow rate. The clogging reserve is usually considered to be about 5 daPa.

8.2.2.2 Extraction filters

To dimension the extraction filters, the pressure drop across the normal extraction circuit and the safety extraction circuit to be considered as follows.

— For the normal extraction filter, the enclosure flow rate, initial pressure drop and the clogging reserve of the filtering system (filter + housing), usually between 5 daPa and 50 daPa, shall be taken into account.

— For the safety filter, the safety flow rate and the initial pressure drop of the filtering system (filter + housing) shall be taken into account; the clogging reserve need not be considered.

8.3 Activated carbon (iodine) traps

8.3.1 Dimensioning rules

The mass quantities of iodine to be trapped are generally not dimensioned, owing, in the case of activated carbons, to the short periods of the isotopes concerned. However, the retention performance of the trap begins to drop off for load rates near 0,1 mg of iodine (total) per gram of carbon (in any case this will have to be higher than 1 mg/g).

However, the dimensioning of an activated carbon or iodine trap shall always to be the subject of a previous analysis that takes into account:

— the aerothermodynamic conditions of its operation;

— the use frequency of the trap;

- the nature of effluents to be processed, and especially their chemical composition;
- the voluminal concentrations and the mass activities of the iodine to be trapped;
- the required retention efficiency.

As a general rule, the dimensioning for activated carbons shall be such that the following two conditions are met.

a) The passing velocity through the adsorbent bed shall be less than 25 cm/s for low thickness layers (< 10 cm) and 40 cm/s for thicker beds.

b) The stay time of the gas in the activated carbon layer shall be less than 0,25 s.

In those cases where activated carbon traps are not suitable, namely, when nitrogen oxides are present, other kinds of adsorbent material shall be used.

8.4 Linking (connection) devices

8.4.1 Ducts

Ducts are dimensioned from the admissible flow rates and velocities.

Taking into account the non-negligible cost of this part, both investment and operation costs shall be considered for the choice of duct diameters.

Depending on the privileged criterion, pressure drops ranging from 0,10 daPa to 0,20 daPa per duct meter may be tolerated.

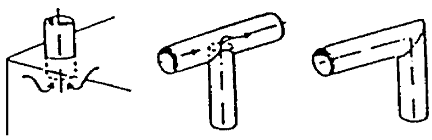
Short changes in direction of duct work shall be advised where necessary (see Figure 1).

8.4.2 Accessories

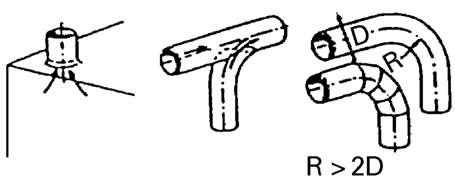
These accessories include linking devices such as nozzles, flanges and unions.

NOTE Other accessories are the insulation (valves, non-return valves, cocks, fire-proof valves), adjustment (throttles, valves) and safety devices.

Recommended designs for linking devices are given in Figure 1.



a) **NOT recommended**



b) **Recommended**

Figure 1 — Linking-device designs

8.5 Control devices

The control devices are the pressure, flow rate, temperature and hygrometry sensors. Their sensitivity, precision and measuring range are fitted to the characteristic quantities to be measured. The measured values may be locally or remotely indicated, and may generate corrective actions, audio-visual information or both.

8.6 Fans

The fans are dimensioned as follows.

a) From their aerodynamic characteristics:

- maximum flow rate of the network (normal flow rate + safety flow rate + eventual reserves), and
- pressure drops of the facility, including the depression upstream and pressure downstream from the fan, calculated at the maximum flow rate.

b) From their mechanical characteristics, including:

- sound level,
- tightness,
- efficiency,
- rotation velocity,
- vibrations,
- temperature level,
- corrosion.

Once these quantities are defined, the choice of fans is made according to the specification curves for the required rotation velocity and efficiency. This choice shall provide a reserve (usually 10 %) for the rotation velocity.

9 Regulation devices

9.1 General

These devices are used to ensure the pressure regulation in the containment enclosures, and are intended to:

- compensate for rapid clogging of enclosure extraction filter;
- limit the pressure variations in the enclosures due to glove movements;
- limit the variation of air-change rates in the enclosure due to variations in depression or air flows in the general extraction network;
- compensate for pressure variations caused by the process implemented inside the containment endosure;
- compensate for pressure variations in the general extraction network (where the network is not equipped with its own regulation system).

Where rapid and important variations affect the reference pressure, depending on the design and the ventilation network parameters, regulation devices are also able to ensure, either fully or partly, the safety flow rate.

For operational situations where the extraction filter can become clogged, the safety function cannot be achieved by the normal extraction circuit. A separate safety circuit is needed. This safety circuit shall be dimensioned to accommodate the total safety flow rate.

9.2 Actuating fluids

Regulation systems are actuated by the ventilation air or gas (containment enclosure atmosphere) or by an auxiliary actuating fluid such as electricity or compressed gases. However, for safety reasons it is preferable to use regulation systems actuated by the internal atmosphere of the containment enclosure instead of an auxiliary fluid.

9.3 Positioning

The regulation devices can be positioned on the enclosure's admission or extraction circuit, generally with a layout as follows.

a) On containment enclosures ventilated using an open network, the regulation device can be installed on the admission or on the extraction side, according to the rules given in clause A.3.

b) On containment enclosures ventilated by semi-open or closed networks, the regulation device is installed on the extraction side.

If automatic regulation devices are present, isolating valves for adjustment purposes are forbidden and shall not be used.

9.4 Regulation devices — Examples

9.4.1 Mobile-piston devices — Single-piston system

9.4.1.1 Description

The single-piston system, or regulation valve, has the following general characteristics:

— tubular plastic body equipped with three threaded outlet orifices that can receive standard unions in stainless steel, copper or polyvinyl chloride (PVC);

— mobile piston sliding inside the valve body, ballasted or not (depending on the desired operating mode);

— two O-rings having the functions of mechanical stop and tightness.

Figure 2 shows a cross-section of a single-piston regulating device.

9.4.1.2 Installation

In an open network, the single-piston system can be installed either on the extraction or admission circuit.

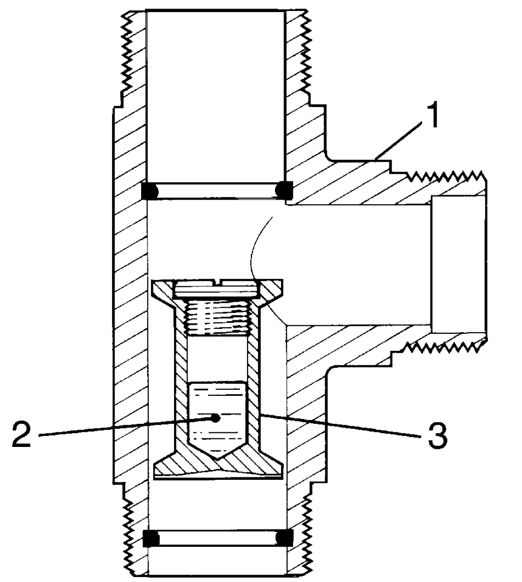
In a semi-open network, it is installed only on the extraction circuit.

9.4.1.3 Operating principle

Installed as shown in Figure 3, the valve ensures the underpressure regulation of the enclosure. If enclosure pressure increases, the piston moves down, putting the enclosure in communication with the extraction collector until normal pressure is recovered. If the enclosure pressure decreases, the reverse happens.

For a given underpressure, the desired extraction flow rate in the enclosure is achieved by adjustment of the internal ballast of the piston.

NOTE This regulation valve will not regulate the enclosure extraction flow rate, because it does not compensate for the clogging of the extraction filter. When such a situation occurs, the extraction flow rate decreases in order to maintain a constant pressure drop between the upper part of the piston and the inner side of the containment enclosure.



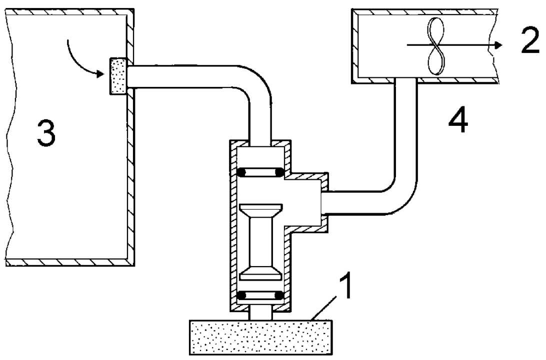
Key

1 Body

2 Ballast

3 Piston

Figure 2 — Single-piston system (regulation valve)



Key

1 Filter

2 Extraction

3 Depressurized enclosure

4 Regulated and minimum underpressure

Figure 3 — Single-piston system (regulation valve) — Operating principle

9.4.1.4 Specifications

The maximum flow rate for this type of valve depends on the design and the level of depression of the general extraction network (e.g. 35 m^3/h for an underpressure of about 120 daPa in the general extraction network).

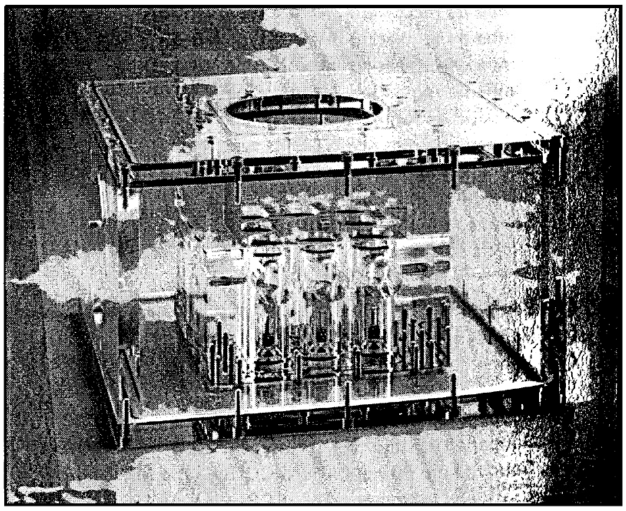
9.4.1.5 Other uses

With the installation shown in Figure 3, the regulation valve also ensures a safety flow rate by fully opening the plug in the case of a tightness break in the containment enclosure, when the extraction filter is unclogged. If the installation direction is reversed, with adjustment the system enables pressure regulation in overpressurized enclosures.

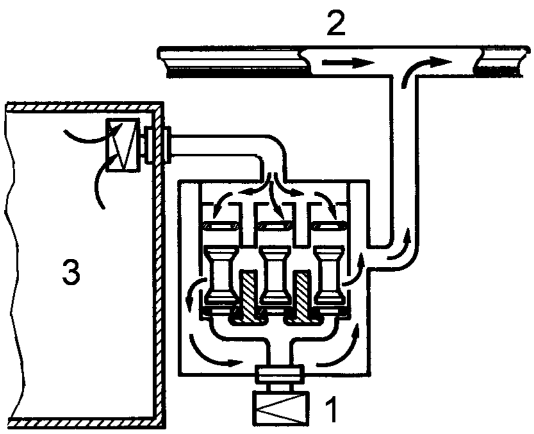
9.4.2 Mobile-piston devices — Multi-piston system

9.4.2.1 Description

A variation on the previous system, the system with multiple pistons is formed by the juxtaposition in the same body of eight elementary valves [see Figure 4 a)], each of which comprises a piston sliding in a vertical chamber. The set is formed by a tube inserted into a rectangular parallelepiped, with the internal tube machined to receive the eight valve bodies.



a) **General view**



b) **Operating principle**

Key

1 Filter

2 General extraction network

3 Depressurized enclosure

Figure 4 — Multi-piston regulation device

9.4.2.2 Installation

The upper end of the chamber is connected to the working enclosure, as with the single-valve system, and the lower end is fitted with a filter. The space between two rectangular parallelepipeds is used for the connection of the ventilation circuit.

9.4.2.3 Operating principle

Installed as shown in Figure 4 b), the device ensures the underpressure regulation of the enclosure. If enclosure pressure increases, the eight pistons move down and place the enclosure in communication with the extraction collector until normal pressure is recovered. If the enclosure pressure decreases, the reverse happens.

For a given pressure, the desired extraction flow rate in the enclosure is achieved by the adjustment of the piston internal ballast.

The device requires a minimum underpressure of 75 daPa in the extraction network.

9.4.2.4 Specifications

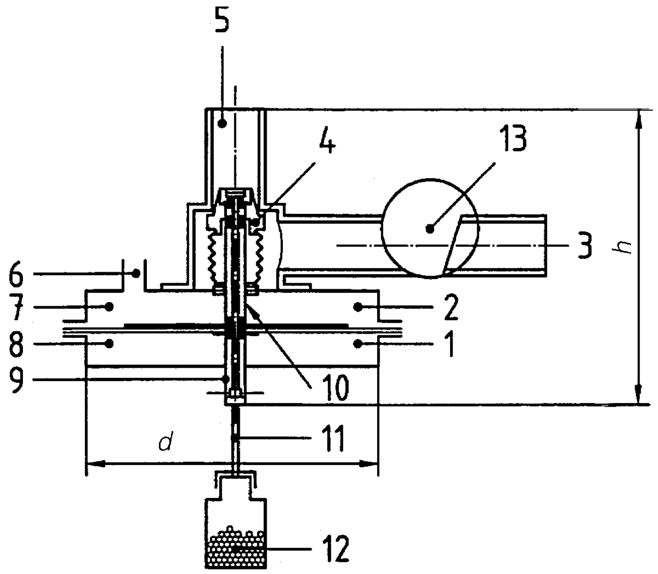
The regulation flow rates handled by such a device can vary from 200 m^3/h to 400 m^3/h for an underpressure in the general extraction network of 120 daPa.

9.4.3 System with elastomer membrane

9.4.3.1 Description

In this design (see Figure 5), the regulation valve is formed of two cylindrical PVC or stainless-steel half sheets, separated by an elastomer membrane, actuated by a rod ballasted by an adjustable weight. The tightness between the plug and the valve body is achieved with a below. The upper chamber of the valve has three orifices for connection with the containment enclosure and the ventilation network.

This valve is available in several standard dimensions according to the range of operating conditions. It can be provided with a fixation yoke on feet, and equipped with two limit microswitches.



Key

1 Atmosphere pressure
2 Enclosure pressure
3 From enclosure exhaust
4 Plug
5 To extraction collector
6 Enclosure pressure measurement tube
7 Upper chamber (p_1)
8 Lower chamber (p_2)
9 Lower spacer
10 Upper spacer
11 Threaded rod
12 Ballast
13 Flow rate indicator

Figure 5 — Regulation device with elastomer membrane

9.4.3.2 Installation

This type of regulation device is designed to be installed on the extraction circuit of the containment enclosure, ventilated in open or semi-open networks.

9.4.3.3 Operating principle

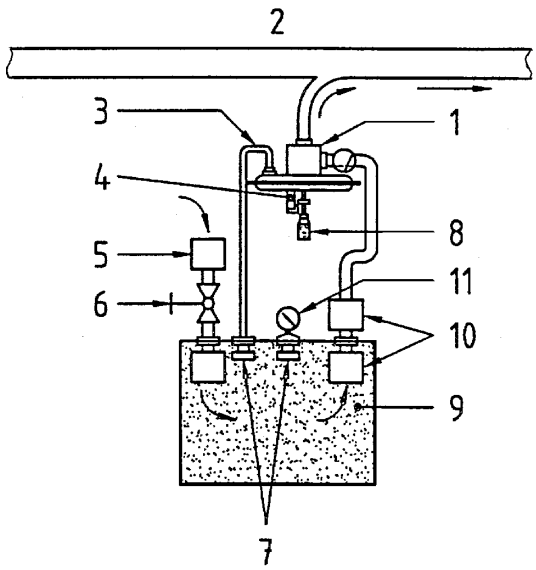
Installed as shown in Figure 6, this regulation valve ensures the following functions:

— depending on the location of the device (admission or extraction circuit), either the regulation of the underpressure or of the air change rate of a containment enclosure at an adjustable constant value;

— the clogging compensation of the extraction filter by reference measurement of the enclosure pressure;

— depending on the ventilation network parameters, full or partial safety flow rate.

The servo control of the regulation is carried out by the membrane position, which adjusts the flow rate according to the pressure difference (p_1 and p_2) between the two chambers. The value of the set pressure is adjusted by the weight of the ballast. The valve needs a minimum underpressure of 100 daPa in the general extraction network.



Key

1 Regulating valve with flow rate indicator
2 General extraction network
3 Enclosure pressure measurement tube
4 Microswitches
5 Inlet filter
6 Optional adjustment shutter or valve
7 Protective suit filters
8 Ballast
9 Enclosure
10 Outlet filters
11 Manometer

Figure 6 — Regulation device with elastomer membrane — Operating principle

9.4.3.4 Specifications

Depending on the model, the regulation flow rates that can be handled by the valves can vary from 5 m^3/h to 20 m^3/h, 20 m^3/h to 100 m^3/h and 100 m^3/h to 400 m^3/h, for an underpressure in the general extraction network of about 100 daPa.

9.4.3.5 Precautions

The valve should be installed as close as possible to the containment enclosure in order to reduce system response times.

The inlet and outlet diameters, as well as the diameter of the enclosure pressure measuring tube, shall not be modified.

