INTERNATIONAL STANDARD

ISO 11933-5

First edition
2001-09-15

Components for containment enclosures —

Part 5:
Penetrations for electrical and fluid circuits

Composants pour enceintes de confinement —

Partie 5: Traversées de paroi pour circuits électriques et circuits de fluide

Reference number
ISO 11933-5:2001(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

Foreword

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

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

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

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

International Standard ISO 11933-5 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*

Introduction

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

— have different geometrical dimensions;

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

— be attached to the wall by different methods;

— use different sealing systems for limiting leaktightness.

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

As a consequence, the aim of this 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.

Components for containment enclosures —

Part 5:
Penetrations for electrical and fluid circuits

1 Scope

This part of ISO 11933 specifies selection criteria for, and describes the design characteristics of, the various electrical- and fluid-circuit penetration components mounted on leaktight or shielded containment enclosures.

This part of ISO 11933 is applicable to:

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

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

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

2 Normative references

The following 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*.

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

3 Terms and definitions

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

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

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

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

3.4
relay control box
small enclosure, generally closed, used to house slave and automated equipment and connect it electrically to controls such as actuators and power-consuming equipment

3.5
connector
electrical connector composed of two plug-in elements

NOTE Depending on use, the plug-in elements can be: removable female plug and wall-penetration plug receptacle; removable male plug and wall-penetration socket; removable female plug and plug receptacle attached to power-consuming equipment; or removable male and female plugs.

3.6
plug receptacle
fixed receptacle, generally on an appliance, providing electrical continuity for one or more conductors when connected to a female plug; downstream element in a connector assembly

3.7
connector assembly
assembly of standardized or specially designed electrical-connection components such as a socket or plug, serving a specific function in a containment enclosure

3.8
male plug
removable plug with male pins that provides electrical continuity for one or more conductors; downstream element in a connector assembly

3.9
female plug
removable plug whose contacts are recesses (female) and which provides electrical continuity for one or more conductors; upstream element in a connector assembly

3.10
socket
fixed body (e.g. wall penetration, supply box) that provides electrical continuity for one or more conductors when connected to the male plug or female plug.

3.11
control console
fixed or mobile unit with sloping top panel housing process controls, monitoring devices and instruments

3.12
fixed console
fixed unit with sloping top panel, integrated within the containment enclosure and housing monitoring and control devices for containment-enclosure-dedicated actuators and power-consuming equipment

3.13
mobile console
mobile unit with sloping top panel, generally housing monitoring and control devices for open-ended equipment

3.14
power-consuming equipment
device or mechanism which, receiving a supply of electricity, outlets another form of energy (e.g. mechanical, chemical, heat, light)

3.15
high-voltage distribution cabinet
cabinet or set of cabinets that can be assembled housing high-voltage electricity supply equipment

3.16
plug board
small, fixed enclosure equipped with several power points fed by the same power supply

3.17
wall penetration
system allowing an electrical circuit or fluid to pass through the wall of a containment enclosure

NOTE For the purposes of this part of ISO 11933, it is necessary to distinguish between a wall penetration that allows the passage of an electrical current or signal, and a fluid wall penetration, which allows the passage of fluids and gases.

3.18
valve
system allowing the flow of a fluid in a pipe to be established or cut off, or the rate of the flow to be controlled

3.19
fitting
connection
system intended for joining fluid pipe elements, permanently or temporarily

4 Selecting a component

4.1 General requirements

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

Such “off-the-shelf” components may be considered suitable for most applications, but only provided they comply with the requirements in this part of ISO 11933. Where specifically nuclear demands need to be met (e.g. resistance to high levels of radiation or specific leaktightness for maintaining a vacuum), the materials and components shall be specially adapted or “nuclearized”.

The components used for special applications related to nuclear safety, such as those involving processes or remote handling, those in use behind shielding walls or subject to repeated use, or those used in the fabrication or operation of special effluent circuits, shall be developed as needed.

4.2 Risk assessment and safety analysis

4.2.1 Principle and parameters

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

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

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

4.2.2 Atmosphere

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

The following shall be taken into account:

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

— purity of the air;

— internal pressure (for normal and emergency conditions);

— normal and safety air-change rates.

4.2.3 Heat radiation

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

4.2.4 Corrosion

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

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

— electrical cables;

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

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

4.2.5 Leaktightness

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

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

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

4.2.6 Fire

In containment enclosures, as in nuclear installations as a whole, fire presents an important risk for the spread of contamination, and therefore shall be carefully assessed.

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

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

Flame-retarding electric cables are recommended.

Equipment with high static electricity risk shall be grounded.

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

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

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

4.2.7 Mechanical risk

A risk is present when rotating pieces or machines are installed on the containment enclosure; this risk shall be taken into account, especially when electric motors are to be installed on enclosure walls.

4.2.8 Electrical risk

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

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

4.2.9 Contamination and irradiation

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

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

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

4.2.10 Chemical risk

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

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

4.2.11 Other risks

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

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

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

4.3 Other requirements

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

5 Electrical components

5.1 Design and installation

5.1.1 General

As well as complying with the general requirements of this part of ISO 11933 and the provisions of other international and national technical regulations, the design of electrical equipment for containment enclosures shall take into account the following technical aspects of construction, use, maintenance and dismantling. These various aspects are closely interrelated, and their respective provisions shall determine the installation and layout of the components used in electrical circuits in containment enclosures.

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

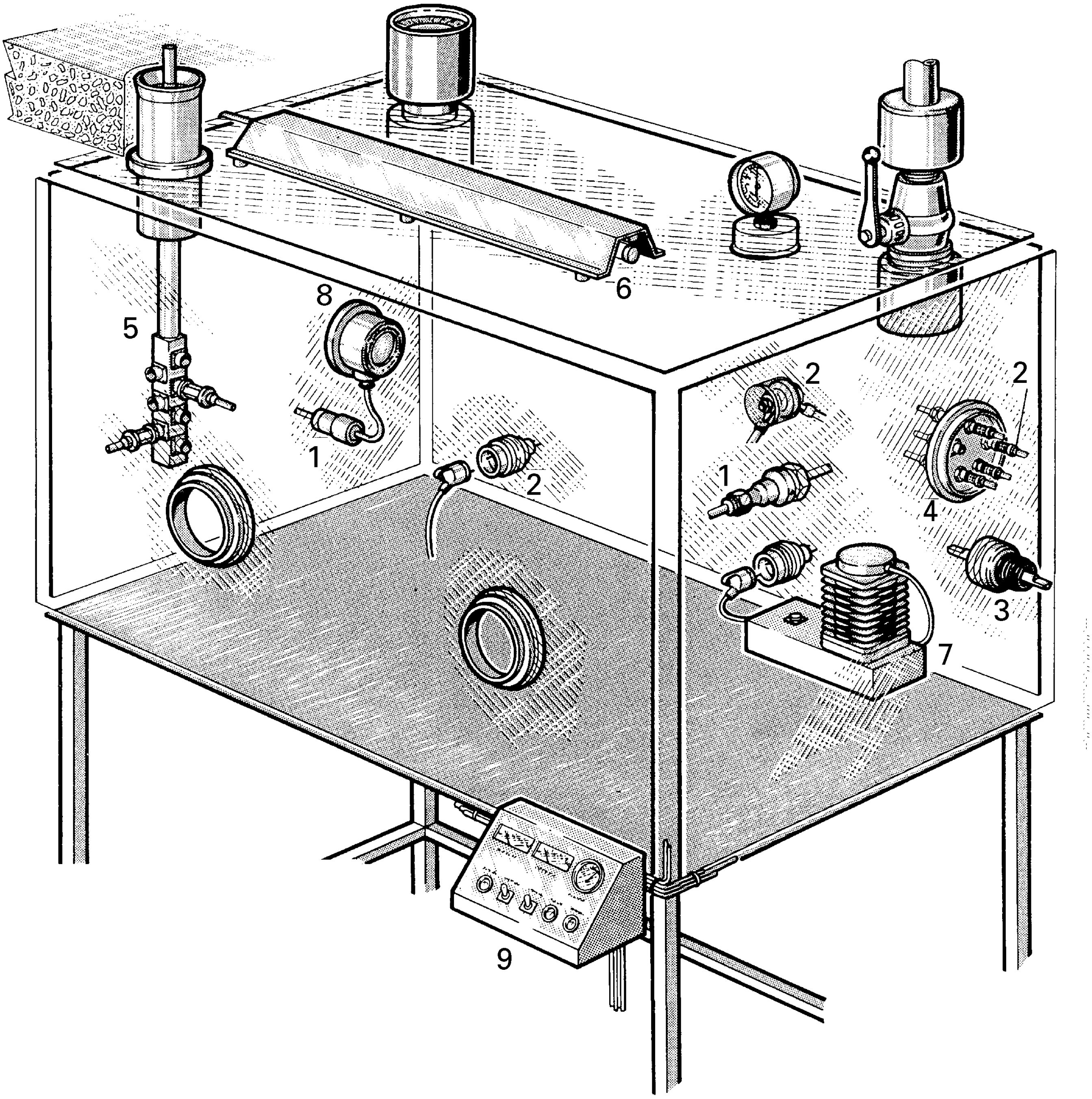
Figure 1 shows a containment enclosure fully equipped with typical electrical components.