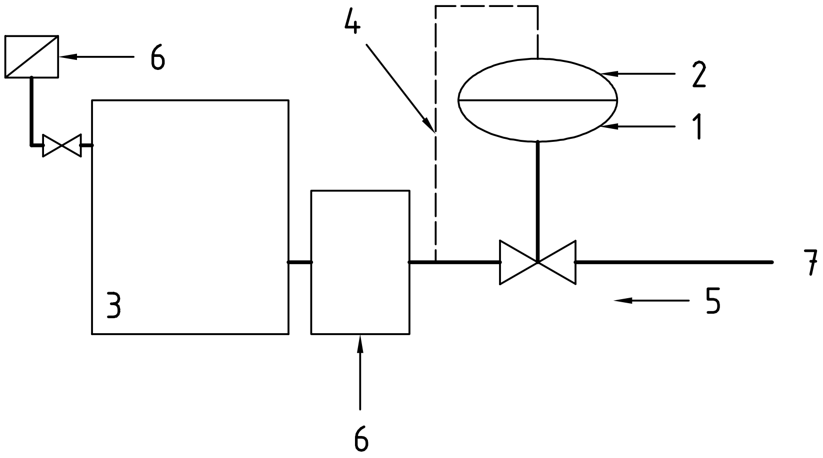
The axis shall be perfectly vertical. The membrane shall be replaced periodically if the ambience is aggressive.

9.4.4 Adjustable control valve

The adjustable control valve is a variation on the regulation system with elastomer membrane. In this device (see Figure 7), the valve is a standard control valve equipped with a diaphragm controller that adjusts the flow rate according to the difference of pressure on each side of the diaphragm.

One side of the diaphragm is a reference pressure (here, the ambient atmospheric pressure) and the other side a sensed pressure (here, the extraction line pressure). The sensed pressure is picked up by a small tube built into the body of the valve, which constitutes a connection with the line leading from the containment enclosure.

When the sensed pressure changes for whatever reason, the diaphragm moves and the valve modulates and counteracts the effect.



Key

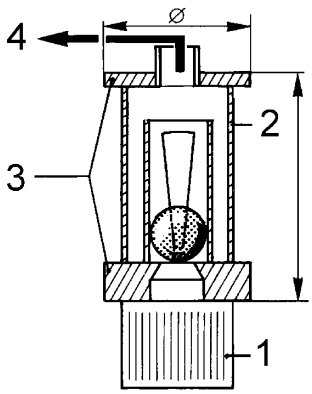
1 Reference pressure
2 Sensed pressure
3 Containment enclosure
4 Internal sensing line
5 Adjustable control valve
6 HEPA filter
7 Toward general extraction network

Figure 7 — Adjustable control device — Operating principle

9.4.5 System with sphere unit

9.4.5.1 Description

In this design, the regulation valve (see Figure 8) consists of a plastic tubular body between two connection flanges, and a stainless-steel or PVC sphere moving in a sleeve with trapeze slots. The valve is produced in the following dimensions: 100 mm diameter, 250 mm height, or 140 mm diameter, 350 mm height.



Key

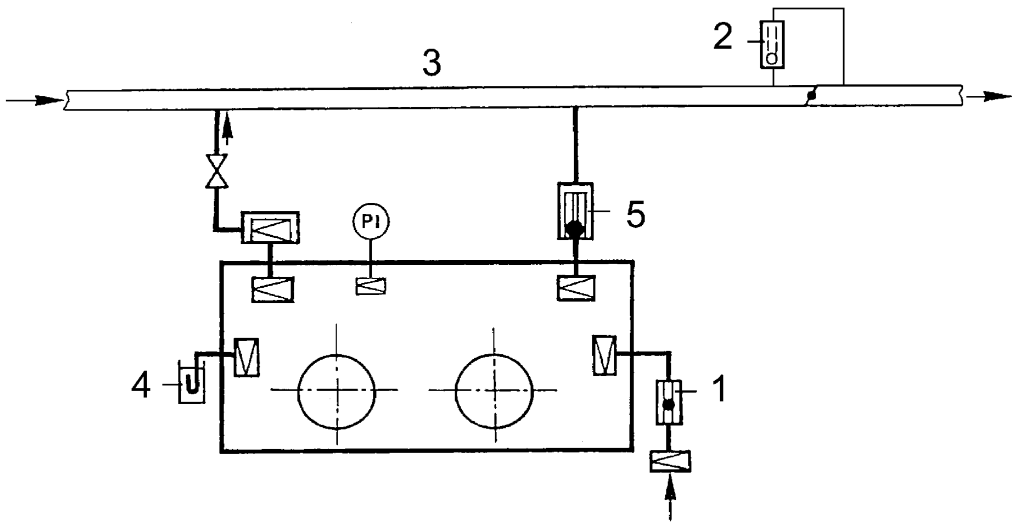
1 Filter
2 Tubular body
3 Flanges
4 To enclosure

Figure 8 — Regulation device with sphere unit

9.4.5.2 Installation

The valve has two utilization modes (see Figure 9). When used for pressure regulation of containment enclosures, it is installed on the air inlet circuit, between two admission filters, for an open network enclosure. This installation prevents the regulation device from becoming dusty.

When used for pressure regulation of networks, it is placed in derivation on the general extraction network, as a by-pass for the balancing throttle. This installation is particularly interesting for low flow rate networks.



Key

1 Enclosure regulation valve

2 Network regulation valve

3 General extraction network

4 Protection device

5 Safety valve

NOTE See Table 1 for symbol meanings.

Figure 9 — Regulation device with sphere unit — Operating principle

9.4.5.3 Operating principle

a) **Containment-enclosure pressure regulation.** The calibration of the sphere maintains it in suspension according to the enclosure pressure. If the pressure increases, the sphere moves down, limiting the air admission into the enclosure due to the slot effect, and even blocking the air inlet in the case of very low relative pressure. On the contrary, if the pressure in the enclosure decreases, the sphere moves up, clearing a larger surface way in order to admit the flow into the enclosure at a greater rate.

b) **Network pressure regulation.** The sphere displacements allow compensation for flow rate variations in the network, maintaining a quasi-stable underpressure level. This utilization is particularly efficient in the case of the tripping of a safety flow in an enclosure, and where it is at the same time desirable to avoid disturbance of the operating regime in other enclosures connected to the network.

9.4.5.4 Specifications

Depending on the model, regulation flow rates handled by this type of valve can vary from 5 m^3/h to 25 m^3/h and from 20 m^3/h to 90 m^3/h.

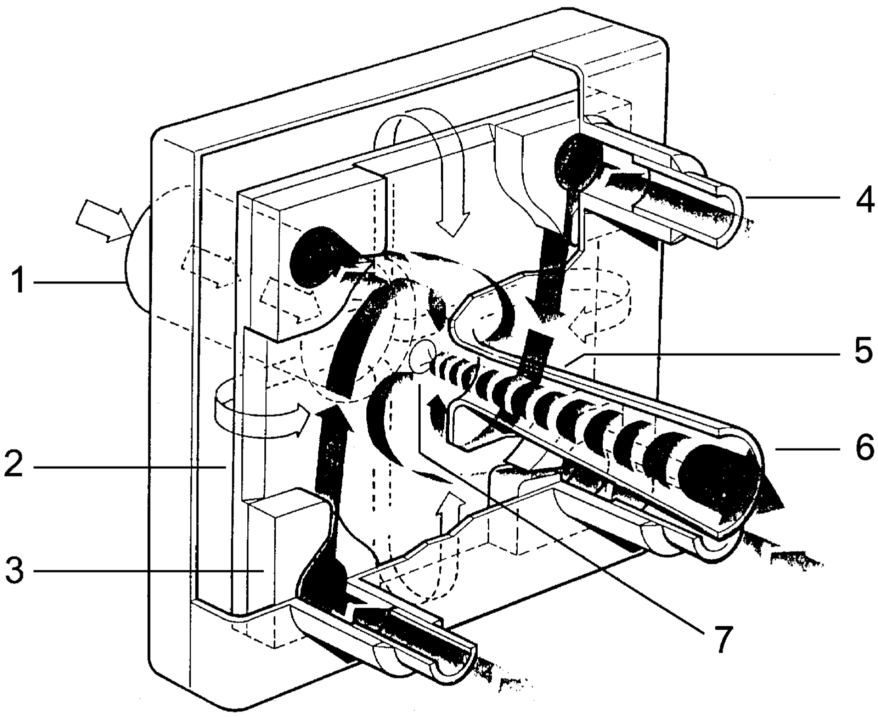
9.4.5.5 Precautions

For the 20 m^3/h to 90 m^3/h valves, filters whose pressure drop at the maximum required flow rate does not exceed the nominal underpressure of the enclosure shall be installed.

9.4.6 System without moving parts (vortex amplifier)

9.4.6.1 Description

The vortex amplifier (VXA) system (see Figure 10) consists of a short cylindrical chamber split into two halves by a plate to form two circular chambers.



Key

1 Cylindrical chamber
2 Plate
3 Compartment
4 Control port
5 Front chamber
6 Radial diffuser
7 Exit port

⇨ Purge flow from glovebox.

➡ Flow to extract duct.

Figure 10 — Vortex amplifier (VXA) — General view

The rear chamber acts as a vortex chamber and is divided into four blocks, each connected to a control port that channels air from the room, via HEPA filters, into the vortex chamber. The mixed air leaves the vortex chamber and passes into the front chamber with a spinning motion. The front chamber contains a radial diffuser for regaining static pressure, allowing the spinning air flow to leave the VXA via the exit port.

9.4.6.2 Installation

The VXA is installed on the admission or extraction circuits of the containment enclosures, ventilated in the open or semi-open network.

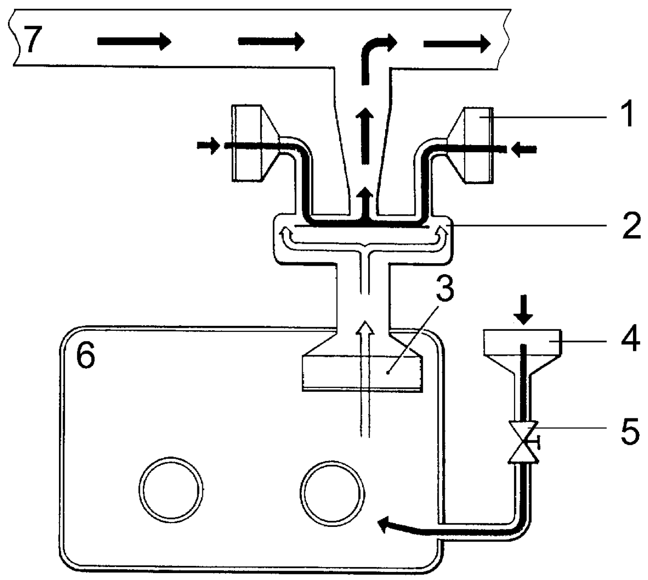
9.4.6.3 Operating principle

Installed as shown in Figure 11, the VXA performs the following functions:

— depending on the location of the device (admission or extraction circuit), regulation of the underpressure or of the air-flow change rate of a containment enclosure at an adjustable constant value;

— clogging compensation of the extraction filter by reference to the control flow rate and pressure drop in the extraction line;

— depending on the ventilation network parameters, full or partial safety flow rate.



Key

1 Control filter
2 Vortex amplifier
3 Outlet filter
4 Inlet filter
5 Inlet control valve
6 Containment enclosure
7 General extraction network

Figure 11 — Vortex amplifier (VXA) — Operating principle

The control offered by the VXA is based on its ability to change resistance without having any moving parts. The resistance is determined by the amount of control flow, which is admitted through the tangential connections.

The vortex amplifier requires a minimum underpressure of 150 daPa in the general extraction network.

9.4.6.4 Specifications

The VXA is available in different dimensions, and its characteristics can vary depending on the condition of use (operating underpressure in the containment enclosure, extraction flow rates under normal and emergency conditions, position, capacities and ranges of resistance of filters, etc.).

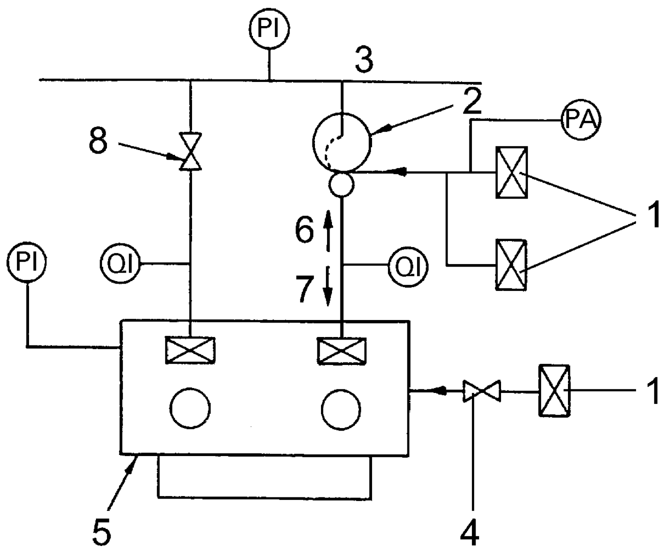
9.4.6.5 Precautions

The vortex amplifier shall not be used in enclosures where the internal atmosphere is liable to be particularly dusty, for example, where operations with powder are being carried out, owing to the danger of rapid clogging of extract filters.

9.4.6.6 Alternative uses

In the situation presented in 9.4.6.5, which pre-empts normal use of the vortex amplifier, two alternative ways of utilizing the VTX are possible.

a) **Single-VXA reverse purge system.** A unique vortex amplifier is installed on the containment enclosure air inlet circuit (see Figure 12). Under normal operating conditions, a small reverse flow is provided through the filter on the main VXA inlet, keeping this filter clean. In the event of a breach in the containment enclosure, the safety flow rate is extracted, in the opposite direction, through the VXA, via the clean filter. This solution nevertheless has the disadvantage of the underpressure of the containment not being regulated by the vortex amplifier characteristics, but only by the bypass valve.



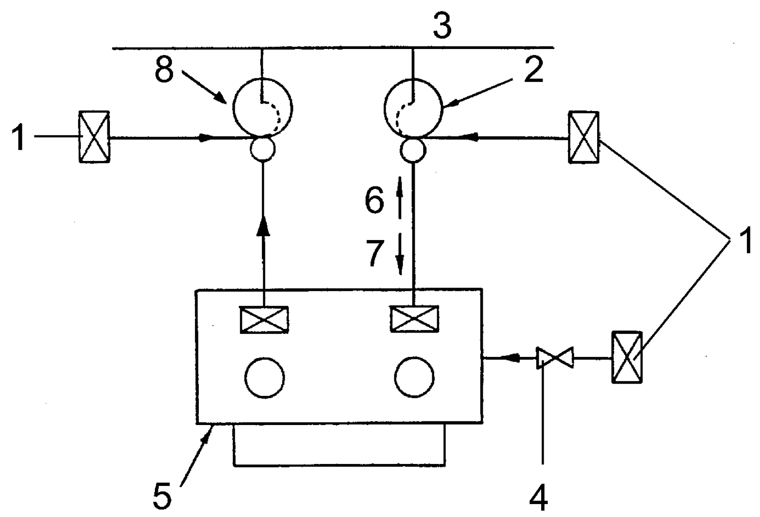
Key

1	Filters	3	General extraction network	5	Containment enclosure	7	Normal flow
2	VXA	4	Control valve	6	Emergency flow	8	By-pass control valve

NOTE See Table 1 for symbol meanings.

Figure 12 — Single-VXA reverse purge system

b) **Double-VXA reverse purge system.** The drawback of the single-VXA reverse purge system can be overcome by this alternative utilization (see Figure 13), in which the characteristics of two VXA devices are chosen such that at the desired operating underpressure in the containment enclosure one of the devices is in the forward-flow condition, while the other is in a reverse-flow condition. Whereas one VXA, like the single-VXA reverse purge system, maintains the filter in a clean condition, the other controls the containment enclosure underpressure, and hence considerably reduces the sensitivity of the enclosure underpressure regulation prior to the purge flow.



Key

1 Filter
2 Reverse purge VTX
3 General extraction network
4 Control valve
5 Containment enclosure
6 Emergency flow
7 Normal flow
8 Normal VTX

NOTE See Table 1 for symbol meanings.

Figure 13 — Double-VXA reverse purge system

10 Safety-flow-rate systems

10.1 General

These yes/no systems help maintain the safety flow rate in the case of inadvertent containment breaking (e.g. pulling out of a glove). They ensure the safety flow rate at the pre-set value either through normal extraction circuit operation or by adding an additional system if the normal flow rate is insufficient. In the later case, the safety flow is the sum of flows coming from the normal extraction circuit and the additional safety circuit. However, in practice the safety systems are nevertheless dimensioned for the maximum required safety flow rates, without taking into account the flow rates ensured by the normal extraction circuit.

The systems are actuated by the ventilation of air or gas (enclosure atmosphere), or by an auxiliary fluid such as electricity or compressed gases, according to the results of the reliability study.

The safety-circuit connection may be either connected to the extraction circuit of the containment enclosures, if the specifications of this circuit are appropriate, or constitute an independent extraction with its own extraction fans. The air extracted from this circuit goes through at least one HEPA filter, which should preferably be installed inside the containment enclosure. The aspiration point of the circuit in the enclosure shall, if possible, be located opposite the potential openings, avoiding the interposition of obstacles in the air path.

10.2 Safety valves — Examples

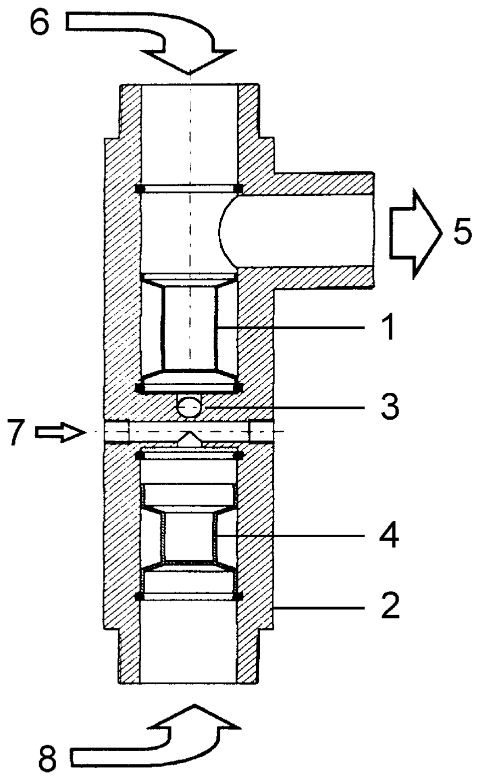
10.2.1 Mobile-piston system

10.2.1.1 Description

The design (see Figure 14) of this safety valve is derived from the single-piston regulation valve described in 9.4.1, and has a cylindrical body containing a second mobile plug screwed to its lower part.

10.2.1.2 Installation

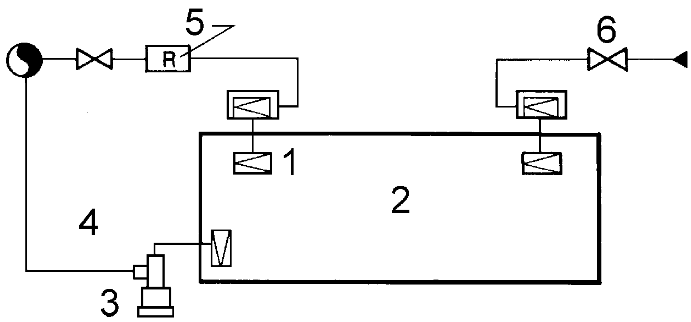
This valve is installed on the circuit ensuring the additional safety flow rate and is connected to the general extraction network (see Figure 15).



Key

1 Piston
2 Body
3 Centre punch
4 Plug
5 Toward extraction
6 Enclosure (safety circuit)
7 Enclosure pressure reference
8 Room pressure reference

Figure 14 — Safety valve with mobile piston



Key

1 HEPA filter
2 Enclosure
3 Safety valve
4 Safety branch
5 Enclosure regulation system
6 Air or gas admission

NOTE See Table 1 for symbol meanings.

Figure 15 — Safety valve with mobile piston — Installation

10.2.1.3 Operating principle

The safety valve with mobile piston is an “all or nothing” device for ensuring the additional safety flow rate (which will depend on the particular valve’s specifications). In case of containment breaking, the piston moves down and places its lower face in communication with the underpressure in the extraction network via the capillary. With this movement, the centre punch blocks the lower aperture communicating with the atmosphere and the valve ensures a full flow rate. When the underpressure in the enclosure returns, the plug moves up and places the lower face of the piston in communication with the atmospheric pressure. Due to the pressure difference between the two faces, the piston moves up and takes its closing position, driving the centre punch; the device is then in its standby position and ready to operate again.

10.2.1.4 Specifications

The safety flow rate of the valve is from about 60 m^3/h to 70 m^3/h. It trips when the enclosure underpressure reaches 10 daPa. Its flow is near zero in closed position.

10.2.2 System with elastomer membrane

10.2.2.1 Description

The design of this safety valve (see Figure 16) is identical to that of the regulation valve described in 9.4.3, except that it has only one microswitch at the opening and the seal of the plug has a special shape enabling a guaranteed null flow rate (valve closed) at normal enclosure underpressure.

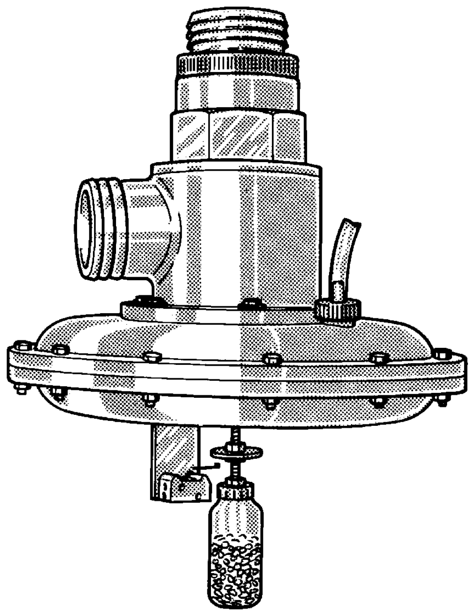


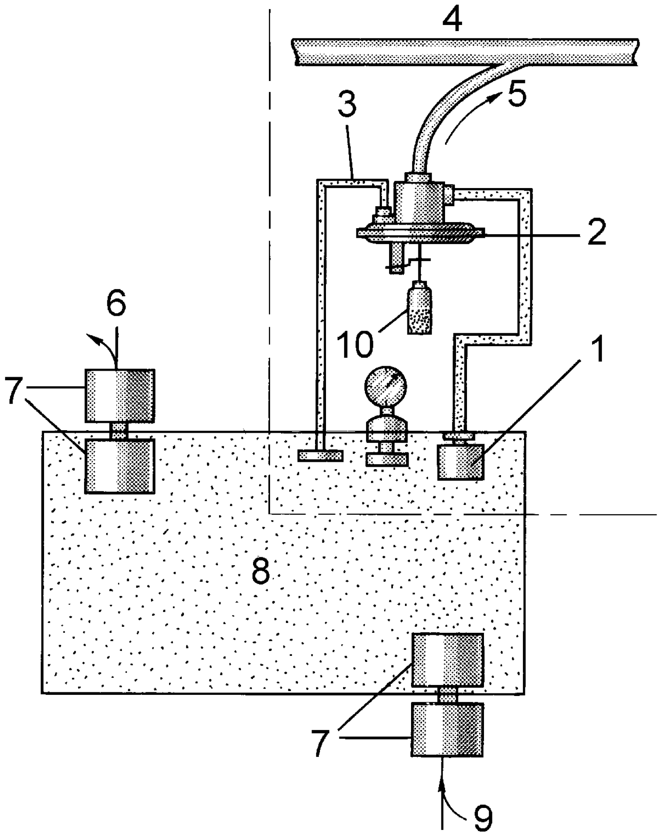
Figure 16 — Safety valve with elastomer membrane — General view

10.2.2.2 Operating principle

The safety valve with elastomer membrane is an “all or nothing” device for ensuring the additional safety flow rate, which will depend on the particular valve’s specifications. In case of tightness breaking, the internal membrane moves fully to maintain the safety flow rate. When the enclosure pressure returns to its nominal value, the membrane returns to its initial position.

10.2.2.3 Installation

The valve is installed on an independent circuit, connected, depending on the case, to the general extraction network or to a special network (see Figure 17). This independent safety circuit has its own HEPA filter, generally located inside the enclosure.



Key

1 Outlet filter
2 Safety valve
3 Enclosure pressure measuring tube
4 General extraction network
5 Safety ventilation circuit
6 Normal ventilation extraction circuit
7 Filters
8 Containment enclosure
9 Normal ventilation admission circuit
10 Ballast

Figure 17 — Safety valve with elastomer membrane — Operating principle

10.2.2.4 Specifications

The valve is made of PVC or stainless steel. Depending on the model, the safety flow rate it provides can be 50 m^3/h, 200 m^3/h or 500 m^3/h.

10.2.2.5 Precautions

The valve should be installed as close as possible to the containment enclosure in order to reduce system response times. The inlet and outlet diameters, as well as the diameter of the enclosure pressure measuring tube, shall not be modified.

The valve dimensioning shall be adapted to the network underpressure and shall take into account the induced pressure drop. The membrane shall be replaced periodically if the ambience is aggressive.

NOTE This safety valve is not designed to perform a regulation function, therefore it is useless to fit it with a flow rate indicator, as is currently the case with all static pressure regulation valves.

10.2.3 System with mobile sphere

10.2.3.1 Description

This safety valve has a stainless steel tubular body assembled between two flanges (see Figure 18). The lower flange has external and internal threads for its fixation on the containment enclosure and for supporting standard filters. On the internal part of the flange, a sleeve with straight slots houses a sliding calibrated sphere. The upper flange also has a thread providing for either a second standard filter or connection to the safety network.

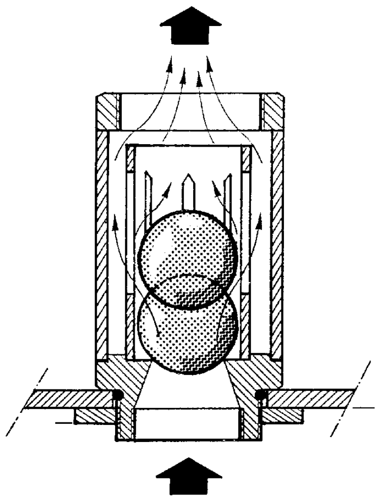


Figure 18 — Safety valve with mobile sphere

10.2.3.2 Installation

The valve is installed on an independent circuit, connected, depending on the case, to the general extraction network or a special network (see Figure 19). This independent safety circuit can have its own HEPA filter, generally located inside the containment enclosure.

10.2.3.3 Operating principle

The safety valve with a mobile sphere unit is an “all or nothing” device for ensuring the additional safety flow rate, which will depend on the particular valve’s specifications.

10.2.3.4 Specifications

Depending on the model, the safety flow rate provided by the valve is 35 m^3/h or 90 m^3/h.

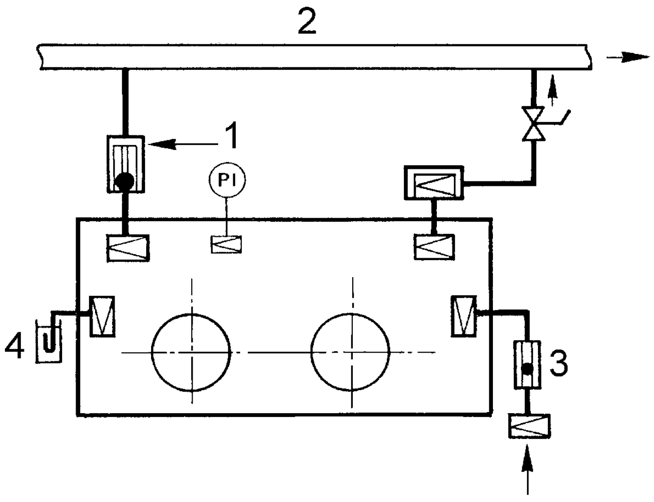
10.2.3.5 Precautions

This safety valve requires a relatively stable underpressure in the general extraction network.

10.2.4 Multifunction (MF) valve

10.2.4.1 Description

This safety valve (see Figure 20) has a stainless steel tubular body containing a set of plugs, pistons, membranes and elastomer below. Its design is derived from the system with elastomer membrane, overall dimensions are 470 mm × 380 mm, and the valve is supplied with an optional fixation plate and admission filter.



Key

1 Safety valve

2 General extraction network

3 Enclosure regulation valve

4 Protection device

NOTE See Table 1 for symbol meanings.

Figure 19 — Safety valve with mobile sphere — Installation

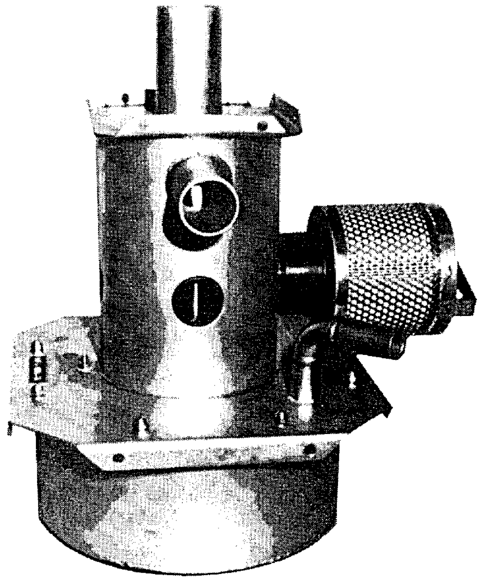


Figure 20 — Multifunction (MF) valve — General view

10.2.4.2 Operating principle

The multifunction (MF) valve enables underpressure to be controlled in every circumstance in a containment enclosure: in normal regime, it keeps this underpressure within the set range; in underpressure increase, it allows admission of a compensation flow; in underpressure decrease, it induces a safety flow.

a) **Underpressure regulation of a containment enclosure** [see Figure 21 a)]. The enclosure underpressure above the piston induces a force that compresses the spring (bearing against plug rod) and lifts the regulation plug. The air passes through the filter and the regulation plug, enters into the enclosure by the inlet filters, and is extracted through the filters towards the collector. If the enclosure underpressure decreases, the piston and the plug move down to admit less air and keep the depression to the desired level (reverse operation in the opposite case). The value of the given underpressure (set point) is adjusted by screwing or unscrewing the cap.

b) **High depression value** [(see Figure 21 b)]. If the enclosure underpressure exceeds a set threshold, the piston pushes the regulation plug, which takes its bearing on the bar and lifts the two high depression plugs. The air penetrates through the corresponding orifices, allowing maintenance of the underpressure at a permissible level. The circuit pressure drop, particularly the filters, is provided for accordingly.

c) **Low depression safety** [see Figure 21 c)]. If the enclosure underpressure decreases to become lower than a threshold value (e.g. pulling away of gloves) the force on the piston no longer compensates the spring effect and the weight of the mobile suite. Consequently, the piston goes down, closes the regulation plug and opens the plug via the heel of the rod. The enclosure then communicates with the extraction collector. The circuit pressure drop, particularly of the filters, makes possible a high flow rate. The air penetrates through the accidental orifice to ensure a dynamic containment, and passes through the filters and the valve to the extraction collector.

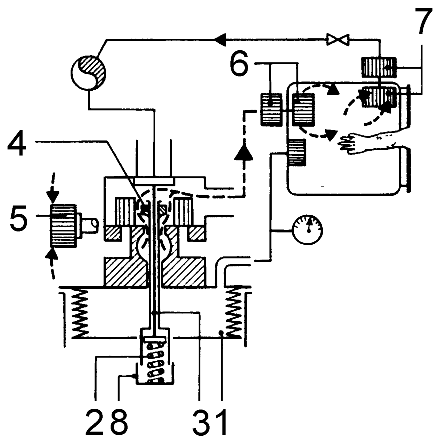
10.2.4.3 Specifications

For regulation in general, the set point is adjustable between 25 daPa and 40 daPa, and the regulation range approximately 5 daPa.

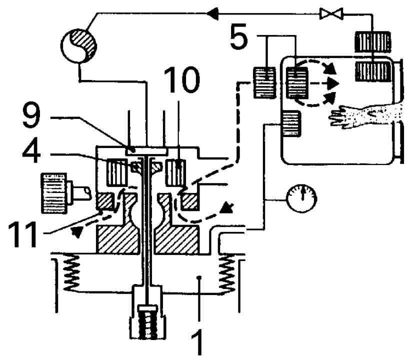
For high-depression regulation, the opening of the plugs is expected for an underpressure of 55 daPa to 60 daPa in the enclosure. The obtained safety flow rate depends on the pressure drop of the circuit [see Figure 21 b)].

For low-pressure regulation, the opening threshold of the plug corresponds to an underpressure in the enclosure of 5 daPa to 10 daPa. The safety flow rate depends, as before, on the pressure drop of the circuit, as well as on the driving underpressure available in the aspiration collector. The pressure drop of the MF valve alone is given in Figure 22 b), with each curve representing one of the two types of available plug types.

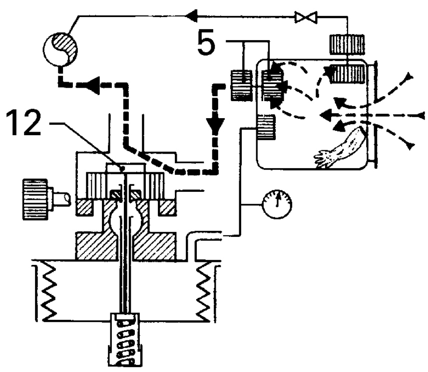
Depending on the model, the flow rates handled by these valves can vary from 0 m^3/h to 4 m^3/h, 2 m^3/h to 10 m^3/h, and from 5 m^3/h to 20 m^3/h.



a) **Underpressure regulation**



b) **High-pressure regulation**

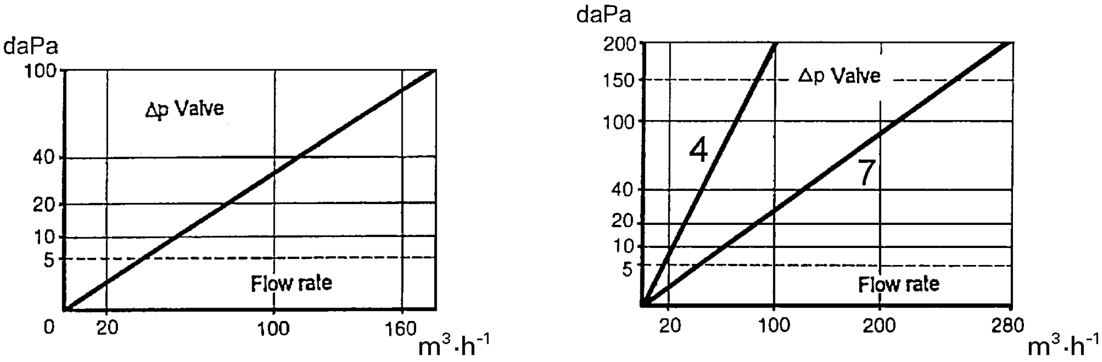


c) **Low-pressure regulation**

Key

1 Piston
2 Spring
3 Plug rod
4 Regulation plug
5 Filter
6 Inlet filter
7 Filters
8 Cap
9 Bar
10 HD plug
11 Orifices
12 Plug

Figure 21 — Multifunction (MF) valve — Operating principle



a) **High-depression regulation** b) **Low-depression regulation**

Figure 22 — MF valve pressure drop

10.2.5 System without moving parts (vortex amplifier)

This device is identical to the VXA regulation device described in 9.4.6. However, instead of ensuring regulation, it enables only the safety flow rate in case of a breach in the containment enclosure.