5.1.2 Materials used in fabrication

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

5.1.3 Work stations

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



Key

1 Continuous wall penetration
2 Non-continuous wall penetration
3 Rotating penetration
4 Ejectable plug (for electrical circuit with or without remote connections)
5 Ejectable holder
6 Fluorescent light
7 Electric motor
8 Explosion detector
9 Control console

Figure 1 — Containment enclosure fully equipped with electrical components

5.1.4 Equipment location and operation

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

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

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

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

To ensure the protection, ease of replacement and durability of the material, the equipment should be connected using the components described in this part of ISO 11933.

5.1.5 Operator safety

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

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

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

5.1.6 Maintenance and intervention

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

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

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

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

5.1.7 Decontamination and dismantling

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

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

The dismantling of electrical equipment can demand the use of special tools, manufactured and tested when the equipment itself was manufactured. Such tools shall be available for use by the operator carrying out final maintenance or dismantling operations, and the correct procedure to be adopted for such operations shall be made known to those concerned.

5.1.8 Installation

5.1.8.1 General principles and recommendations

The layout of electrical components in a containment enclosure shall be designed and implemented in accordance with the following principles.

— Ensure the safety of personnel and of surrounding equipment from electrical hazards.

— Facilitate handling when the electrical equipment is in operation, at the point of waste disposal or dismantling.

— Prevent electrical equipment acting as a vector for contamination.

— Simplify modifications to, or maintenance of, the equipment.

— Conform, when necessary, with other standards and regulations related to aesthetic and ergonomic considerations (shape, colours, etc.).

Flexible steel (or aluminium where appropriate) conducts are recommended for the connection of equipment subject to vibration, as is the use of liquid-tight, flexible metallic conducts with approved fittings.

Steel conducts should be used for routing power cables to motors supplied from variable-frequency controllers in order to minimize noise to and from adjacent circuits. Variable-frequency controllers should be specified to include filters.

5.1.8.2 Location

5.1.8.2.1 Inside the containment enclosure

In as far as possible, only essential electrical equipment shall be located inside the enclosure, in an area directly accessible using standard handling devices.

Less accessible areas (front panel) may also be used if a means for moving the equipment into the handling area when necessary (e.g. articulated support bracket), or additional handling facilities (glove box), are provided.

An adjacent containment enclosure may also be used for repairing contaminated electrical equipment, thus temporarily improving accessibility.

5.1.8.2.2 Outside the containment enclosure

If there is a substantial risk of contamination, it is often preferable to locate the equipment outside the enclosure. This prevents contamination or even irradiation of the equipment and reduces chemical and heat-related risks, etc.

High-voltage distribution cabinets, control consoles and safety equipment may generally be located outside the enclosure. However, in the case of components used to produce a direct effect inside the enclosure, penetration of the leaktight seal or the shielded protection can cause specific problems.

EXAMPLE An agitator motor can be located outside the enclosure, but a penetration will be needed for the moving part; lighting can be installed externally but a window could be needed in an opaque wall.

The possibility of using intermediate areas below the enclosure or between the containment enclosure and the shielded protection should be examined in detail prior to installation. A particular location could be accessible when the plant is new, but may become inaccessible after a period of use, owing to irradiation or accidental contamination, etc.

5.1.8.3 Equalizing the potential of metallic structures

All metallic structures, including glove boxes and frames, shall be grounded to the frame earth of the building.

NOTE This precautionary measure will also facilitate the discharge to earth of static.

5.1.8.4 Electromagnetic compatibility

All electric components used in containment enclosures shall comply with existing electromagnetic compatibility standards and regulations.

5.2 Specific component requirements and recommendations

5.2.1 Plug boards

Each plug board shall be fitted with a ground fault protector (GFP), with each socket outlet individually protected by an automatic circuit-breaker.

5.2.2 High-voltage distribution cabinets

High-voltage distribution cabinets shall, wherever possible, be placed inside the laboratory. However, a cabinet may be placed outside it, provided the laboratory can be closed off in the event of contamination, or if the enclosure is not large enough.

Each cabinet shall:

a) be of suitable dimensions and able to be locked with a key;

b) be easily accessible to maintenance staff;

c) not hinder operators;

d) blend in with the enclosure, complying where necessary with local regulations on colour, shape, etc.

Where a cabinet is located in a laboratory, a circuit-breaker or other remote shut-down device shall be located near the entrance to the laboratory.

5.2.3 Low-voltage distribution cabinets (large and small distribution boxes)

Distribution boxes shall be located in the area adjacent to the containment enclosure. They shall be subject to the same provisions as those applicable to high-voltage distribution cabinets (5.2.2). Nevertheless, owing to their smaller size, they may be disconnected and moved if necessary to facilitate specific handling operations.

5.2.4 Control consoles

Control consoles, whose primary function is to make available to the operator control, monitoring and indicator devices, shall be:

— functional (sensible choice of location, of environment, layout of controls, etc.);

- aesthetic (pleasing shape and colour, non-reflecting surfaces, etc.);
- in accordance with ergonomic regulations;
- designed to facilitate all types of intervention (repairs and modifications), including separation of electronic, electrical, hydraulic and pneumatic circuits, and possible complete disassembling of their components, shut-down circuits and isolators.

Control consoles shall be located well away from potential liquid spills, humidity, etc. However, relays may be located in a separate console not far from the enclosure. Measuring apparatuses may be located on a control console outside the enclosure, but close to the operator. Attention should be given to the length of cables (see 5.2.5). Operators shall be protected from the risk of electric shocks.

Depending on the case, one of the following set of requirements shall be met.

- For leaktight enclosures or lines of glove boxes, where the console is small, it shall be attached to the glove box or located on a side and fixed to a framework or pivoting arm; if larger and used in glove-box lines, it shall be mounted on an individual chassis equipped with wheels and placed in front of the glove boxes or glove-box lines.
- For shielded containment enclosures, the console shall be attached to the enclosure, under the shielding window, or mounted on an individual chassis equipped with wheels or fixed on a pivoting arm; it may also be located in a separate room, or at a certain distance from the containment enclosure at production facilities where all operations are remotely operated or where there are glove box lines.

NOTE Control consoles can be either custom-built or selected form manufacturer's standard models.

5.2.5 Electrical cables

5.2.5.1 General

Electrical cables used in containment enclosures shall be as short as possible, direct and, where necessary, be protected against external hazards. In particular, the following circuits shall be separated:

- high-current or high-voltage,
- electronic or low-current,
- remote control, measurement, or lighting cables,
- radiant (HF), which should receive special attention.

5.2.5.2 Inside cabling

Cabling inside containment enclosures is realized by grouped (e.g. ejectable plugs) or individual wall penetrations. In either case, the cable is installed using cable trays or appropriate support pieces, or mounted using the pig-tail guide system. Where needed (in aggressive or hazardous environments), special protection for cables, such as a metallic housing, shall be provided.

5.2.5.3 Outside cabling

Cabling outside the containment enclosure shall be achieved according to the state of the art and respecting local safety regulations. Cabling shall be as short as possible, while using local electricity-supply equipment as far as possible.