11 Protection devices

11.1 General

It is often necessary to fit the containment enclosure with a protection device, itself protected by a filter, to limit pressure effects in an operating anomaly (excessive overpressure or underpressure), without outside contamination, or to avoid the rupture of a panel (see Figure 23). A number of devices fulfil this function, including:

— hydraulic valves,

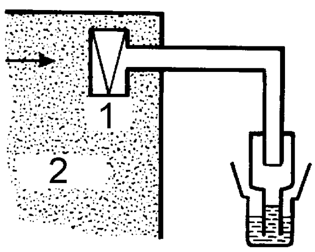
— mechanical valves,

— disruption devices,

— safety siphons.

Examples of different types of hydraulic valve are given in 11.2; mechanical valves are described in 11.3.

Hydraulic valves are often preferred to mechanical valves, as they are more reliable (no moving mechanical parts), cannot be clogged and operate as efficiently by pressure excess as by depression.



Key

1 Filter

2 Enclosure

Figure 23 — Protective device — General view

11.2 Positioning

The protection device shall, as a general rule, be positioned as close as possible to the potential explosion or implosion source. In particular, if this risk is preponderant in the containment enclosure itself, it is recommended that the device be installed directly on the enclosure, and not on the admission or extraction circuits.

11.3 Hydraulic valves — Examples

11.3.1 Low-flow-rate hydraulic valve

This hydraulic valve (see Figure 24) is installed, after HEPA filtration, on a containment enclosure wall. It consists of a PVC tank with a stainless-steel cover. A variety of models accept flow rates ranging from 40 m^3/h to 80 m^3/h. Pressure drops corresponding to a flow rate of 50 m^3/h are approximately 80 daPa when the valve operates in overpressure and 90 daPa when it operates in negative pressure.

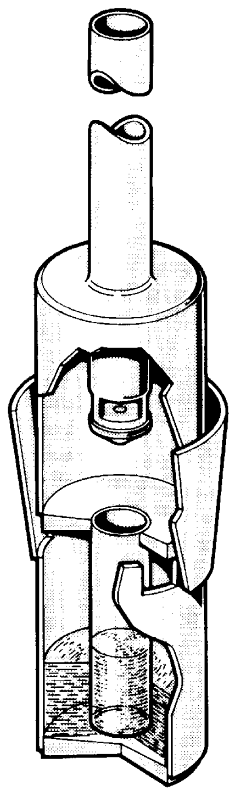


Figure 24 — Low-flow-rate hydraulic valve

The valve has an oil reserve which maintains the isolation of the containment enclosure from the laboratory, with the plunger limiting the pressure variations depending on the oil height.

Identical valves can be made in transparent glass or polymethylmethacrylate (PMMA).

11.3.2 Medium- or high-flow-rate hydraulic valve

This hydraulic valve (see Figure 25) is installed after HEPA filtration on containment or leaktight enclosures at risk of implosion risk (pneumatic transfer). Flow rates of up to about 350 m^3/h are acceptable. The valve has a transparent PVC or PMMA body, a movable part comprising a bell-jar and devesiculator plates, as well as two complementary compartments for avoiding any back diffusion of liquid in the containment enclosure or filtering media.

The hydraulic reserve allows containment enclosure isolation to be maintained up to a value function of the oil height. Above this value, the mobile part is driven up and comes to a stop, giving a free path to air and reducing pressure drops and oil dragging.

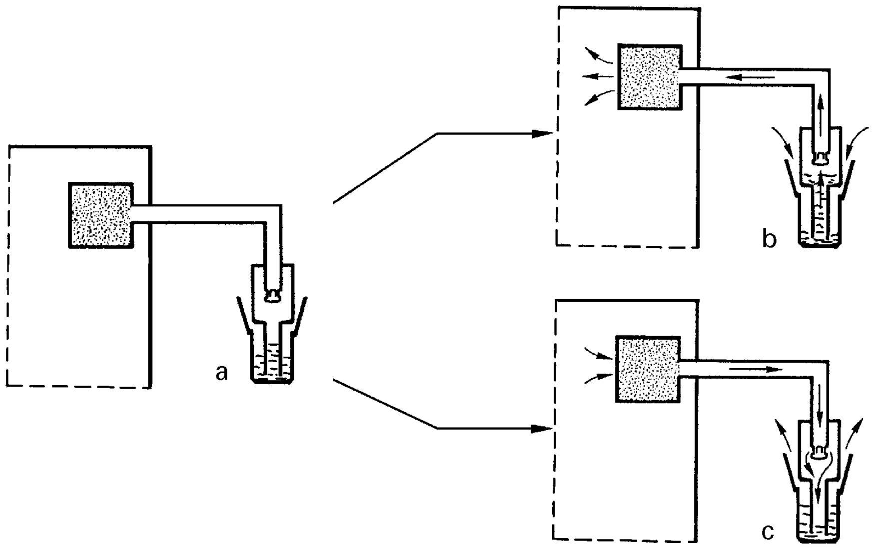
11.3.3 High-flow-rate hydraulic valve

This hydraulic valve (see Figure 26) is installed on a glove port or bag port. It shall be protected by a HEPA filter.

It is used on containment enclosures or leaktight enclosures with either a high-flow-rate vacuum pump or a high-pressure gas supply.

Flow rates of above 350 m^3/h are acceptable.

The valve's operating principle is the same as that of the low-flow-rate valve. It is shown in Figure 27 in normal position [a)], with abnormal underpressure [b)] and with abnormal overpressure [c)] in the enclosure.



[a] Equilibrium status (enclosure at nominal depression).

[b] Odd operation (excessive depression).

[c] Odd operation (excessive overpressure).

Figure 25 — Medium-high-flow-rate hydraulic valve

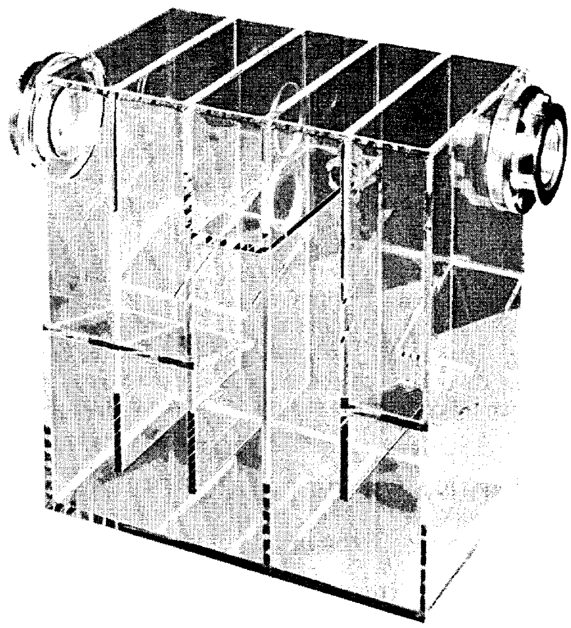
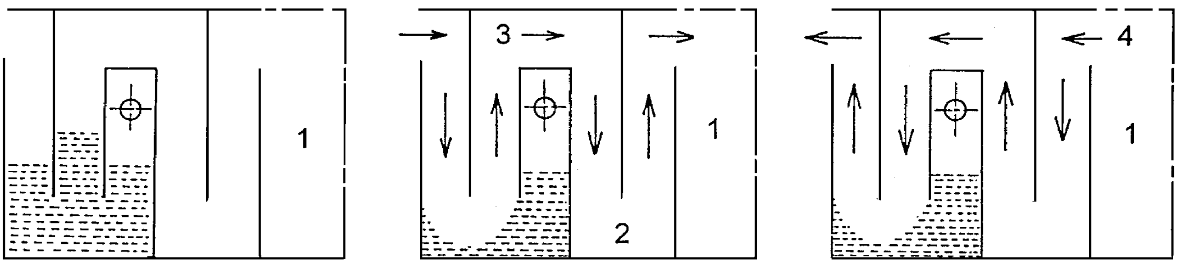


Figure 26 — High-flow-rate hydraulic valve



a) **Normal position** b) **Abnormal underpressure** c) **Abnormal overpressure**

Key

1 Enclosure
2 No-back-diffusion compartments
3 Air
4 Neutral gas

Figure 27 — Multicompartmental high-flow-rate hydraulic valve — Operating principle

11.3.4 General requirements

Hydraulic valves shall have graduated marks indicating:

— the initial filling threshold (zero level);

— the equilibrium level, enclosure at nominal underpressure (nominal level);

— the levels corresponding to the trip value of the device (maximum depression or overpressure level).

The size of HEPA filters shall be compatible with the dynamical efficiency of the valve.

The use of oil with low viscosity is recommended.

WARNING — It is imperative that the protection filter of the valve be replaced after any inadvertent trip for excessive underpressure.

11.4 Mechanical valves

These valves (see Figure 28) are used to eliminate the accidental overpressure of a containment or gas-tight enclosure. In the case of a containment enclosure in overpressure with lost neutral gas, the valve acts as pressure regulator. A filter installed inside the enclosure eliminates the risk of contamination.

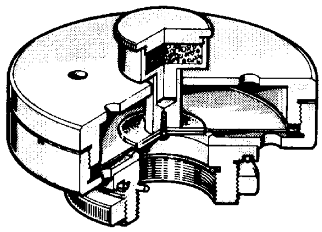


Figure 28 — Mechanical protection valve

12 Air-cleaning systems

12.1 Filters

12.1.1 Purpose

The purpose of the admission and extraction filters is to ensure the containment of any contamination during normal operation and in a break in ventilation (it is said that an enclosure “breathes” through its filters). Furthermore, the admission filter protects the internal equipment by keeping back the dust of the atmospheric air admitted from the room, and retards the clogging of the extraction filters.

Figure 29 shows a general containment enclosure filter design.

12.1.2 General requirements

Every gas circuit enabling the airing of an enclosure shall be equipped with filters.

The components of the filter shall support the fluid passing through it and the particles it is designed to stop.

12.1.3 Nature and types of filters

The containment enclosure filters are provided with a metallic or plastic casing, and can be of open-, closed- or perforated-casing type. The choice of the filter type and its dimensioning are a function of:

— the pressure drop (filters with open or perforated casings cause less pressure drop than filters with closed casing),

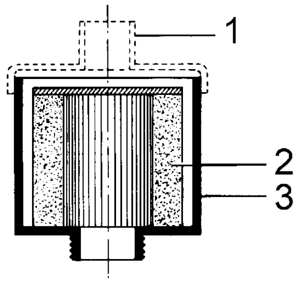
— the atmosphere of the glove box or containment enclosure.

As a general rule:

— for the chemistry, depending on the filter’s installation, open or closed PVC casings are used;

— for the metallurgy, metallic casings in sheet steel coated with an anti-acid paint or casings in sheet aluminium or stainless steel are used.

Examples of different types of containment-enclosure filters are given in 12.1.5 to 12.1.8.



Key

1 Cover

2 Filter cartridge (formed by a filter element fastened to the casing)

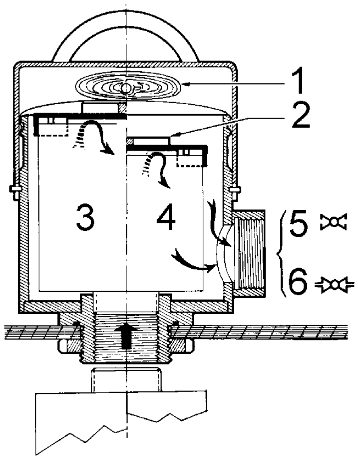
3 Casing

Figure 29 — Containment-enclosure filter design

12.1.4 Housing

A filter with an open or perforated casing can either be contained in a gas-tight housing (see Figure 30) incorporated in a ventilation circuit, or protected by a cover allowing connection to an extraction circuit (thus avoiding the use of a box) or of flexible tubing in the case of internal filters.

Housings of metallic or plastic are mounted outside the enclosure, allowing connection or disassembling of rigid ducts, and protecting the filter elements against the shock. The use of a vinyl bag during the replacement ensures continuity of containment.



Key

1 Intervention bag

2 Glued cross-piece

3 Filter 160

4 Filter 140

5 Female valve

6 Male valve

Figure 30 — Containment-enclosure filter housing

12.1.5 Push-through filter

12.1.5.1 Operating principle

The push-through filter system (see Figure 31), which uses translation-replaceable cartridges, is fitted to containment enclosure ventilation circuits (glove boxes for handling radioactive products, sterile and medical enclosures, etc.). The system generally improves operating safety and reduces maintenance time. It consists of a cylindrical sheath, fixed rigidly to the enclosure wall, into which the filter cartridges can be inserted, the gas-tightness being maintained by a double-lip gasket. A new filter element is inserted by pushing the old element inside the enclosure without breaking tightness. This replacement is carried out remotely using a push rod.

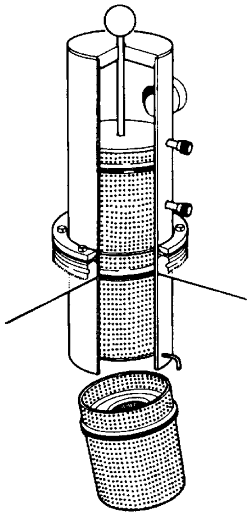


Figure 31 — Push-through filter system — General view

12.1.5.2 Design

The push-through filter system has a PVC or stainless-steel tube into which HEPA filter elements with a double-lip tightness gasket (ref. 3206-03) are inserted. The tube, designed to be directly fixed onto the enclosure wall, has the following design and characteristics (see Figure 32 and Table 6):

— at one end, a removable obturator with double-lip gasket for the introduction of the filter elements;

— a lateral offtake for air or gas admission or extraction, equipped with an adjustment valve;

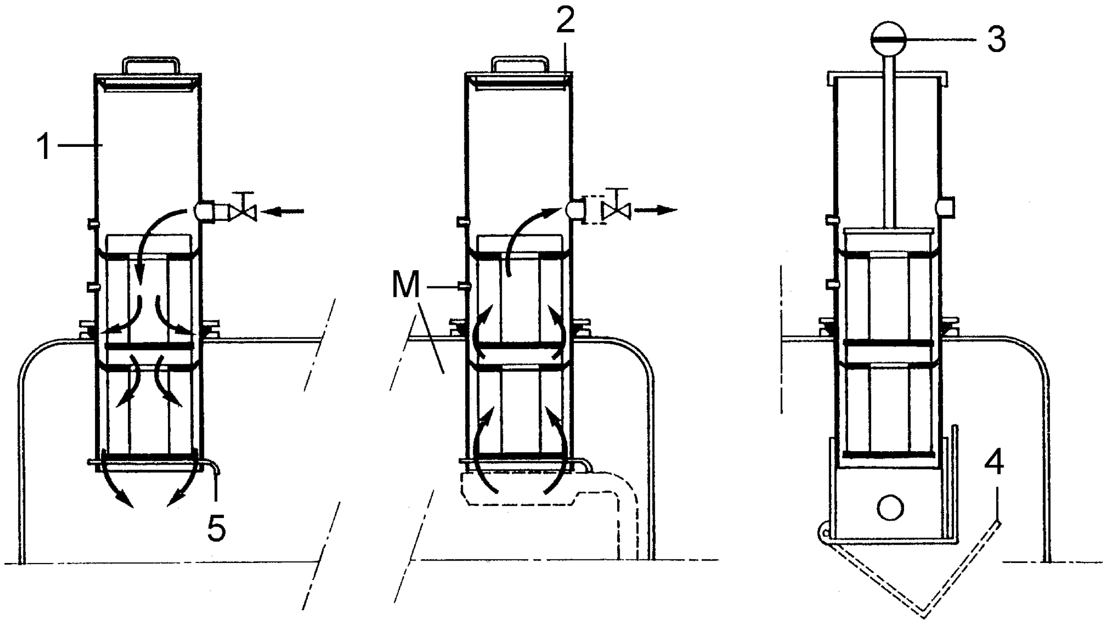
— measuring points of static pressure for the control of pressure drop of filter elements;

— at the other end (i.e. on the filter element evacuation side), either

    1) a safety pin, or

    2) an articulated receptacle with lateral off-take for extraction, flexible on the working level.

The filter system can be installed in different positions, vertically or horizontally. It may be installed outside the enclosure. When there are two filters in a series, there are always two double-lip gaskets between the cell and the outside, thus eliminating any risk of accidental contamination (see Figure 33).



Key

1 Tube

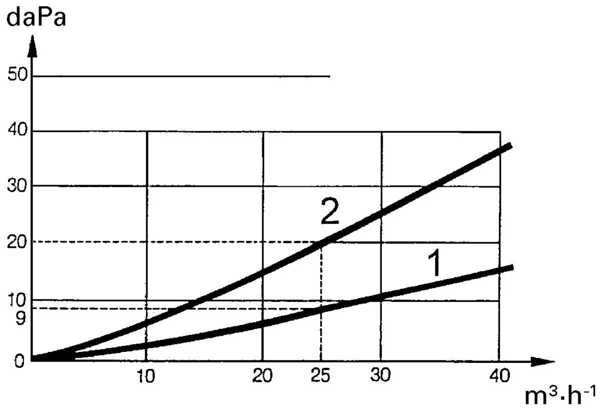
2 Obturator

3 Ejection push rod

4 Receptacle

5 Safety pin

Figure 32 — Push-through filter system — Operating principle



Key

1 One filter

2 Two filters in series

NOTE The curves indicate the pressure drops of the filter element alone, with respect to the flow rate. The nominal flow of this kind of filter is about 25 m^3/h (push-through filters with a 200 m^3/h flow rate exist, but their dimensions are larger and need a special layout study).

Figure 33 — Push-through filter — Pressure drop

Table 6 — Main push-through-filter characteristics

	Designation	Material
Assembly (without filter) [a]	With pin	Stainless steel PVC
	With receptacle and lateral offtake	Stainless steel PVC
Spare parts	Obturator	Stainless steel PVC
	Ejectable push rod	PVC
	Receptacle with lateral offtake	Stainless steel PVC
	Pin	Stainless steel PVC

[a] All assemblies include an obturator.

12.1.5.3 Replacement of filter elements

The push-through filter system allows replacement of filter elements without containment breaking. The filter shall be replaced in the following successive steps.

a) Remove the obturator.

b) Remove the pin or, depending on case, open the receptacle.

c) Introduce a new element on the side opposed to the gasket.

d) Using the ejection push rod, push the filter element until the old filter is ejected.

e) Put back the obturator, the pin or the receptacle.

12.1.6 Protection-suit filter

12.1.6.1 Operating principle

The protection-suit filter is generally used on containment enclosures for protection of equipment (manometers, regulation valves, etc.). Of small capacity, it can be mounted in open or closed casings, or inserted in gas-tight housings. The filter cartridge is made of glass-fibre paper. The filter can be of two basic designs: open- or closed-casing.

12.1.6.2 Open-casing design

The open-casing protection suit filter (see Table 7 and Figure 34) can be made of injected PVC or polycarbonate and has the following dimensions:

— external diameter, 93 mm;

— height, 35 mm;

— aperture diameter, 20 mm;

— thread, diameter 24, pitch 2 (special).

Table 7 — Characteristics of a new open-casing protection-suit-filter

Pressure drop Pa	**Flow rate** $m^3 \cdot h^{-1}$
60	1
130	3
220	5

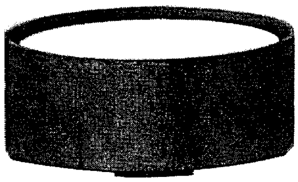
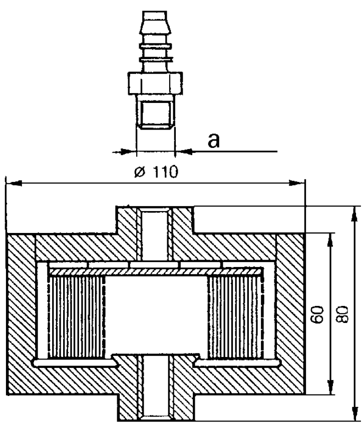


Figure 34 — Protection-suit filter with open casing — General view

12.1.6.3 Closed-casing design

This closed-casing protection suit filter (see Figure 35 and Figure 36) has a body of welded PVC, with tapped holes into which connection nipples are screwed. The filter is held inside the body by a glued gasket, ensuring a clear air path.

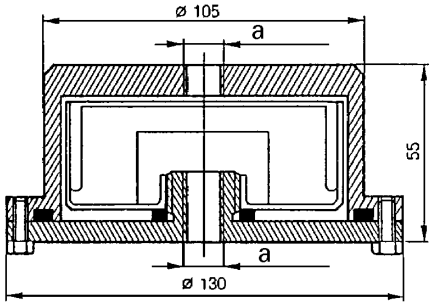
Dimensions in millimetres



[a] Quarter-inch diameter.

Figure 35 — Protection-suit filter with closed casing (model A)

Dimensions in millimetres



a Quarter-inch diameter.

Figure 36 — Protection suit filter with closed casing (model B)

12.1.6.4 Casing

The casing that houses the protection suit filter is generally used outside the containment enclosure. It consists of a body and a cover made of light alloy or stainless steel, which are tapped to enable the mounting of a connection nipple. A threaded end on the internal face of the cover allows the filter to be screwed on.

12.1.7 Other filters

12.1.7.1 Operating principle

Other filters used on the admission and extraction circuits of containment enclosures include open- (see Figure 37 and Figure 38, and Table 8), perforated- (see Figure 39 and Table 9) and closed-casing models (see Figure 40 and Table 10). These filters have a diameter of 130 mm, 140 mm or 160 mm and may be used either as is, or assembled in a gas-tight metallic case to enable their replacement under gas-tight conditions.

12.1.7.2 Design

For these filters, the casing is made of PVC or stainless steel. The filtering medium is of fireproof glass-fibre paper (fire behaviour class M1), waterproofed and folded, with constant spacing between the folds. The luting ensuring filtering-medium gas-tightness inside the casing is of polyurethane (PU) or PVC, and the gasket is of neoprene (polychloroprene) or Viton[3].

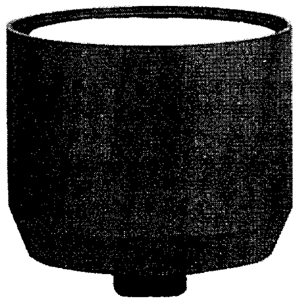
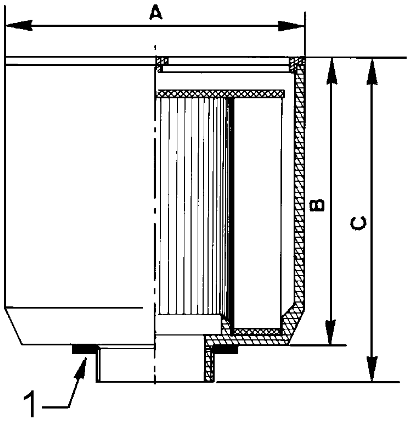


Figure 37 — Filter with open casing — General view

3) Neoprene and Viton® are examples of products available commercially. This information is given for the convenience of users of this part of ISO 11933 and does not constitute an endorsement by ISO of these products.



Key

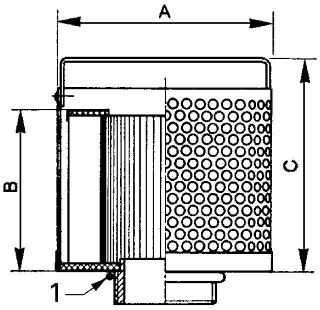
1 Elastomer flat seal

Figure 38 — Filter with open casing — Dimensions (see Table 8)

Table 8 — Main characteristics of filters with open casing

Filters		**Low flow rate** (∅ 140 mm)		**High flow rate** (∅ 160 mm)
Range of flow rate ($m^3 \cdot h^{-1}$)		10 to 20	10 to 30	20 to 50[a]
Casing material		PVC or stainless steel	PVC or stainless steel	PVC or stainless steel
Casing:				
outer diameter	A	140	140	160
height	B	110	110	153
total height	C	130	130	173
Filtering surface (m^2)		0,42	0,42	0,66
Pressure drop (Pa)		(average data for new filters)		
for flow rate ($m^3 \cdot h^{-1}$)	10	70	50	—
	20	210	110	70
	30	—	180	110
	50	—	—	200

[a] This model is supplied with a handling cross-piece on the casing.



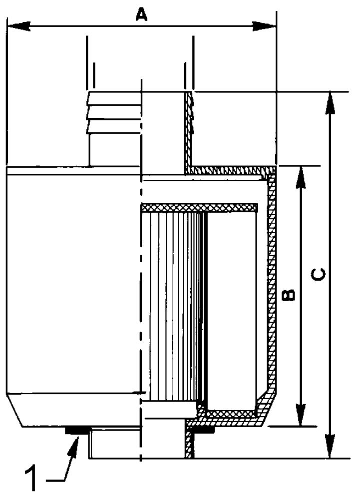
Key

1 Elastomer O-ring seal

Figure 39 — Perforated-casing filter (see Table 9)

Table 9 — Main characteristics of filters with perforated casing

Filter (∅ 130 mm)	**Range of flow rate** m³/h	**Casing material**	**Dimensions** mm	**Filtering surface** m^2	**Flow rate** m^3/h	**Pressure drop** Pa
	10 to 50	Stainless steel	Casing: outer dia. A: 130 height B: 139 total height C: 159	0,42	10 20 30 50	50 110 180 —



Key

1 Joint

Figure 40 — Closed-casing filter (see Table 10)

Table 10 — Main characteristics of filters with closed casing

Filter		Low flow rate (∅ 140 mm)	High flow rate (∅ 160 mm)
Range of flow rate ($m^3 \cdot h^{-1}$)		40 to 200	80 to 250
Casing material		PVC	PVC
Casing			
outer diameter	A	140	160
height	B	125	153
total height	C	190	218
Filtering surface (m^2)		0,42	0,66
Pressure drop (Pa)		(average data for new filters)	
for flow rate ($m^3 \cdot h^{-1}$)	10	40	80
	20	120	—
	30	200	130
	50	—	250

12.1.7.3 Pressure drop — Entire filter system

For new filters, manufacturers generally give pressure-drop data that takes only the filtering medium into consideration. However, the influence on overall pressure drop of the filter housing and the mechanical device retaining the intervention bag can be very important, especially at high flow rates. Figure 41 shows an example of such influence, with the curves illustrating the variation in the pressure drop, according to the flow rate, for the three configurations: filter alone, filter plus housing, and filter plus housing plus mechanical device.

12.1.8 Remote-handling protection-suit filter

12.1.8.1 Operating principle

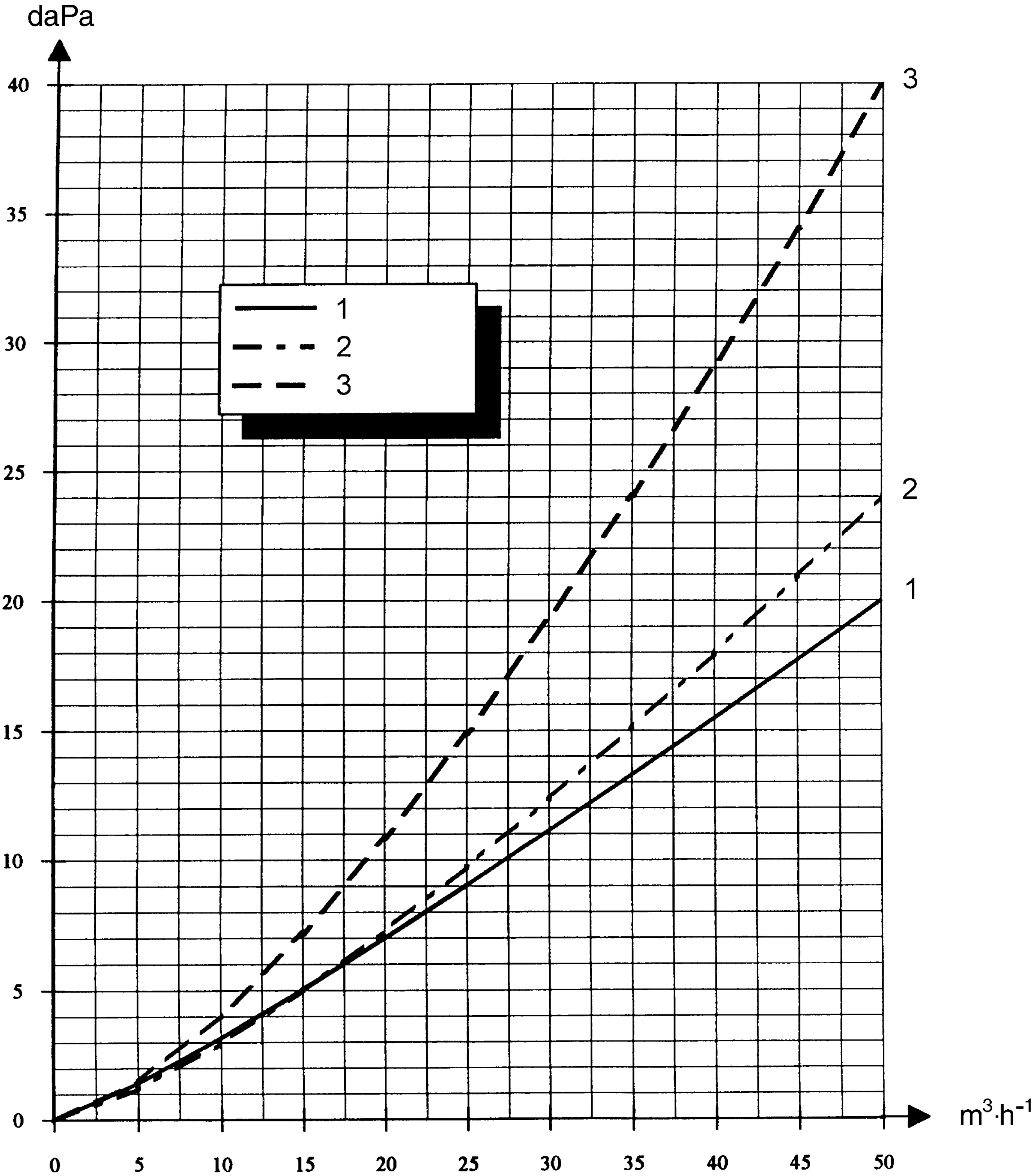
This protection suit filter (see Figure 42), used for the protection of manometers and regulation valves, is specially designed for enclosures equipped with remote handling tongs. It consists of a standard PVC filter onto which are welded a handle for remote handling and a PVC nipple with gasket and orientation pin for fitting with a bayonet-type feedthrough.

12.1.8.2 Metallic feedthroughs

There are two types of feedthroughs:

— the bayonet type, welded on the enclosure wall for mounting remote-handling protection suit filters (see Figure 43);

— the welded type, for the screwing on of a standard protection suit filter (manometer protection, depression measuring points).



Key

1 Filter alone

2 Filter + housing

3 Filter + housing + mechanical device

Figure 41 — Pressure drop of entire filter system

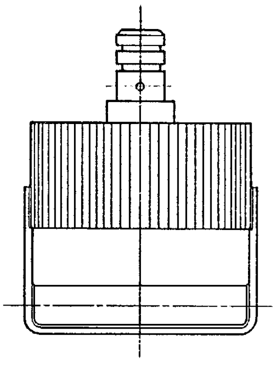
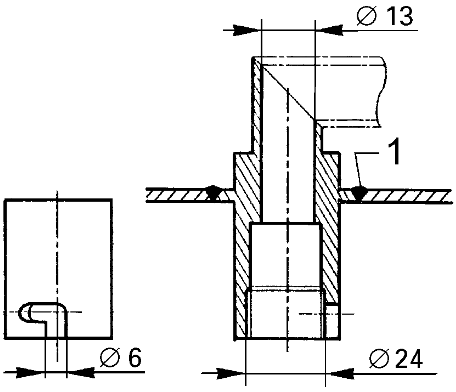


Figure 42 — Remote-handling protection suit filters

Dimensions in millimetres



Key

1 Welding

Figure 43 — Feedthroughs for remote-handling protection suit filter

12.2 Trapping devices

12.2.1 General requirement

Any time an implemented process poses a potential or permanent risk of the release of radioactive iodine in the gaseous phase, it is necessary to equip the enclosure with trapping devices to ensure the protection of operators and prevent the radioactive-effluent limits of the facility from ever being exceeded, regardless of the operating conditions.

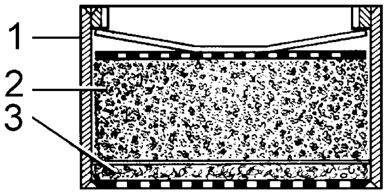
12.2.2 Operating principle

From among the range of techniques available, the trapping of volatile components of iodine by solid adsorbents is the favoured technique (see Figure 44). Its main advantage lies, in terms of safety, in the operating passivity of its corresponding devices. There are two main categories of adsorbent materials:

— activated carbons, for the great majority of applications;

— zeolites and molecular sieves, useful anywhere that the nature of the effluent does not allow use of activated carbons (e.g. where nitrogen oxides are present).

Examples of the different types are given in 12.2.4 to 12.2.5.



Key

1 Transparent wall
2 Soda lime
3 Rockwool

Figure 44 — Trapping cartridge design — General view

12.2.3 Special applications

12.2.3.1 Trapping acids

For the trapping of acids, devices consisting of a sieve of soda lime with a coloured indicator may be used. The soda lime is preceded by a rockwool mattress on the complete surface (thickness of soda lime about 60 mm). For hydrofluoric acid, the rockwool shall be suppressed and the filling completed with soda lime.

12.2.3.2 Neutralizing solvents

It is recommended that any solvents produced be neutralized as near as possible to their emission point, in order to avoid a rapid deterioration of the filtering medium.