5.2.6 Connector assemblies

5.2.6.1 Designation and classification

A connector assembly can include plug-in penetrations, removable male and female plugs, and plug receptacles or sockets. Three different types of connections can be obtained using these assemblies.

Type 1 connection, for wall penetration, consists of a removable female plug, a fixed penetration body and a removable male plug, and is also called a double connection (see Figure 2).

Type 2 connection (see Figure 3), for connection on a containment wall or an apparatus, consists of either a removable male plug and fixed plug receptacle on a wall, or a mobile female plug and fixed receptacle on an apparatus or other piece of equipment. This assembly is also known as a single connection.

Type 3 connection, for use with extension cable, consists of removable female and male plugs (see Figure 4). This type of assembly shall be equipped with mechanical retaining devices to prevent any untimely breaking of the connection.

5.2.6.2 Construction

Each constituent part of a connector assembly is composed of a body or shell, an insulator holder, and female (recesses) or male (pins or terminal) electrical contacts.

The body or shell can be in metal or plastic. Its mechanical strength shall be selected depending on the operating conditions (mechanical stress or frequency of manipulation).

The insulator holder mechanically retains the contacts. The nature of the dielectric material shall be appropriate for the operating conditions (temperature, chemical aggressiveness of the environment, radiation resistance, breakdown voltage, etc.).

The electrical contacts provide electrical continuity between connectors. They are generally of brass, sometimes silver-plated or gold-plated, and can be screwed, crimped or soldered to the conductors.

5.2.6.3 Other general requirements

Unless specifically instructed otherwise, never connect or disconnect energized equipment.

Use equipment suitable for each voltage category or type of current.

Display all special use instructions in writing, near the item of equipment.

5.2.6.4 Female plug

The female plug shall be the upstream element in a connector assembly or the source of electrical energy.

5.2.6.5 Male plug

The male plug shall be the downstream element in a connector assembly or the receiver of electrical energy.

5.2.6.6 Socket

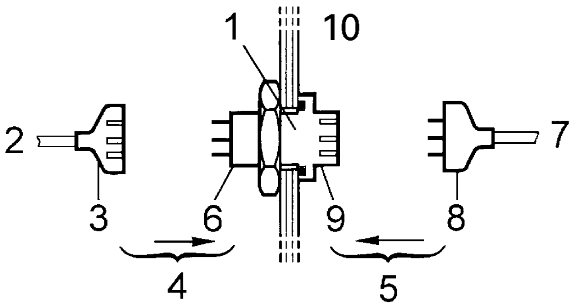
The socket shall be the upstream element in a connector assembly.

5.2.6.7 Plug receptacle

The plug receptacle shall be the downstream element in a connector assembly.

5.2.6.8 Connector

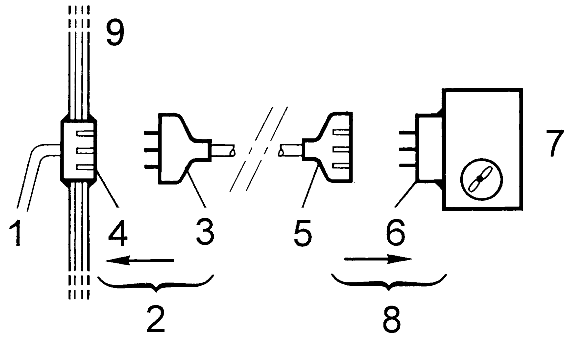
A connector can have one or more conductors, be manually or remote-operated, quick-fastening or otherwise.



Key

1 Wall penetration
2 Power supply
3 Female plug
4 Connector
5 Connector
6 Plug receptacle
7 Use
8 Male plug
9 Socket
10 Inside of enclosure

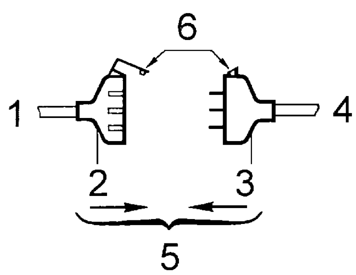
Figure 2 — Type 1 connector assembly (wall penetration)



Key

1 Power supply
2 Connector
3 Male plug
4 Socket
5 Female plug
6 Plug receptacle
7 Fixed or mobile power-consuming equipment
8 Connector
9 Inside of enclosure

Figure 3 — Type 2 connector assembly (wall or apparatus)



Key

1 Power supply
2 Female plug
3 Male plug
4 Use
5 Connector
6 Mechanical retaining device

Figure 4 — Type 3 connector assembly (extension cable)

5.2.7 Wall penetrations

5.2.7.1 General

A wall penetration allows an electric current or signal to be passed through the wall of a containment enclosure. Wherever possible, and whenever the equipment located outside the enclosure is not subject to frequent modifications, the wall penetration shall have a single plug-in point inside the enclosure. Otherwise, a double plug-in arrangement shall be used, for increased flexibility of connection and easier checking.

There are three types of wall penetration for enclosure electrical circuits: the plug-in penetration, which has a plug-in connection that can be on one or both sides (when single-sided, the connector is similar to a fixed plug receptacle), the direct or continuous penetration, which has cables with one or more conductors, and the special wall penetration (e.g. for wave guide, high-frequency current, coaxial cables and connections for thermocouples).

5.2.7.2 Plug-in

This penetration is recommended for mobile items of equipment, and for all monitoring and measuring devices, as it is suitable for transmitting signals. Its advantages are its extreme flexibility of use for frequent connection and disconnection, its separate and individually identifiable functions, and the ease of installation of additional electrical connections between the inside and the outside of the enclosure. Its disadvantages are its fragility, a lower level of electrical safety, and a sensitivity to chemical attack.

5.2.7.3 Direct or continuous

The direct or continuous penetration is recommended in all cases where the power-consuming equipment is fixed or if the supply feeds a distribution box. Its advantages are that there is no connecting or disconnecting involved and no contact resistance, simplified installation, good electrical safety levels and reduced overall dimensions. Its disadvantages are the need for a special procedure for replacing the cable in order to avoid contamination, and a lower level of wall-penetration leaktightness.

5.2.7.4 Special

These are wall penetrations for terminal lugs, coaxial cables, thermocouples, high-frequency (HF) equipment etc. They are specific to each design type.

5.2.7.5 Examples

5.2.7.5.1 Non-continuous, double plug-in socket

This is a leaktight, double plug-in wall penetration for standard or special connections. It can be used for all types of containment enclosure. It comprises the following (see Figures 5 and 6):

a) a body of plastic material [polyvinyl chloride (PVC), polyethylene or polymethylmethacrylate (PMMA)], or of metallic alloy (stainless steel or light alloy):

— when plastic, electrical contacts (female recesses and male pins) generally made of brass or stainless steel and sometimes silver- or gold-plated, directly incorporated in the body,

— when of metallic alloy, equipped with an insulator holder, made of polypropylene, polytetrafluoroethylene (PTFE) or a thermoretractable material, for retention of the electrical contacts;

b) leaktight O-ring elastomer seals on the wall;

c) a threaded ring, realized in the same material as the body.

The earthing contacts can either be conceived in the same manner as the main contacts (model A, Figure 5) or in a special design (model B, Figure 6). On both models, the earthing contacts are orientated in the direction opposite to that of the main contacts, on both sides of the containment enclosure wall (i.e. inside and outside the enclosure).

Leaktightness is achieved by O-ring seals on the enclosure wall and between the body and the insulator holder when needed, and with an insulator plastic holder and moulded electrical contacts.