12.2.4 Examples of activated carbon traps

12.2.4.1 Trap cartridge of 130 mm diameter

The activated carbon trap cartridge of 130 mm diameter (see Figure 45 and Table 11) shall be used on containment enclosure extraction circuits wherever there is a potential risk of radioactive iodine release. It can be mounted under gas-tight casing or otherwise, but shall be preceded or followed, or both, by HEPA filters.

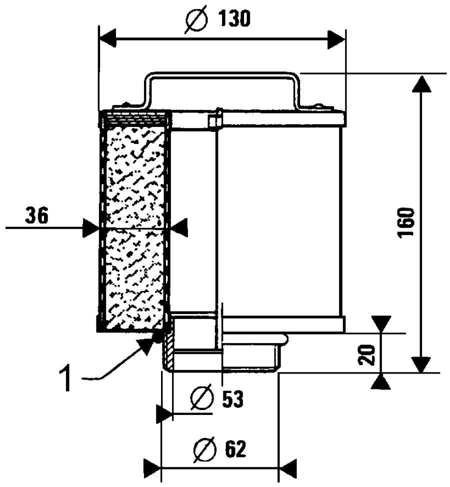
The traps have a casing of stainless steel with an end threaded at 2,5 ISO pitch.

Their adsorbent material is of activated carbon, impregnated with 1 % of potassium iodide. The gas-tight gasket is made of a high-performance synthetic such as Viton.

Table 11 — Specifications for ∅ 130 mm activated carbon traps

Carbon volume (l)	1,1	
Contact time (s)	0,2	0,25
Flow rate (m^3/h)	20	16
Pressure drop (Pa)	200	160

Dimensions in millimetres



Key

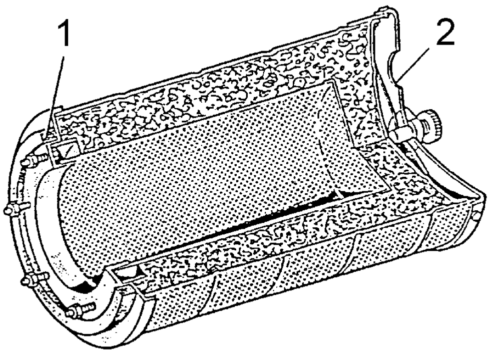
1 Viton gasket R35

Figure 45 — Activated carbon trap cartridge (130 mm diameter)

12.2.4.2 Cartridge of large dimensions

The activated carbon cartridge (see Figure 46) is mounted in a metallic coffer in painted carbon steel or stainless steel that can house one or several filter elements. The cartridge consists of a perforated, plate-cylindrical casing containing activated carbon 50 mm thick and 13 500 cm^3 in volume. It is fixed by studs to the coffer's internal plate.

While the air direction is a matter of indifference, the cartridge position shall never be oriented cover down, due to cramming.



Key

1 Tightness gasket

2 Filling cover

Figure 46 — Activated carbon trap — Cartridge type

12.2.4.3 Dihedron

The activated-carbon dihedron (see Figure 47) consists of a 50 mm uniform layer of activated carbon between plates welded to a metallic frame. It is equipped with a permanent-action cramming device and has the following dimensions and weight:

— length, 600 mm;

— height, 202 mm;

— width, 130 mm;

— weight, about 14 kg.

The pressure drop is 30 daPa at 200 m^3/h with a coal carbon impregnated with 1 % of potassium iodide.

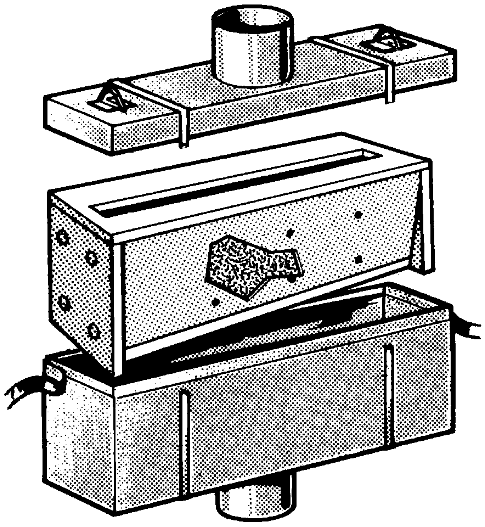


Figure 47 — Activated carbon trap — Dihedron type

12.3 Filter housings

12.3.1 General

Housings protect the containment enclosure filters installed outside the enclosure, facilitating the connection and the disassembling of ventilation sheaths and protecting the filter elements against shocks.

Certain models, associated with a vinyl bag, guarantee containment continuity during filter replacement without interruption of the ventilation function, as well as making possible the disassembling of the connection ducts. The use of such models is recommended.

The various housing types and models are described in 12.3.2 and 12.3.3, with requirements and recommendations given as to their use.

12.3.2 Housings for filters of type 140 or 160 (direct outlet)

12.3.2.1 Restriction of use

These housing types (see Figure 48) with direct outlet are still found in older installations, but do not allow filter replacement without disassembling of the ventilation circuit or containment breaking. For this reason, wherever possible, these types of housing shall not be used.

12.3.2.2 PVC housing (welded fixation)

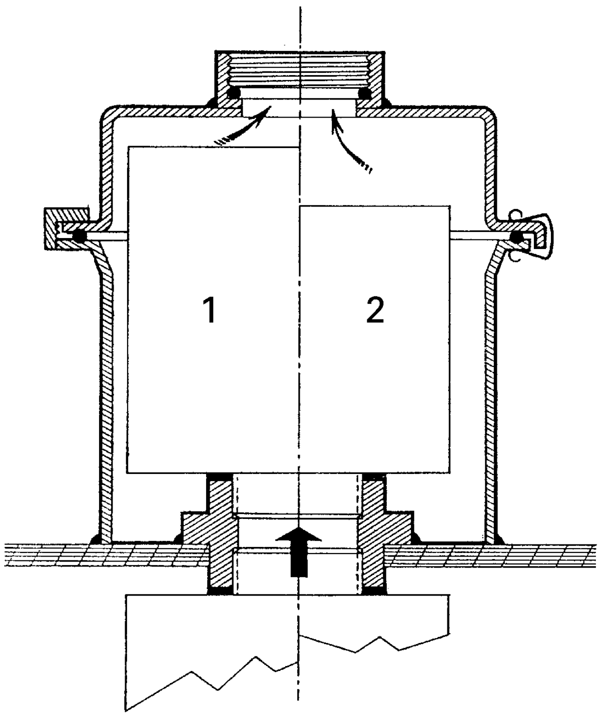
This housing (see Figure 48) has two bodies: an upstream body welded onto the containment enclosure wall, and a downstream body assembled with flexible clamps. Tightness is ensured by an O-ring gasket, while the outlet can receive a male or female valve mounted on an intermediate union.

12.3.2.3 PVC housing (screwed fixation)

This housing is dismountable, having a screwed feedthrough (see Figure 49). The outlet can receive a male or female valve mounted on an intermediate union. The housing closing is done with flexible clamps, while tightness is ensured by an O-ring gasket.

12.3.2.4 Metallic housing (screwed fixation)

This housing consists of two stainless-steel- or aluminium-alloy-plated shells (see Figure 50), assembled with quick coupling systems. Tightness is ensured by O-ring seals. The dimensions indicated in Figure 50 c) are approximate.



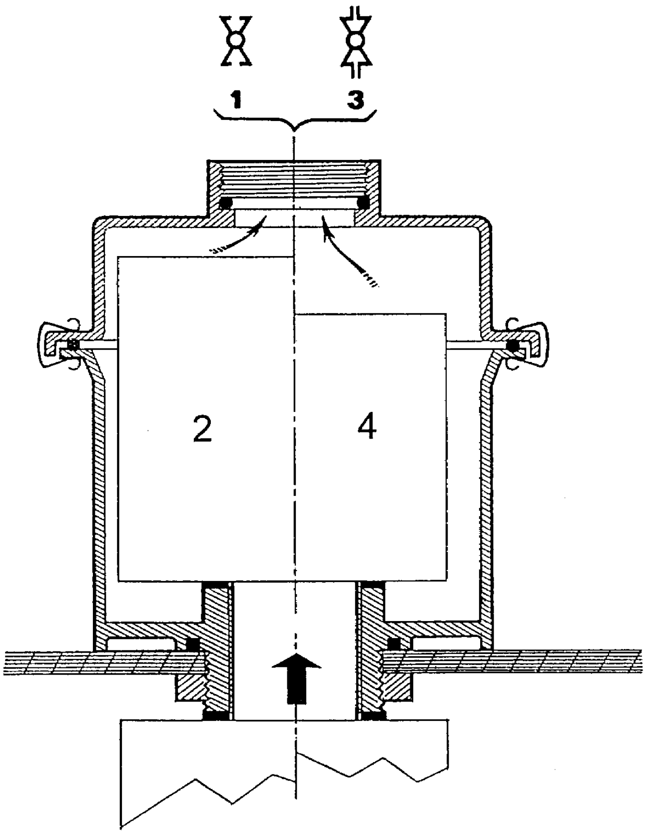
Key

1 Filter (160)

2 Filter (140)

NOTE If desired, the housing can be closed with a large nut.

Figure 48 — PVC welded housing for type 140 or 160 filter with direct outlet



Key

1 Female valve

2 Filter (160)

3 Male valve

4 Filter (140)

Figure 49 — PVC screwed housing for type 140 or 160 filter with direct outlet

12.3.3 Housings for type 140 or 160 filters (lateral outlet)

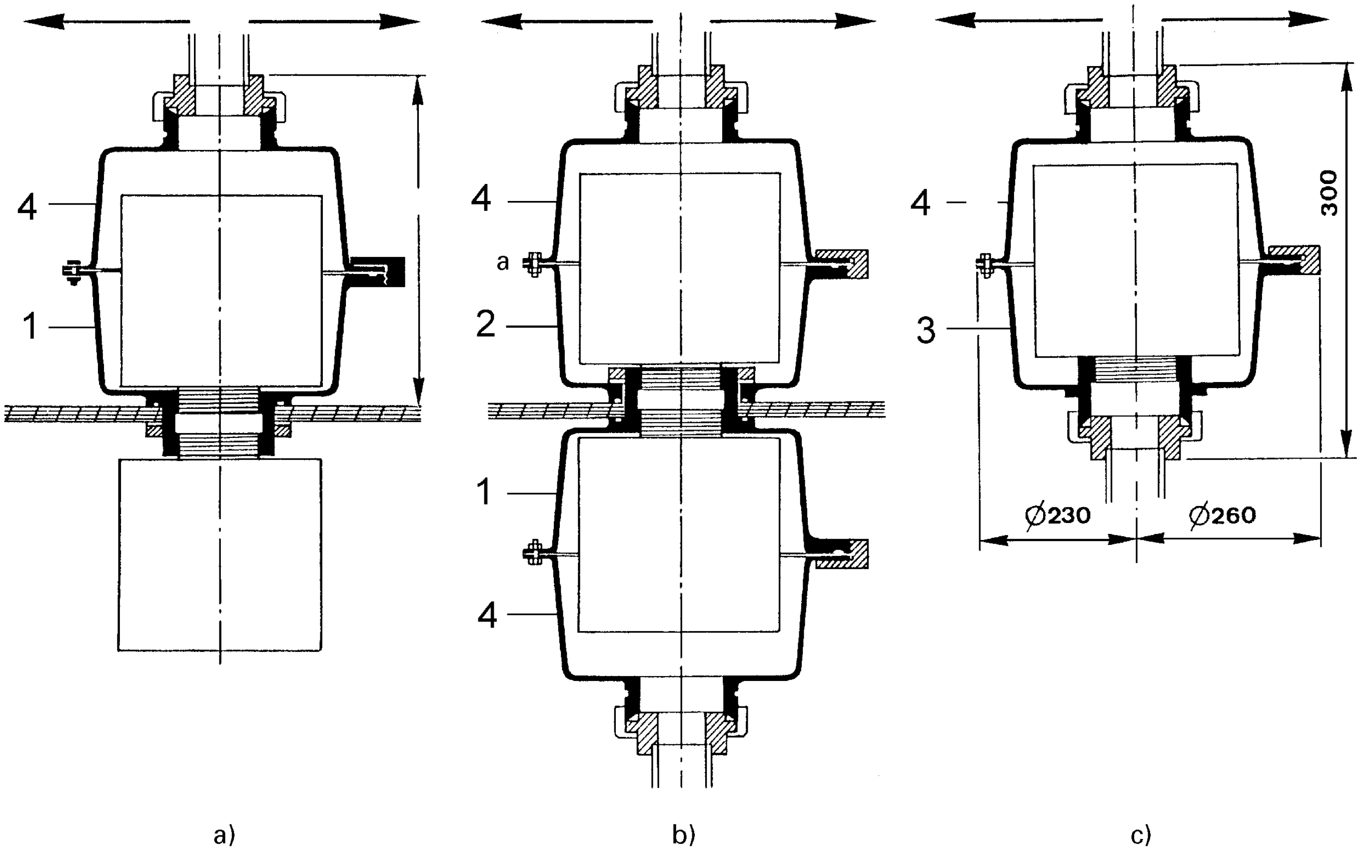
12.3.3.1 General

These metallic or plastic housings (stainless steel or PVC) with lateral outlet enable the filter to be replaced without containment breaking. The housings are welded on the wall or dismountable and fitted with a screwable feedthrough using the same drilling diameter as a single feedthrough (∅ 80,5 mm). The outlet generally has a PVC spherical cock-casing valve mounted on an intermediate union (see Figure 51).

For screwed housings that must be frequently dismounted, the assembly direction shall be reversed (gasket inside, screw and union outside), or the screw shall be arranged so as to be accessible.

NOTE For replacement of the filter under a welded bag, see ISO 11933-2.

Dimensions in millimetres

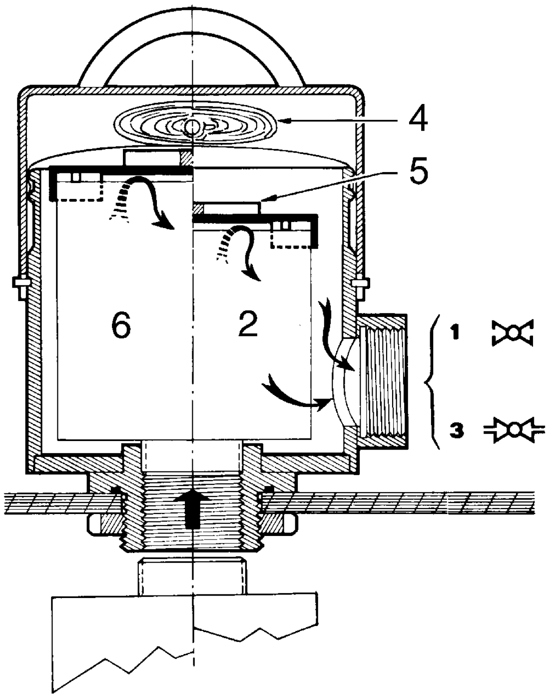


Key

1 Plated shell with double threaded penetration
2 Simple plated shell without coupling
3 Simple plated shell with single threaded penetration
4 Simple plated shell for welding connection

[a] For easy assembly, it is recommended that the shell be placed outside the leaktight enclosure.

Figure 50 — Metallic screwed housing for type 140 or 160 filter with direct outlet



Key

1 Female valve
2 Filter (140)
3 Male valve
4 Intervention bag
5 Glued cross piece
6 Filter (160)

Figure 51 — PVC screwed housing for type 140 or 160 filter with lateral outlet

12.3.3.2 Metallic housing (welded fixation)

The housing (see Figure 52) is welded on the enclosure wall and connected by welding to the ventilation duct (DN 50 schedule 10 S). Its body has two grooves for receiving an intervention bag, which remains rolled up on a small PVC bar during operation, and the handle fixed to the filter element prevents the bag from blocking the air aperture. The housing is closed by a stainless steel cover nested and held by two strainer clamps.

Depending on applications, and particularly in high-depression circuits (vacuum circuits), this housing may be equipped with the following options:

— 4 mm diameter gasket, compressible by the cover;

— tube for equalizing the pressure on both sides of the intervention bag.

12.3.3.3 PVC housing (screwed fixation)

This dismountable housing is fitted with a screwed feedthrough (see Figure 53). The outlet can receive a male or female valve mounted on an intermediate union. The housing body has two grooves for receiving an intervention bag that remains permanently rolled up on a PVC small bar during operation. In order to prevent the bag from blocking the air aperture, the filters have a glued cross-piece giving path to the air on the circumference.

The closing of the housing is with a bayonet-type nesting cover. The filters are mounted inside the housing with their original plate gasket.

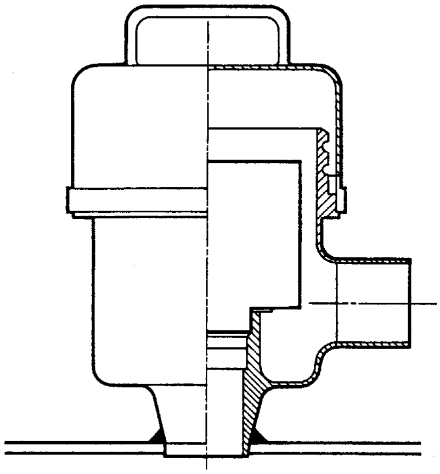


Figure 52 — Metallic welded housing for type 140 or 160 filter with lateral outlet

12.3.3.4 Metallic housing (screwed fixation)

This housing is either identical to that described in 12.3.2.4 or conforms to the design shown in Figure 53.

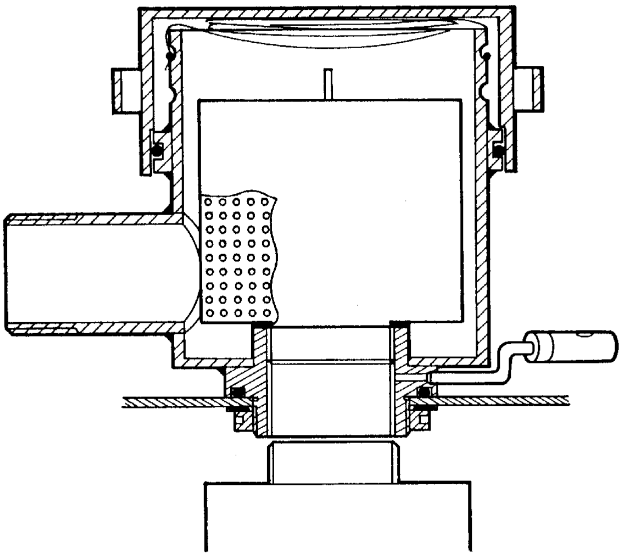


Figure 53 — Metallic screwed housing for type 140 or 160 filter with lateral outlet

13 Pressure measurement devices (manometers, pressure controllers)

13.1 General

Containment enclosure pressure measurements are carried out using manometers for direct readings, or pressure controllers.

Manometers (see 13.2) can be either of the liquid-displacement or membrane-deformation type, either of which can be equipped with electric contacts. Their scaling is either a simple scale (positive or negative pressure reading) or a central zero scale (positive and negative pressure reading). They measure differential pressures.

On all manometers, zero checking shall be carried out from time to time. It is recommended that the manometers be protected by a protective-suit filter. For liquid manometers, this filter shall be insulated from the liquid.

NOTE The choice of a manometer is a difficult compromise between reliability and price, especially as far as contact quality is concerned.

Pressure controllers (see 13.3) do not allow pressure measurement. Instead, when the pressure value reaches one or several pre-set levels, they can trip an alarm or regulate the pressure.

The choice of equipment for chemistry enclosures shall take the risk of corrosion into account.

13.2 Manometers

13.2.1 Membrane-deformation type

This type of manometer, made of alloyed metal or plastic materials, consists of a graduated display on which a needle moves, actuated by a membrane or capsule (high pressure). The advantage of this type is that it is easy to read (reduced dimensions). Its disadvantage is that it is fragile and subject to corrosion.

The usual diameter of the display is about 100 mm (for the glove boxes).

A protective suit filter is recommended for protecting the manometer in high-contamination enclosures.

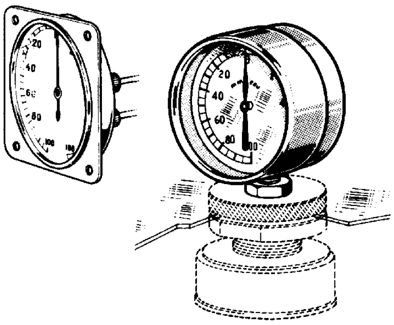


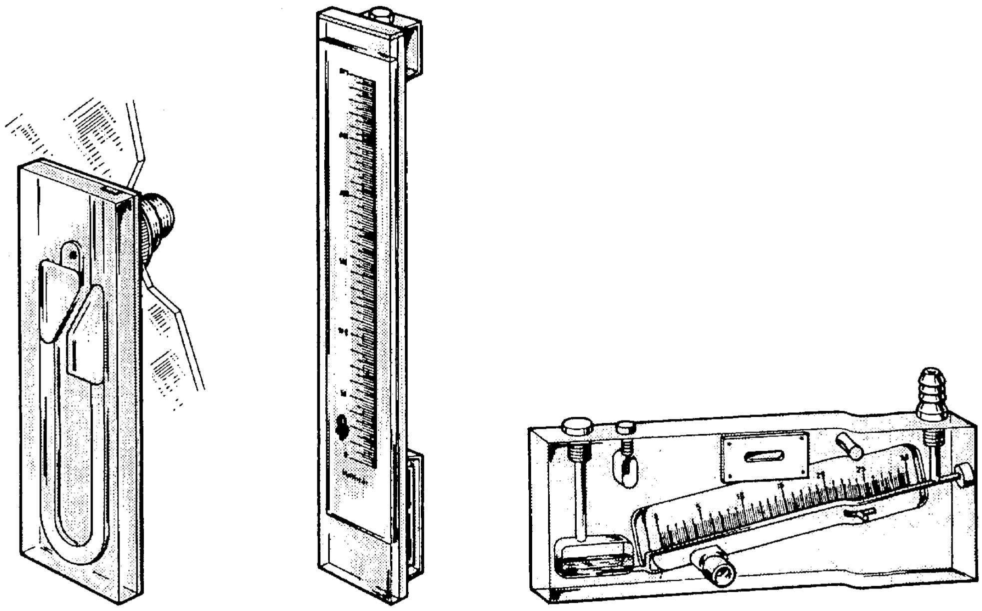
Figure 54 — Membrane-deformation manometer

13.2.2 Liquid-displacement type

This type of manometer (see Figure 55) is made of PMMA and consists of a liquid column, either U-shaped [a)], vertical [b)] or inclined [c)], with a relative density of from 0,8 to 0,9. Its advantages are that it is reliable and sturdy. Its disadvantage is that it is cumbersome at high pressures.

WARNING — Risk of liquid dispersion and loss of containment due to lack of liquid. Never use an evaporable liquid.

In order to avoid any accidental lack of liquid, it is necessary to provide a sufficient reading range and eventually a liquid reserve on the manometer.



a) b) c)

Figure 55 — Liquid-displacement manometer

13.2.3 Contact manometer

This is a manometer (see Figure 56) to which the manufacturer has added electrical contacts indicating the maximum and minimum pressure values adjusted by the user. It can be used to regulate the negative or positive pressure of an enclosure, or to trigger alarms, and comes in a variety of models:

— electrode model, with a liquid such as water or mercury;

— mechanical contact (needle model);

— photoelectric enclosure (needle model);

— electric-capacitance measure models.

Its disadvantage is that for threshold adjustment there is no possibility to adjust the gap (differential).

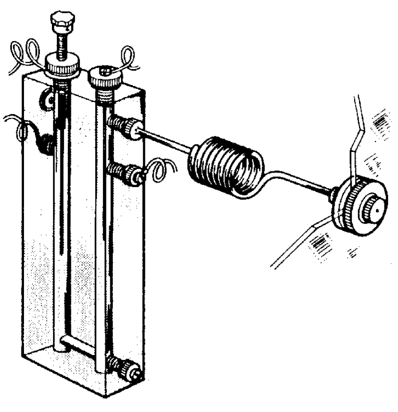


Figure 56 — Contact manometer (water model)

13.3 Pressure controller

The pressure controller (see Figure 57) does not allow a pressure reading, but rather provides threshold values that allow pressure regulation or alarm triggering. Its main advantage is that it allows threshold adjustment with gap adjustment. Its disadvantage is that it does not enable a direct pressure reading.

This component shall be powered using very low voltage.

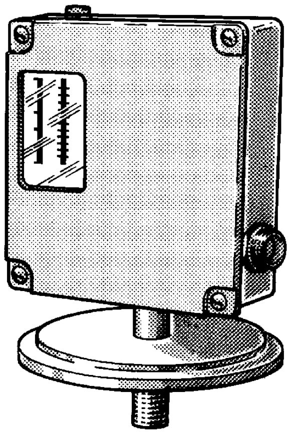


Figure 57 — Pressure controller

14 Operation, control and maintenance of ventilation and air-cleaning systems

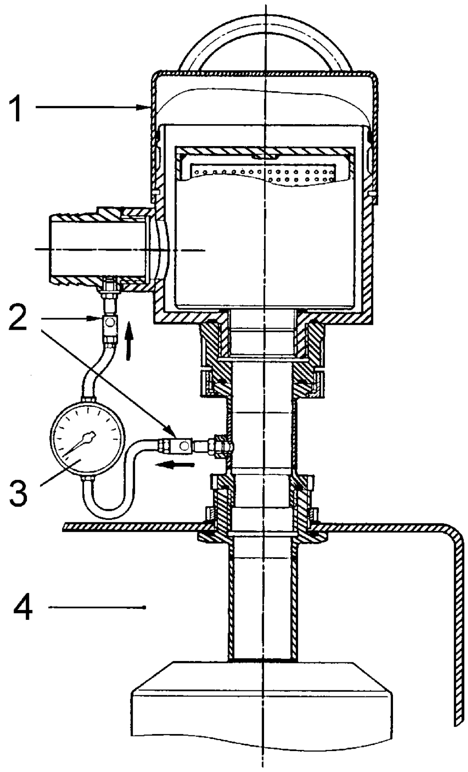
14.1 Checking ventilation flow rates

As in the case of containment-enclosure negative pressure, a containment enclosure's ventilation flow rate is an important safety element. Thus it is desirable that operators have at their disposal a permanent means of checking it. Furthermore, periodic, formal checking of the flow rate should be carried out, with this periodicity depending on the type of products intended to be handled.

The usual checking means are:

- differential pressure manometer, installed on the second extraction filter if the containment enclosure is equipped with one (see Figure 58);
- valve flow rate indicator, installed downstream of the extraction filters;
- classic measurement of flow rate with Pitot tube or anemometer, carried out by a specialist.

If the checked flow rate is different from the nominal one, it is necessary to modify the adjustments or replace the filters.



Key

1 Filter housing
2 Manometer coupling
3 Manometer
4 Enclosure

Figure 58 — Differential pressure manometer

14.2 Checking protection valve liquid levels

The checking of liquid levels of a protection hydraulic valve is carried out visually. The levels must agree with the initial marks. The working of gloves, remote manipulators or pliers can give verification of the normal condition of each function. Between two verifications, any important default on the checked level leads to a resetting of the level and an inquiry addressed to the operator. The indication records and corresponding alarms, if any, shall be checked periodically.

14.3 Gas-cleaning-device maintenance (checking filter clogging)

A filter is said to be clogged when the deposit formed at its surface creates a pressure drop such that the flow rate becomes insufficient. In this case, the stopping power increases, but the flow rate tends towards zero. The smaller the dust or aerosol, the higher the clogging velocity.

In practice, for the same enclosure flow rate and depression, when the clogging compensation throttle is fully open, it can be concluded that the filters are clogged.

The extraction filter has reached its maximum clogging when the depression in the enclosure decreases in spite of the full opening of the clogging compensation throttle (the flow rate indicator displays a value lower than the nominal one).

The admission filter has reached its maximum clogging when the depression in the enclosure increases in spite of the full opening of the clogging compensation throttle (the flow rate indicator displays a value lower than the nominal one).

14.4 Filter replacement

14.4.1 General requirements and recommendations

The HEPA filters shall be replaced:

— if they reach their maximum clogging value (see 14.3),

— if the value of their efficiency is lower than that of the minimum one (see 14.3),

— if they emit radiation due to the deposit of radioactive particles.

On enclosures where checking is, practically speaking, ineffective, the periodicity of replacement for the primary filters (upstream filters in case of two filters in a series) shall be at least annually for admission filters and every two years for extraction filters.

The following are recommended actions for filter replacement.

a) For the upstream extraction filter (internal to the enclosure), operate as rapidly as possible to decrease contamination and clogging of the filter external to the enclosure.

b) Before disassembling the extraction filter (external to the enclosure) reduce (for filters under casing) or suppress (in the case of other filters) the ventilation flow while maintaining the depression in the enclosure.

c) Before disassembling the upstream admission filter (external to the enclosure) keep the extraction of enclosures ventilated (in an open or semi-open circuit), or insulate the neutral gas circuit (in the case of enclosures ventilated in closed circuit).

In all three cases, particular precautions shall be taken to avoid any contamination of the operator and the room atmosphere.

After a filter replacement, the adjustment of valves and compensation throttle shall be carried out in order to reset to the desired flow rate and depression.

14.4.2 Replacement methods

14.4.2.1 Tank with gas-tight air lock

In the case of a filter element in a tank with a gas-tight air lock, wherever there is a risk of contamination of the filter element, the element shall be replaced in gas-tight handling. To replace the filter of a tank with gas-tight air lock, it is necessary to stop the ventilation or to have a second filtration circuit in parallel. For this kind of filter the operating mode is described above.

Replace the filter by the following steps (see Figure 59).

a) See Figure 59 a).

   1) Check the irradiation coming from the filter.

   2) Close the insulation throttles of the tank.

   3) Remove its cover.

   4) Unroll the evacuation bag.

   5) Unlock the filter using the cam-shafts.

b) See Figure 59 b).

   1) Outlet the old filter into the bag.

   2) Weld the bag as indicated.

   3) Cut in the middle of the weld.

   4) Evacuate the filter.

c) See Figure 59 c).

   1) Slip the bag stump on the external shoulder of the bag port.

   2) Place the new bag, containing the new filter, on the internal shoulder.

   3) Tear away the stump and introduce it into the pocket of the new bag.

   4) Introduce the new filter into the tank.

d) See Figure 59 d).

   1) Weld the pocket of the new bag as indicated.

   2) Cut in the middle of the weld.

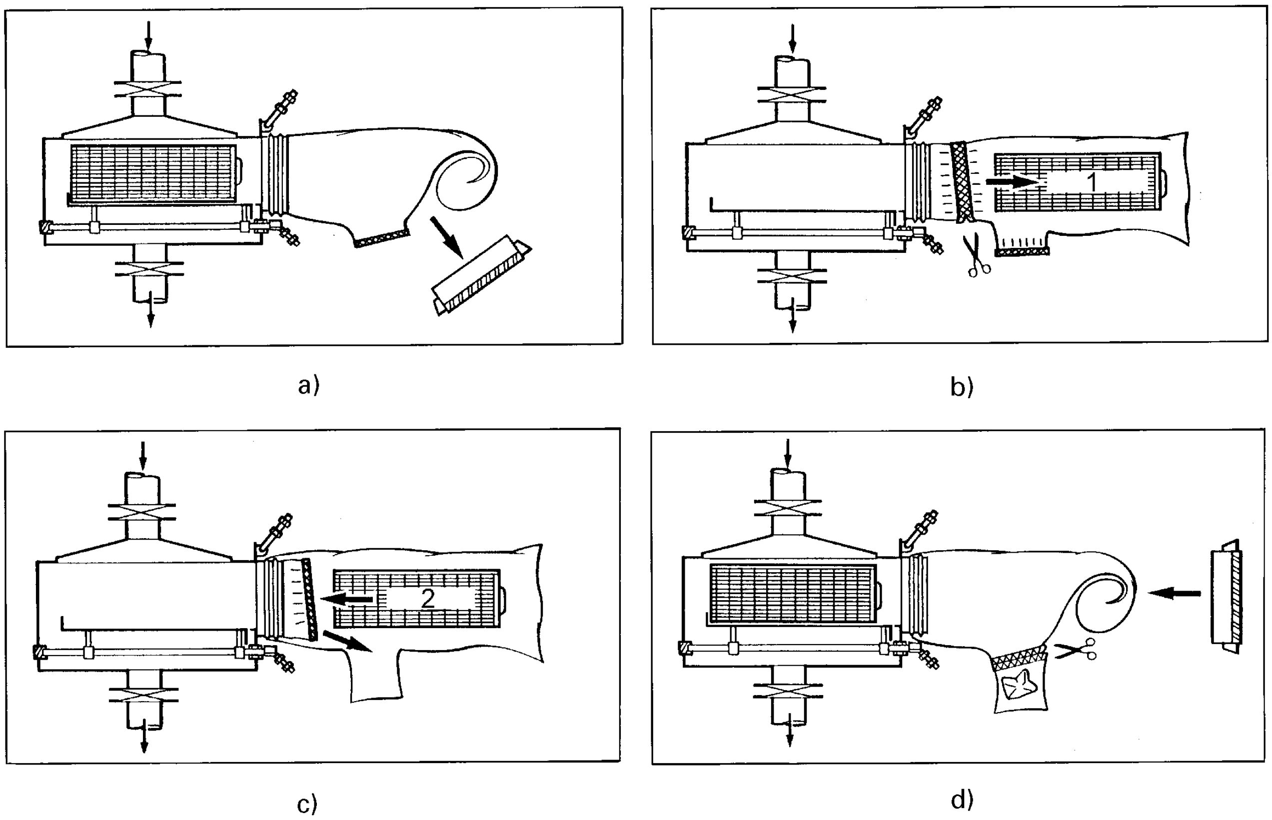
   3) Evacuate the pocket containing the stump.

   4) Lock the filter using the cam-shafts.

   5) Roll the bag and hold it with adhesive tape.

   6) Put back the cover.

   7) Open the insulation throttles.



Key

1 Old filter

2 New filter

Figure 59 — Replacement of filter element in tank with gas-tight airlock

14.4.2.2 Replacement without breaking containment

Where there is a risk of important contamination of the external filter, the filter can be changed under gas-tight conditions and without breaking containment, while maintaining a low ventilation flow rate.