This type of penetration may be used for class 1 containment enclosures (see ISO 10648-2). It is designed to be used with:

— standard plug-in connectors such as those shown in Figures 5 and 6 (2P + E, 3P + E, where P = phase and E = earth);

— special terminal flat plugs, for which, depending on the model, the penetration socket is equipped with 7, 19, 31 or 61 pins or snaps, corresponding to an external diameter of 90 mm, 125 mm, 160 mm or 210 mm (see Figure 7);

— special, multi-contact 3, 6, 9 or 12 pins, for low-current measurement applications for which, depending on the model, the body of the electrical wall penetration can be threaded (model A, Figure 8) or unthreaded (model B, Figure 9);

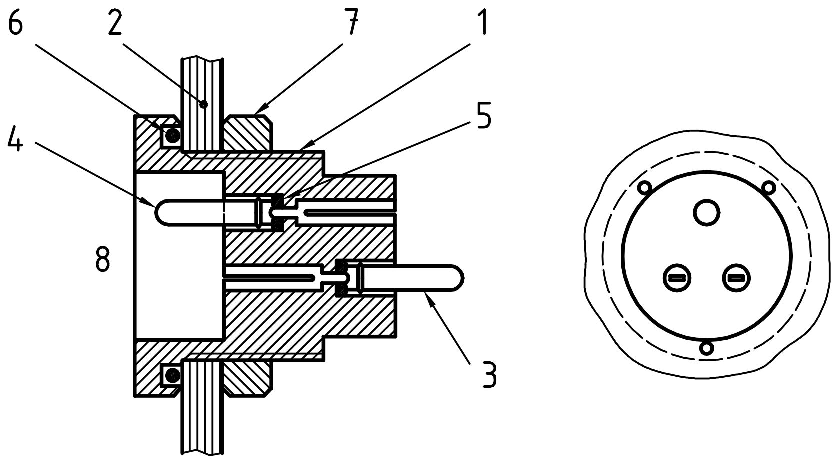
— special high-current (100 A to 400 A) contactors (e.g. for high frequency welding systems) which require a housing for the operator protection and which, depending on their function, are designed for single (model A, see Figure 10) or multiple penetrations (model B, see Figure 11).

In order to prevent the spread of contamination, the O-ring seal should be mounted inside, and the threaded ring outside, the containment wall. In order to ensure electrical protection, the electrical contacts of the wall penetration device should be placed as follows: female for contacts inside the containment enclosure; male for contacts outside the enclosure.

These models are applicable to all types of current, voltage categories and standard or special polarities.

Welded instead of threaded wall penetrations of this type are also available

NOTE On request, an extension for a side entrance or outcome can be manufactured.



Key

1 Body

2 Enclosure wall

3 Electrical contacts (using pins)

4 Earthing contact

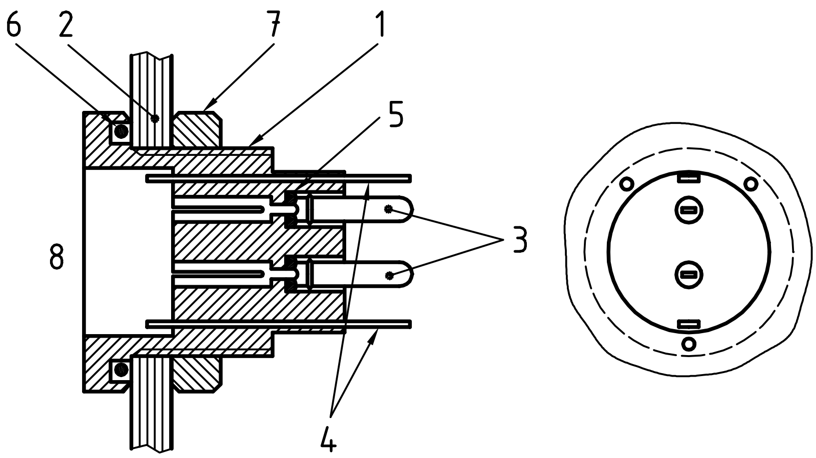
5 Elastomer seal

6 O-ring seal

7 Threaded ring

8 Inside of enclosure

Figure 5 — Double plug-in wall penetration socket — Model A



Key

1 Body

2 Enclosure wall

3 Electrical contacts (using pins)

4 Earthing contacts

5 Elastomer seal

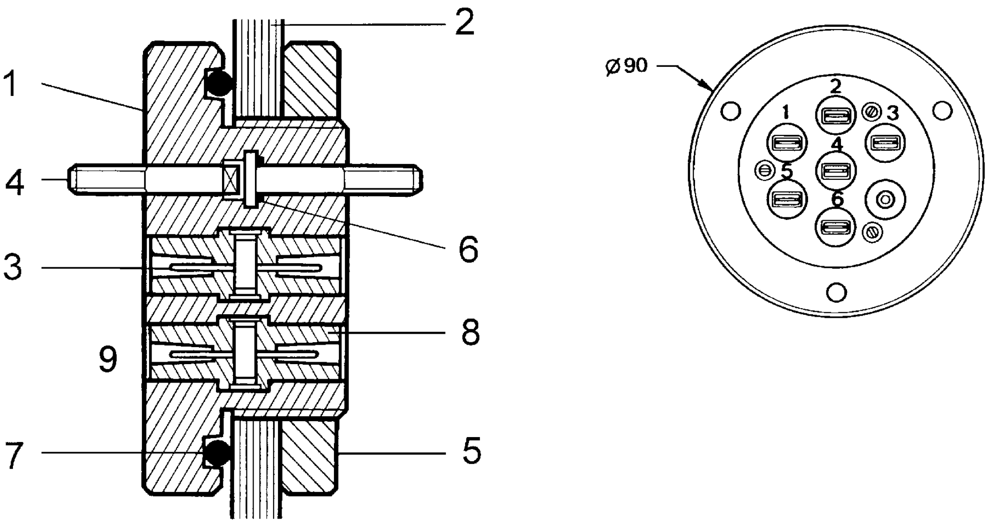
6 O-ring seal

7 Threaded ring

8 Inside of enclosure

Figure 6 — Double plug-in wall penetration socket — Model B

Dimensions in millimetres

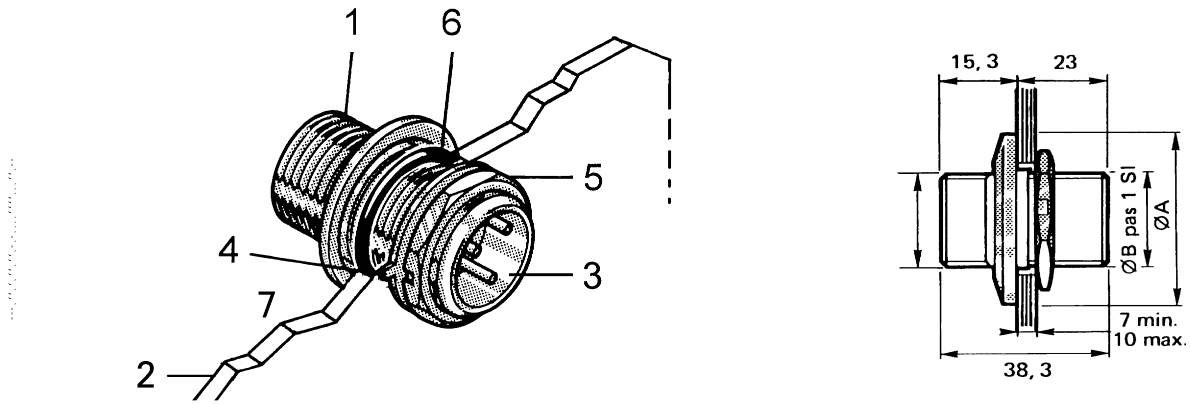


Key

1 Body
2 Enclosure wall
3 Electrical contacts
4 Earthing contact
5 Threaded ring
6 Elastomer seal
7 O-ring seal
8 Insulator holder
9 Inside of enclosure

Figure 7 — Special double plug-in wall penetration socket for flat terminals

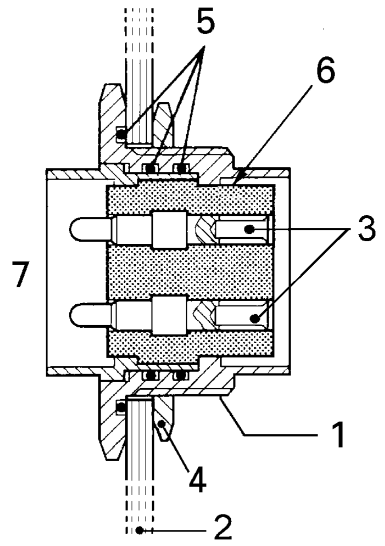
Dimensions in millimetres



Key

1 Body
2 Enclosure wall
3 Electrical contacts
4 Plastic slice
5 Threaded ring
6 O-ring seal
7 Inside of enclosure

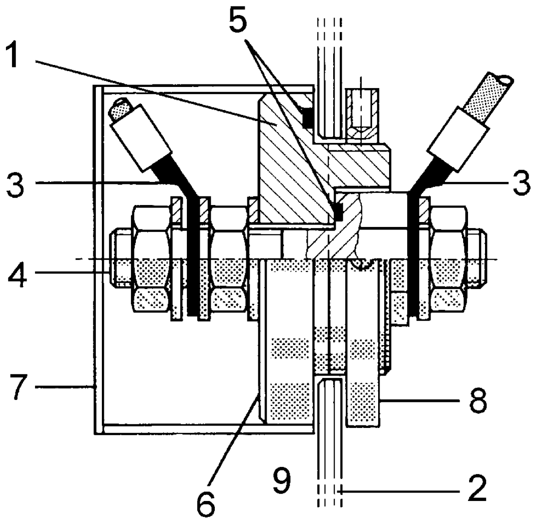
Figure 8 — Special double plug-in wall penetration socket for low-current applications — Model A (threaded)