As a preliminary step, check the level of irradiation coming from the filter. Then carry out the following steps (see Figure 60).

a) Open and set aside the cover, unroll the bag contained in the casing, unscrew the contaminated filter and proceed to the RF welding of the bag (A).

b) Cut in the middle of the weld (B). Evacuate the contaminated filter.

c) Remove the adhesive retaining the bag on the casing of the filter and slip the obturation stump on the upper shoulder or groove of the casing (C).

d) Present the new bag containing the new filter previously fitted with a glued cross piece. Cap the stump and fix with adhesive the new bag on the lower shoulder/groove of the casing (D).

e) Tear away the stump and introduce it into the pocket of the removing bag, then proceed to the RF welding and cut the pocket (E).

f) Roll the remaining part of the bag onto an appropriate bar (F), then immobilize the bag on the casing so that it stays as bent as possible above the filter.

g) Put the cover back on the casing.

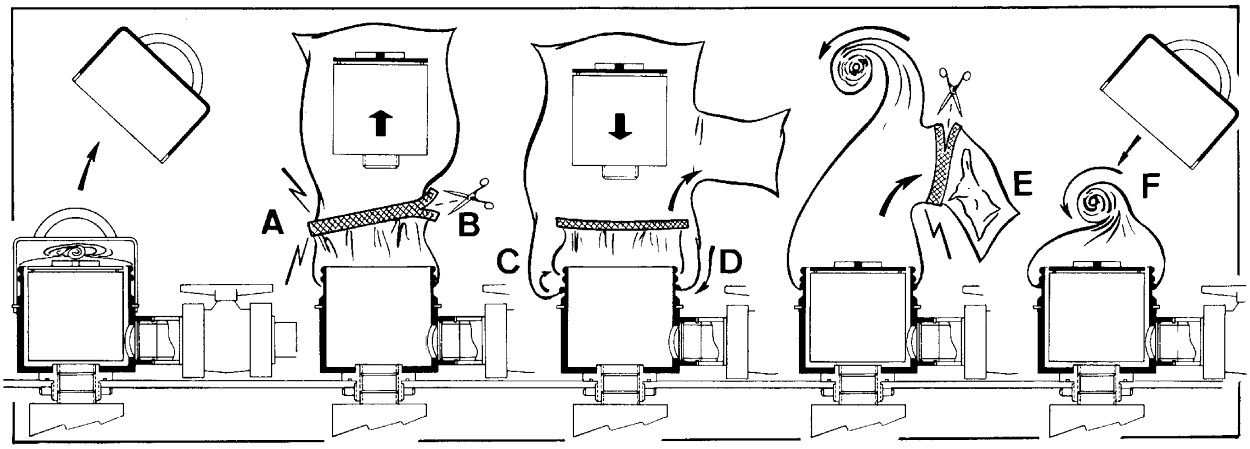


Figure 60 — Enclosure filter replacement without breaking containment

Annex A
(normative)

Containment enclosures

A.1 Classification of containment enclosures by leak tightness

Classification is based on the hourly leak rate, T_f, according to ISO 10648-2. Table A.1 gives a standardized classification of containment enclosures according to their hourly leak rate.

Table A.1 — Classification of containment enclosures according to their hourly leak rate

Class	T_f (h^{-1})	Example
1 [a]	$\leqslant 5 \times 10^{-4}$	Containment enclosure with controlled atmosphere under inert gas conditions
2 [a]	$< 2{,}5 \times 10^{-3}$	Containment enclosure with controlled atmosphere under inert gas conditions or with permanently hazardous atmosphere
3	$< 10^{-2}$	Containment enclosure with permanently hazardous atmosphere
4	$< 10^{-1}$	Containment enclosure with atmosphere which could be hazardous

[a] The classification of leak tightness required for a particular application under classes 1 and 2 shall be decided by the designer, operator and safety authorities. Normally, class 1 shall be applied for technical reasons when higher gas purity is required.

A.2 Positioning of regulation devices (enclosure-network admission/extraction circuit)

Depending on the kind of variation for which the regulation device has to compensate, the general considerations given in Table A.2 should be taken into account before selecting the means of installation on an admission or extraction circuit.

Table A.2 — Nature of compensation by regulation device, according to location

Kind of variation	Correction induced by:	
	Regulation device on admission side	**Regulation. device on extraction side**
Underpressure of general extraction network ↗ (–100 → –150 daPa)	Complete change rate ↗ [a] ΔP GB [b] ≃ constant	Complete change rate ≃ constant ΔP GB ↗
Underpressure of general extraction network ↘ (–100 → –50 daPa)	Complete change flow rate ↘ ΔP GB ≃ constant	Complete change rate ≃ constant ΔP GB ↘
Conclusion for this type of perturbation:	Complete change rate is regulated GB depression ≃ constant	GB depression is regulated Complete change rate ≃ constant
Pressure drop of extraction filter ↗	Complete change rate ↘ ΔP GB ≃ constant	Complete change flow rate ≃ constant ΔP GB ≃ constant if pressure ref. is into BAG
		Complete change rate ↘ ΔP BAG ↘ If pressure ref. is not into BAG
Pressure drop of admission filter ↗	Complete change rate ≃ constant ΔP GB ↘	Complete change rate and ΔP GB ↘
Conclusion for this type of perturbation:	Depending on the location of the regulation device, either complete change rate and/or ΔP GB is regulated	
Leak into the containment enclosure, or entering gas	Complete change rate ≃ constant ΔP GB ≃ constant	Complete change rate ↗ ΔP GB ≃ constant
Extraction flow rate ↗ (opening of extraction valve or additional process extraction)	Complete change rate ↗ ΔP GB ≃ constant	Complete change rate ≃ constant ΔP GB ≃ constant

[a] Complete change rate: R_n extraction = R_n admission + R_n leak.

[b] ΔP GB: underpressure into the containment enclosure (glove box) with respect to the ambient atmosphere.

A.3 Main characteristics of containment enclosures according to class and nature of product handled

Table A.3 presents the following.

— The classification of containment enclosures according to their leak tightness (see ISO 10648-2).

— Their distribution into specific subclasses, according to the risk associated with the products handled, and required special design.

— The risk assessment that has to be made: the radiotoxity of the products handled, their physical and chemical state, the kind of operation (with attention to explosion and fire).

— The main characteristics related to ventilation, filtration and air-cleaning.

Table A.3 — Characteristics of containment enclosures by class and nature of product handled

Class	**4**	**3**	**2**	**1**		
				c	b	a
Static containment enclosure:	without controlled atmosphere		with controlled atmosphere			
Enclosure:	that could be hazardous for workers and the environment	permanently hazardous for workers and the environment	inert gas conditions or with atmosphere permanently hazardous for workers and environment	inert gas conditions for protection of the process		
Leak rate T_f (h^{-1})	$< 10^{-1}$	$< 10^{-2}$	$< 2,5 \times 10^{-3}$	$\leqslant 5 \times 10^{-4}$		
Pressure inside enclosure (room)	Permanent (20 daPa to 40 daPa)					
Products handled	Chemical or toxic products Radioactive or sterile products					
		Chemical or toxic products or/and products sensitive to humidity and to oxygen. Contaminating products with a very high specific radioactivity				
				Contaminating products with very high specific radioactivity and/or product-sensitive		
				to humidity	to humidity and to oxygen	to moisture or to oxygen traces
Atmosphere	Ambient air Gas or dry air	Gas (total maximum impurity concentration of 1 %) or ambient air or dry air		Dry air or gas H_2O: 100 ppm to 200 ppm	Neutral gas, argon, nitrogen, helium. Max. impurity: < 1000 ppm $H_2O \simeq$ 40 ppm $O_2 \simeq$ 30 ppm	Neutral gas: argon, nitrogen, helium. Max. impurity: < 100 ppm $H_2O < 5$ ppm $H_2 < 10$ ppm
Type of network	Open network					
		Semi-open network				
			Closed network			
Ventilation system outside enclosure — Admission	Ambient air taken from room (can be filtrated, conditioned, gas or dry air)			Dry air	Neutral gas	
		Gas or dry air taken from storage or unit				
Ventilation system outside enclosure — Extraction	With general extraction network				Gas in circulation through a purification unit	

Annex B
(informative)

Ventilation filter standardization

B.1 Background

Air filters for general air-cleaning include particulate filters and vapour filters. Particulate filters include coarse, fine, HEPA and ultra-low-penetration particulate air (ULPA) filters. All categories are classified according to filtration performance. The different national, European and international standards, as well as relevant trade-association standards such as Eurovent, classify according to the test aerosol used.

EXAMPLE

Soda fluorescein (particles of 0.15 µm): NF X 44-011.

Monodispersed DOP (dioctylphtalate) of 0.3 µm: US MIL STD 282.

NaCl (sodium chloride) of 0.35 µm: Eurovent 4/4.

Paraffin oil: DIN 24185.

The efficiency test methods for HEPA and ULPA filters allow the use of either homogeneous monodisperse or polydisperse aerosols for the determination of particulate filtration efficiencies as a function of particle size. The particle size at which maximum penetration occurs is first determined in flat-sheet media tests. Tests on filter elements (constructed using the same filter medium) can be carried out using either a homogeneous monodisperse aerosol of the size at which maximum penetration occurs (the most penetrating particle size, or MPPS, see Figure B.1), or a polydisperse aerosol whose median size is close the MPPS. Tests with monodisperse aerosols can be conducted using condensation counting equipment, while tests using polydisperse aerosols require the use of optical sizing particle counters.

When determining the efficiency of filter elements, the downstream aerosol concentration can be determined from air samples obtained using either an overall (single-point sampling after mixing) or scan method. The scan method also allows "local" efficiency to be determined.

B.2 New standards

Requirements for new European test standards were initially compared with the characteristics of the existing standard methods described in B.1.

Filtration-performance testing requirements continue to advance along with the technology of micro-miniature electronic devices. By and large, the nuclear industry's filtration efficiency requirements are not subject to the same upward pressure. However, it was felt that the potential for improved performance for ULPA filters could in some circumstances be beneficial.

It was concluded that the existing standardized methods did not provide an adequate technical basis for meeting the requirements. Deficiencies in existing procedures in the following areas were identified, with the need established:

a) to adopt a generally acceptable, continuous classification system for HEPA and ULPA filters;

b) for a test method capable of covering the entire efficiency range, from 85 % to 99,999999 %, or $\mathrm{DF}/10^{7}$;

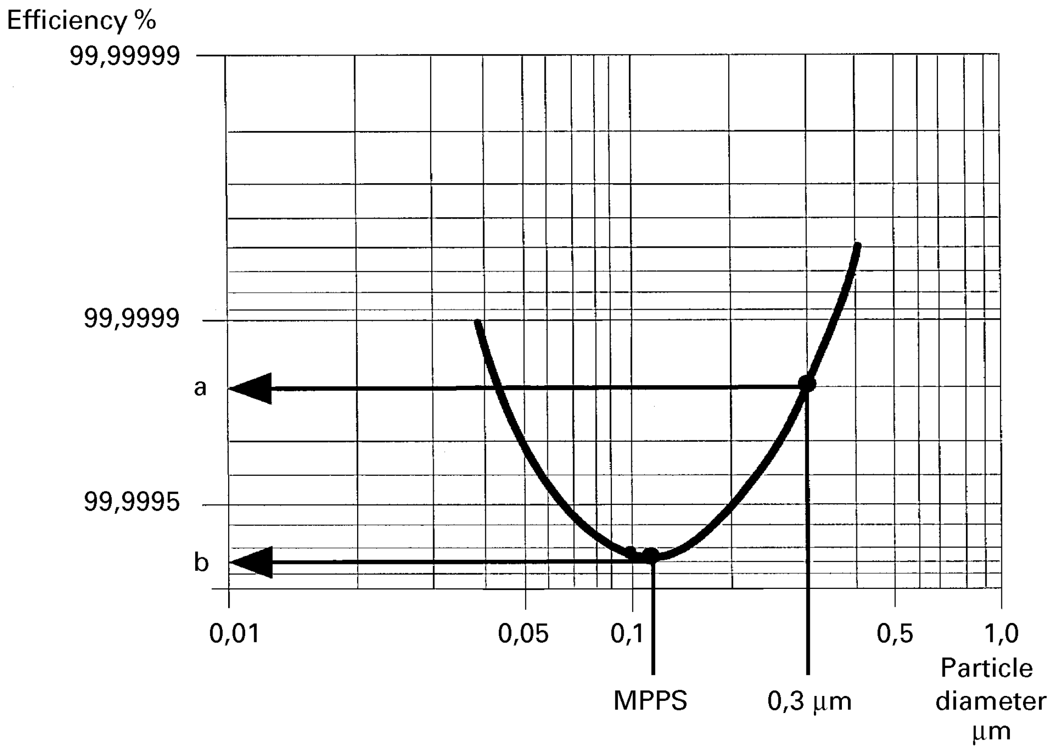
c) to test at MPPS;

d) to express test results in terms of particle numbers rather than particulate mass;

e) to include leakage measurements in testing arrangements and relate them to the overall efficiency and classification of the filters;

f) to include particle size efficiency measurements within the overall procedure;

g) to establish a correlation between results from test-rigs operated by different organizations.



[a] Efficiency DOP

[b] Efficiency MPPS

Figure B.1 — Most penetrating particle size (MPPS)

B.3 Groups and classes of air filters

Particulate air and vapour filters are classified according to their filtration performance (see table B.1).

Table B.1 — Groups and classes of air filters according to filtration performance

Filter type	Performance characteristics	
	Group	**Class**
Particulate air filter	G	Coarse filters, classes G1 to G4
	F	Fine filters, classes F5 to F9
	HEPA	High efficiency particulate air, classes, H10 to H14
	ULPA	Ultra-low penetration air, classes U15 to U17
Vapour filters	Sorption	Removal of gaseous or vapour contaminants

B.4 EN 779 requirements

For classification according to EN 779 of class G and F filters, the following criteria are used:

— air flow of 0,944 m^3/s (3400 m^3/h) if the manufacturer does not specify any rated air flow rate;

— 250 Pa maximum final pressure drop for coarse (G) filters;

— 450 Pa maximum final pressure drop for fine (F) filters.

If the filters are tested at 0,944 m^3/s and at the maximum final pressure drop, they are classified according to Table B.2 (e.g. G3, F7).

If the filters are tested at other air flows or lower final pressure drops they are classified according to table B.2 followed by the test conditions in parenthesis (e.g. G4, 0,7 m^3/s, 200 Pa; and F7,1,25 m^3/s, 300 Pa).

Table B.2 — Classification according to EN 779

EN 779 class	**Final Pressure drop** Pa	**Average Arrestance,** A_m (%) **Synthetic dust (1)**	**Average Efficiency,** E_m (%) **0,4 µm particles (2)**	**Equivalence Eurovent 4/5**
G1	250	$A_m < 65$	—	EU 1
G2	250	$65 < A_m < 80$	—	EU 2
G3	250	$80 < A_m < 90$	—	EU 3
G4	250	$90 < Am$	—	EU 4
F5	450	—	$40 < E_m < 60$	EU 5
F6	450	—	$60 < E_m < 80$	EU 6
F7	450	—	$80 < E_m < 90$	EU 7
F8	450	—	$90 < E_m < 95$	EU 8
F9	450	—	$95 < E_m$	EU 9

NOTE 1 The loading dust (synthetic test dust) specified is identical to that cited in ASHRAE 52.1 and 52.2. The dust is not representative of the real world, but has been used for over 20 years to simulate filter loading. The dust will continue to be used until a more representative dust is developed (research projects are currently underway).

NOTE 2 A liquid aerosol has been chosen for the efficiency test for the following reasons:

— experience has already been gained by users of Eurovent 4/5 techniques so that much equipment already exists;

— liquid aerosols are easier to generate than solid aerosols in the concentrations, size range and degree of consistency required;

— the aerosol can be brought to the Boltzman charge distribution, which represents the charge distribution of aged ambient atmospheric aerosol.

B.5 EN 1822 and Eurovent requirements for HEPA and ULPA filters

Table B.3 gives the classification of HEPA and ULPA filters proposed by CEN Standard 1822, while Table B.4 gives that of Eurovent 4/4 (NaCl method).

Table B.3 — Classification according to EN 1822

Filter		MPPS values					
		Overall			Local		
Group	**Class**	**Min. Efficiency** E (%)	**Max. Penetration** P (%)	**Min. DF**	**Min. Efficiency** E (%)	**Max. Penetration** P (%)	**Min. DF**
HEPA (H)	H10	85	15	6,7	—	—	—
	H11	95	5	20	—	—	—
	H12	99,5	0,5	200	97,5	2,5	40
Nuclear industry domain	H13	99,95	0,05	2 000	99,75	0,25	400
	H14	99,995	0,005	20 000	99,975	0,025	4 000
ULPA (U)	U15	99,9995	0,0005	200 000	99,9975	0,0025	40 000
	U16	99,99995	0,00005	2 000 000	99,99975	0,00025	400 000
	U17	99,999995	0,000005	20 000 000	99,9999	0,0001	1 000 000

Table B.4 — Classification according to Eurovent 4/4

Filter class	Limits		
	Initial efficiency E_i (%)	**Initial penetration** P_i (%)	**Min. DF** DF_i
E10	$99,0 < E_i < 99,9$	$5 < P_i < 0,1$	$20 < DF_i < 1\,000$
E11	$99,9 < E_i < 99,97$	$0,1 < P_i < 0,03$	$1\,000 < DF_i < 3\,300$
E12	$99,97 < E_i < 99,99$	$0,03 < P_i < 0,01$	$3\,300 < DF_i < 10\,000$
E13	$99,99 < E_i < 99,999$	$0,01 < P_i < 0,001$	$10\,000 < DF_i < 100\,000$
E14	$99,999 < E_i$	$0,001 < P_i$	$100\,000 < DF_i$

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