Key

1 Body
2 Enclosure wall
3 Electrical contacts (using contactors)
4 Threaded ring
5 O-ring seals
6 Insulator holder
7 Inside of enclosure

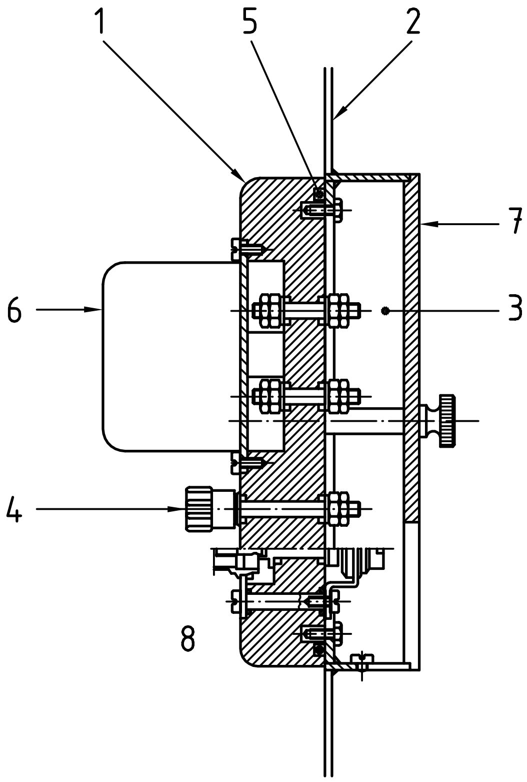
Figure 9 — Special double-pin wall penetration socket for low current applications — Model B (unthreaded)



Key

1 Body
2 Enclosure wall
3 Cable terminals
4 Penetration screw
5 O-ring seals
6 Insulator holder
7 Housing
8 Threaded ring
9 Inside of enclosure

Figure 10 — Special single-penetration socket for high-current circuits — Model A



Key

1 Body

2 Enclosure wall

3 Cable terminals

4 Penetration screw

5 O-ring seal

6 Housing

7 Cover

8 Inside of enclosure

Figure 11 — Special multi-penetration socket for high-current circuits and other services — Model B

5.2.7.5.2 Continuous wall penetration for coaxial cables

This direct wall penetration for all type of coaxial cable can also be used for all types of containment enclosure. It consists of the following three- or four-piece connection (model A, Figure 12, or model B, Figure 13):

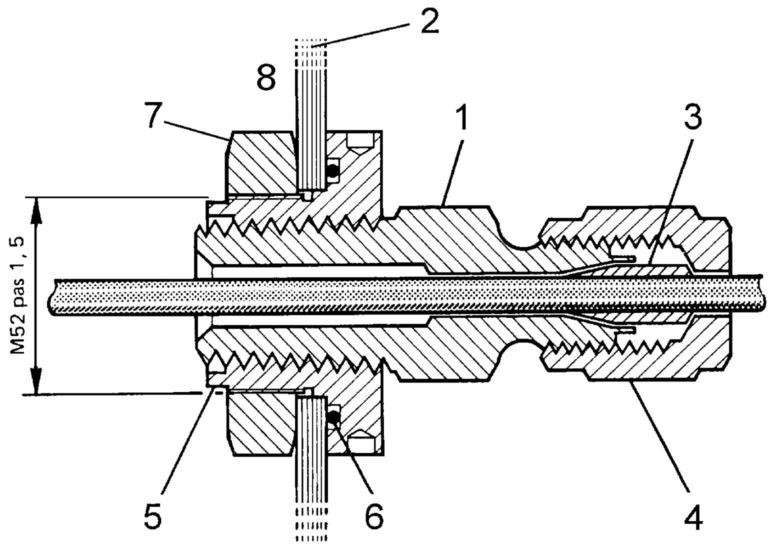
— body of plastic (PVC, polyethylene or PMMA) or stainless steel;

— metallic or plastic nut which contributes to the leaktightness of the coaxial cable;

— metallic or plastic intermediary threaded ring, screwed onto the body (single stuffing-box principle);

— leaktight wall penetration fitting mounted on the enclosure wall using a threaded ring and an elastomer O-ring seal.

Dimensions in millimetres



Key

1 Body

2 Enclosure wall

3 Metallic or plastic nut

4 Intermediary threaded ring

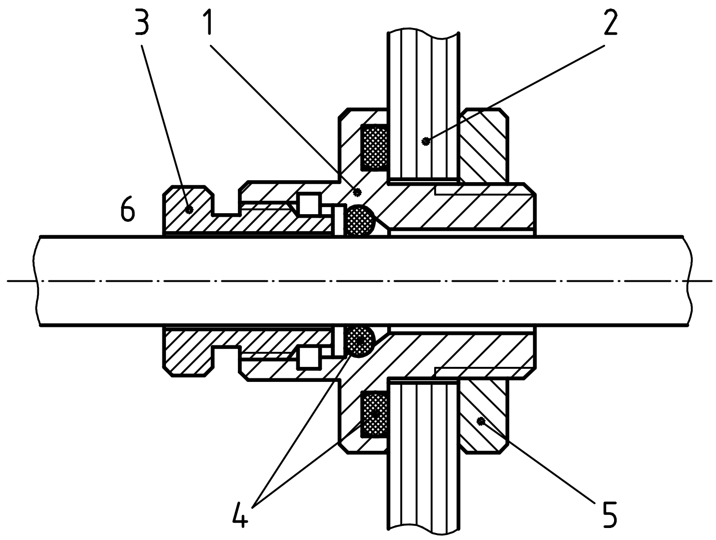
5 Wall penetration fitting

6 O-ring seal

7 Threaded ring

8 Outside of enclosure

Figure 12 — Wall penetration for coaxial cable (single-stuffing box principle) — Model A



Key

1 Body

2 Enclosure wall

3 Intermediary threaded ring

4 Elastomer seals

5 Threaded ring

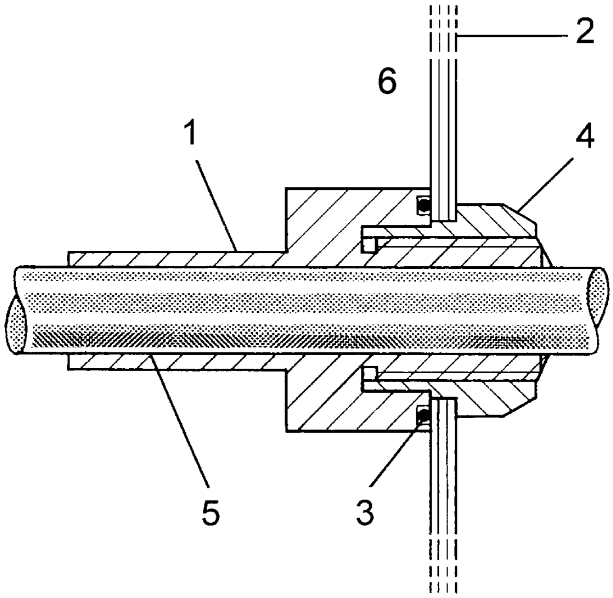
6 Inside of enclosure

Figure 13 — Wall penetration for coaxial cable (single-stuffing box principle) — Model B

Depending on the design of the wall penetration, leaktightness is achieved using an O-ring seal on the enclosure wall, by thermoretractation of the body on the cable when the body is of plastic (see Figure 14), or deformation of the nut during screwing of the intermediary threaded ring on the cable, or by screwing the conical body onto the wall penetration.

This type of wall penetration can be used with all kinds of cable, and when not in use can be replaced by rigid plugs.

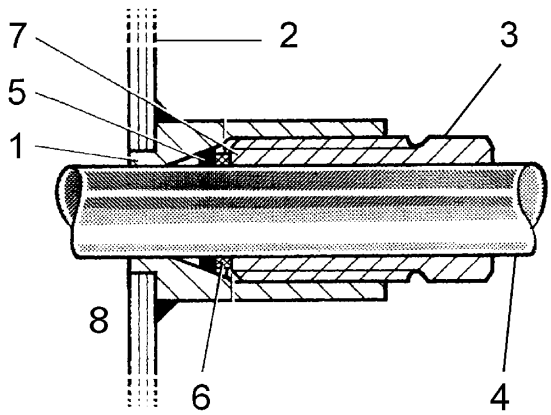
Welded instead of screwed wall penetrations of this type are also available (see Figure 15).



Key

1 Thermoretractation device
2 Enclosure wall
3 O-ring seal
4 Threaded ring
5 Cable
6 Inside of enclosure

Figure 14 — Screwed continuous wall penetration for coaxial cables (thermoretractation system)



Key

1 Wall penetration fitting
2 Enclosure wall
3 Hexagonal screw
4 Cable
5 Elastomer seal
6 Metallic slice
7 Single stuffing box device
8 Inside of enclosure

Figure 15 — Welded continuous wall penetration for all cables

5.2.7.5.3 Special removable penetrations for shielded or unshielded containment enclosures

These special holders (ejectable rigid plug or mobile jack), which are equipped with removable electrical connectors, normally form a part of the containment enclosure wall and can be ejected inside the containment enclosure. They are suitable for shielded or unshielded containment enclosures of all classes, and are of two types.

a) Type A (see Figure 16) is a rigid, ejectable plug made of metal (light alloy or stainless steel), such as is described in ISO 11933-1. It comprises:

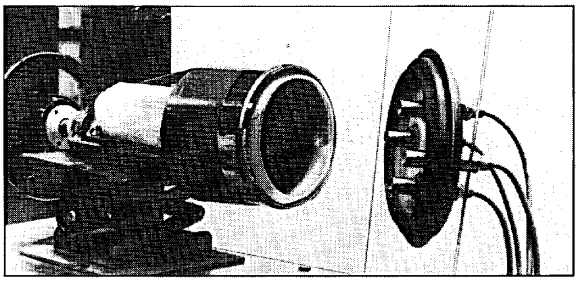
— a containment-enclosure ring mounted on the enclosure wall,

— an ejectable rigid plug made of plastic material (generally polyethylene) and fitted with 5 or 8 connectors.

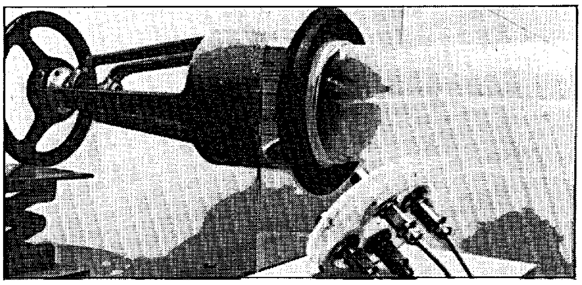
b) Type B (see Figure 17) is a mobile jack consisting of:

— a fixed metallic tube mounted on the containment enclosure wall,

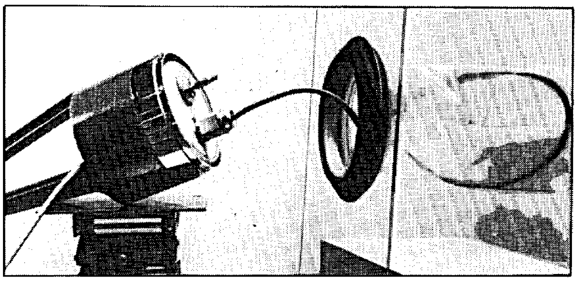
— a mobile jack, ending in a square tube fitted with several removable connectors, fastened on the through-wall tube by two O-ring seals made of elastomer [Viton®, Perbunan® or other[1]].



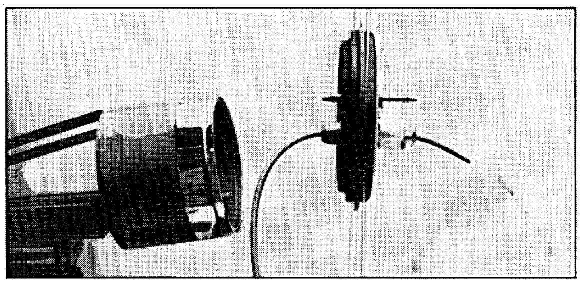
a) Connection of the ejecting device on the ejectable rigid plug equipped with wall penetrations



b) Removal of the rigid plug and its replacement by an intermediary welded bag mounted on an ejectable support ring, which accommodates the different premounted tubes, cables, connections and accessories



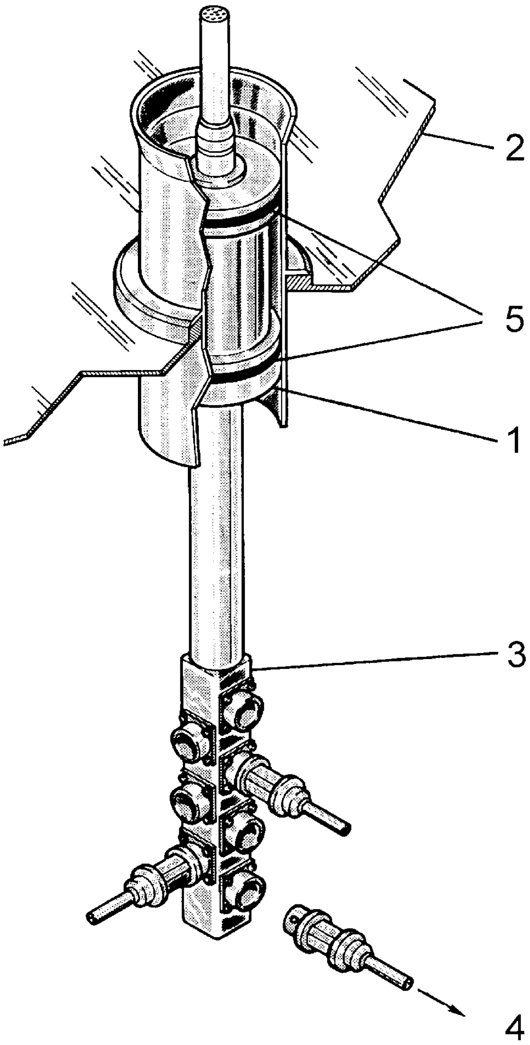
c) Presentation of the new rigid plug



d) Connection of the new plug and simultaneous ejection of the intermediary welded bag

Figure 16 — Ejectable rigid plug with electrical connectors — Replacement

1) Viton® and Perbunan® 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 Piston
2 Enclosure wall
3 Distribution box
4 Main connectors
5 O-ring seals

Figure 17 — Mobile jack with electrical connectors

These penetrations allow the distribution of several electrical points of use inside the containment enclosure, which can be exchanged very easily in case of failure or when otherwise needed.

The entire leaktight component is disconnected from the inlet and outlet electrical cables, and is replaced by pushing the old component into the containment enclosure, where it is considered to be radioactive waste, and inserting a new component fitted with the appropriate connectors. As an intermediary step, a welded bag can be used in order to retain the different accessories (e.g. pre-mounted tubes, cables, connection assemblies).

Type A needs a special ejecting device, and allows exchange without breaking containment. Type B can be operated manually, but, because of the breaking of containment during the exchange, needs a special protection device.

5.2.8 Lighting components or systems

5.2.8.1 Sources of light

The main sources of light used with containment enclosures are:

- incandescent lamps, characterized by an emission flux of 15 lm/W to 20 lm/W;
- fluorescent lamps, characterized by an emission flux of 40 lm/W to 50 lm/W;
- discharge lamps, characterized by an emission flux of more than 50 lm/W.

NOTE Tungsten, fluorescent or sodium lamps are suitable for shielded enclosures; sodium vapour lamps, while having very good lighting efficiency, do not render colours well.

5.2.8.2 Contactors

These are support pieces for lamps and electric lines, generally consisting of a plastic insulator holder in which the contactors are moulded.

5.2.8.3 Support devices

These are support pieces for lamps (e.g. flexible arms), tube holders (e.g. housings, sleeves) and other lighting components. According to use, they are made of metal or plastic (PC or PMMA). In the case of housings for fluorescent lamps, leaktight elastomer seals shall be used.

Special care shall be taken to insulate all metallic components, equalizing the potential and connecting to earth.

5.2.8.4 Design

Lighting systems shall be designed to obtain a uniform illumination inside the containment enclosure, while offering maximum comfort to operators.

The required levels of illumination at the work place are:

- 150 lx to 300 lx in glove boxes,
- 1000 lx to 3000 lx in shielded containment enclosures.

The type of lighting depends on the quantity of light needed, the size of the containment enclosure, and the nature of the operations taking place there.

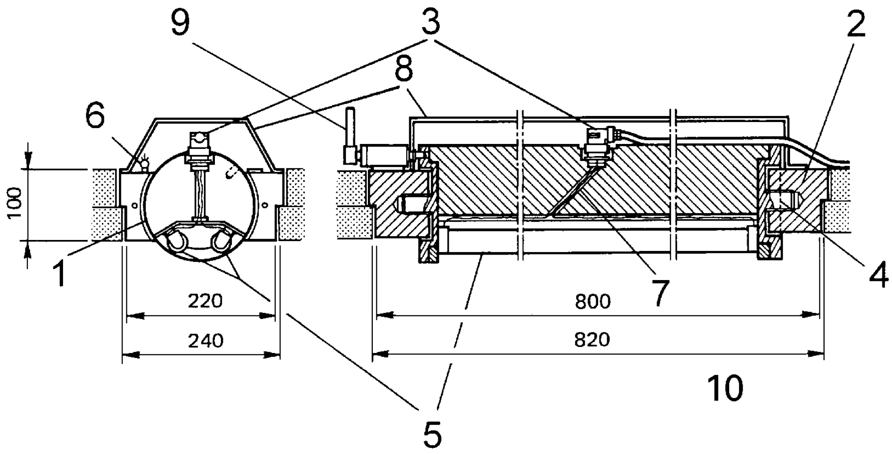
The light fitting is usually suspended above or on the side of the enclosure walls in a suitable transparent panel. The light source shall be located such that direct illuminance of the operators is avoided.

The emission intensity shall be such that interfering reflections are avoided. The level of illuminance at the work places shall be twice that of the ambient level. Excess heat due to lighting devices in containment enclosures shall be eliminated. The vicinity of sensitive (plastic) material shall be avoided and care shall be taken to counteract the action of ultraviolet light on rubber or plastic (especially manipulator and tong gaiters).

In the case of glove boxes, light sources should be located outside the enclosure. In other cases, and especially for shielded containment enclosures, lamps should be mounted on removable shielded plugs, behind protective glass.

EXAMPLE Light for shielded enclosure (see Figure 18): this shielded light fixture with two fluorescent tubes is intended for mounting on a shielded enclosure wall. The design of the lighting block allows it to be mounted on the ceiling of all types of shielded containment enclosure, and for a tube to be easily replaced without breaking the radiation protection shielding. The device comprises a leaded cylinder system, mounted between a through wall ring including the pivots. The fluorescent tubes are mounted on the lower part of the cylinder system. The electrical supply passes through an inclined passage. A metallic housing is mounted on the top of the system.

Dimensions in millimetres



Key

1 Leaded cylinder system
2 Through-wall ring
3 Electrical pins
4 Pivot
5 Fluorescent tubes
6 Handle for rotation of the tube
7 Inclined passage
8 Metallic housings
9 Immobilisation pin
10 Inside of enclosure

Figure 18 — Lighting block for shielded enclosure

5.2.9 Electric motors

5.2.9.1 Location

Electric motors may be located inside or outside the containment enclosures. The choice of the type of location shall take the following considerations into account.

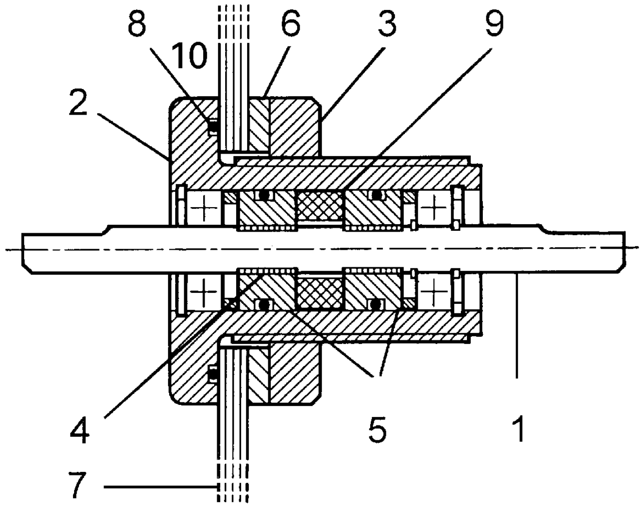
— Locating a motor *inside* an enclosure is recommended when only a few motors are to be installed, or when there is no restriction on the installation of electrical wall penetrations or the progress of cabling inside the enclosure. The advantage of this is that rotating penetrations are not needed. The disadvantage lies in the fact that the motor is required to be adapted to the internal atmosphere. Penetrations for electrical circuits and a great number of cables are needed to be installed and to progress inside the containment enclosure. Where there is risk of flood, explosion or fire, the protection of the motors shall be improved.

  The motors shall be considered as radioactive waste when out of service. Operator safety (5.1.5) and excess heat (4.2.3) shall be taken into account.

— Locating a motor *outside* an enclosure is recommended when it is not adapted to the internal atmosphere of the enclosure. There are a number of advantages to this: design of the motor is simpler, accessibility and maintenance easier, and the volume of the containment enclosure can be smaller. The disadvantages are that this solution needs rotating penetrations (see 5.2.9.2) or other wall-penetration techniques, increasing the probability of a reduction in the leaktightness of the containment enclosure (except in the case of static motors with magnetic coupling systems).

5.2.9.2 Rotating penetration

The rotating penetration shall allow the leaktight transmission of a movement through an enclosure wall, without loss of containment. This wall penetration uses O-rings systems and oil charged with a magnetic material mounted between the axis of the penetration and the main body (see Figure 19). It comprises a body screwed onto the containment enclosure wall, with movement achieved through a central axis mounted on a bearing system. Low friction and leaktightness are maintained by two magnetic pieces, which keep the charged oil in place.



Key

1 Axis
2 Penetration body
3 Threaded ring
4 Holes for charged oil
5 Magnet pieces (main component)
6 Elastomer slice
7 Enclosure wall
8 O-ring seal
9 Magnet piece (secondary component)
10 Inside of enclosure

Figure 19 — Rotating penetration for electric motors

5.2.10 Detection, alarm and process apparatuses

5.2.10.1 Types

The following different types of apparatus needing an electrical wall penetration are used in containment enclosures.

a) Explosion detectors, consisting of:

1) Fire detectors, which follow three principles of detection:

— thermal increase,

— flame detection,

— ignition detection.

2) Flood detectors, which are of two types:

— electrical sensors,

— pneumatic detection systems.

b) Process apparatuses of various types. Special attention shall be taken in respect of heat- or cold-production apparatuses, due to the risk of interaction with the material of construction of the enclosure (panels, manipulator gaiters, gloves, welded bags, etc.).

5.2.10.2 Constraints of use

All such apparatuses shall comply with the required conditions of use applicable to the interior of the containment enclosure, including nature of atmosphere, corrosion and contamination risks, and temperature (see 4.2). Their location shall facilitate access for maintenance and dismantling.

6 Fluid components

6.1 Design and installation

6.1.1 General

Two main types of fluid are used in the circuits of containment enclosures: basic and process. Basic fluids include untreated industrial water (recycled and non-recycled), demineralized water, compressed air, cooling fluids, inert gases (argon, nitrogen), and decontamination liquids (e.g. acids, bases). The list of process fluids is almost unlimited, taking into account the multiplicity of their uses for both nuclear and other purposes.

Although management of basic fluids is perfectly controlled, that is not the case for process fluids, the use of which, even in relatively small quantities, can be extremely hazardous (corrosion, temperature, various types of incompatibility, etc.).

When selecting the constituent components for specific fluid circuits in containment enclosures, the relevant literature setting out their basic resistance to the main types of physical and chemical attack shall be consulted and taken into account.

The installation of fluid circuits in containment enclosures in a nuclear plant (new plant, modifications or extensions) shall be subject to the safety and operating regulations in force in that plant.

At an appropriate stage, the designers or operators, or both, shall consult the plant safety officer or the appropriate local authorities, to ensure that the components possess the required characteristics.

Figure 20 shows a containment enclosure fully equipped with typical fluid-circuit components.

6.1.2 Uniformity

6.1.2.1 Stress resistance

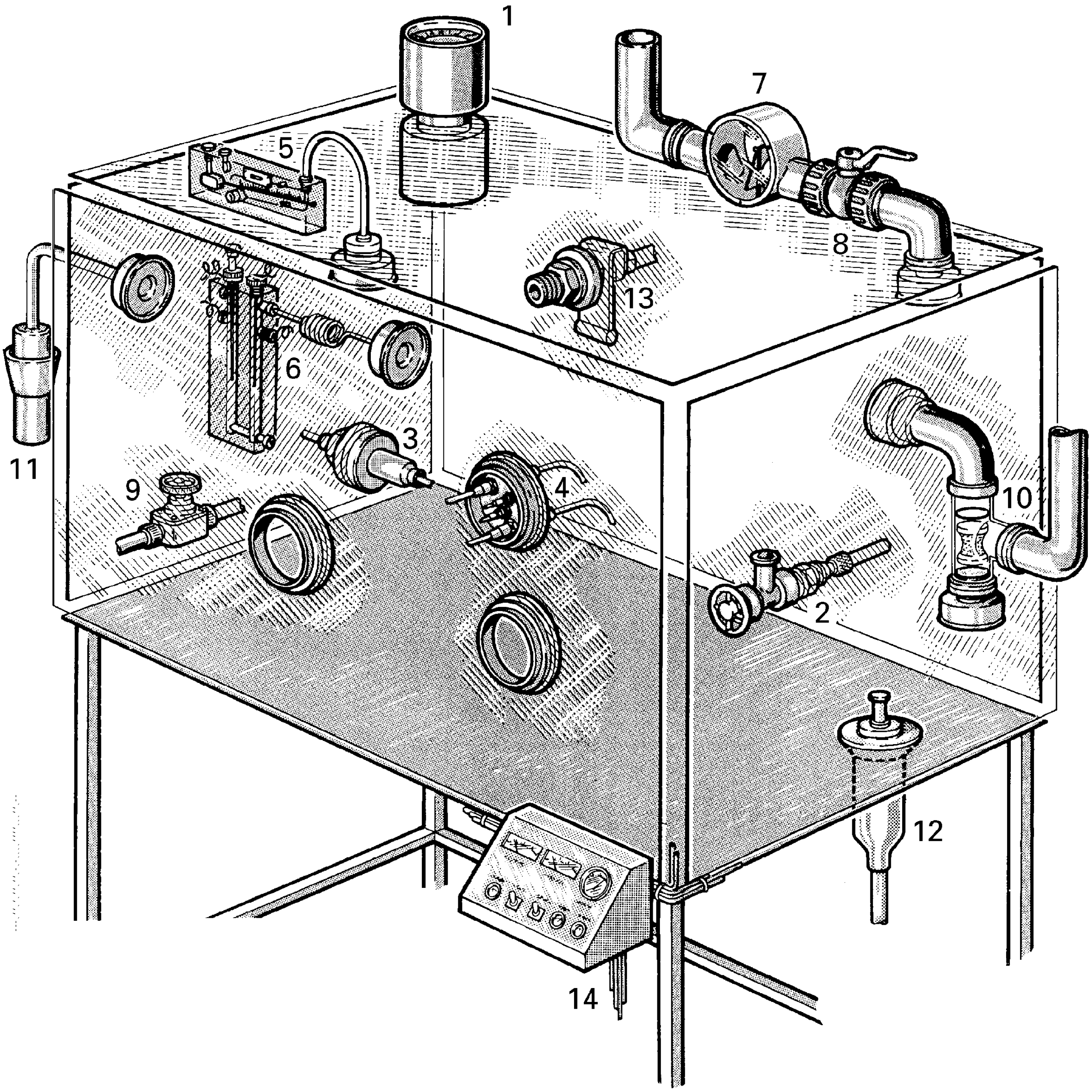
Internal stresses are determined by the characteristics of the fluid being conveyed by the circuit: its chemical aggressiveness, pressure and temperature. All components in permanent or accidental contact with the fluid (including pipelines, fittings, seals, valves and retaining springs) shall be selected on the basis of their ability to satisfactorily withstand the stresses to which they will be subjected.

External stresses shall also be taken into account. Generally, these vary from one end of the circuit to the other, and include corrosive atmosphere inside the enclosure, inert atmosphere outside the enclosure, flexibility, and resistance to friction or impact.

6.1.2.2 Continuity of construction

The circuit shall be constructed using the least possible number of fittings and junctions, since such items invariably decrease leaktightness. Changes of cross-section should also be avoided.

The diameter of a pipe shall be selected in accordance with requirements, and as far as possible, all pipework connections shall be made using parts suitable for that diameter.



1 Inlet filter
2 Wall penetration associated with angle remote handling valve
3 Wall penetration with thermal insulation
4 Ejectable plug for fluid circuits with or without remote connections
5 Pressure gauge with liquid
6 Pressure gauge with liquid and electrical contactors
7 Visual air flow detector
8 Globe valve
9 Membrane valve
10 Control valve for ventilation
11 Hydraulic guard
12 Siphon with remote plug
13 Remote handling fitting equipped with a clamping device
14 Control console

Figure 20 — Containment enclosure fully equipped with fluid-circuit components

6.1.3 Installation

6.1.3.1 Inside the containment enclosure

The layout of the various components in the circuit shall take into account operating requirements, the handling resources inside the enclosure (gloves, tongs, remote-handling devices) and the accessibility of items used for operation or maintenance.

Fluid circuit entry to the enclosure is via a penetration never located at the work station, occasionally located on the ceiling but which usually passing through a wall. There is often a quick-fastening junction at the penetration. In particular, it should be ensured that the circuit connections can be made using the handling facilities available, taking into account accessibility, orientation and the forces involved.

Fixed and rigid pipes should not be used unless it is certain these will never need to be removed while the plant is in operation. For ease of removal, flexible pipes should be placed in gutters or on brackets, and never introduced into tubes with the same function.

6.1.3.2 Outside the containment enclosure

Each circuit shall be equipped with an easily-accessible isolation valve, located upstream of a control device where applicable. The location of the valve shall allow intervention in a single containment enclosure only, without the need to cut off the supply to an entire laboratory.

For shielded containment enclosures, the pipes shall penetrate the shielding using an arrangement that prevents any radiation leakage (baffle) or localizes it in an area inaccessible to personnel (roof). The pipes shall then run between the shielding and the enclosure to the enclosure penetration point. The “irradiation loading” to which the pipes will be subjected and their inaccessibility shall be taken into account (no connections or seals on this section). The use of metallic pipes is strongly recommended.

Accessibility of wall penetrations in the enclosure is achieved on the shielding by lead plugs mounted on hinges or special doors.

The leaktight enclosure may also be fitted with external rigid welded pipes and the removable fitting moved inside an accessible area.

6.2 Special requirements and recommendations

6.2.1 Separation of functions inside the enclosure

It is recommended that circuits be separated according to their function, both inside the containment enclosure and at wall penetrations, as follows:

- circuits for aggressive fluids (effluent, reagents, etc.),
- circuits for water,
- circuits for gas, etc.

In particular, effluent circuits shall be distinguished from tributary circuits.

6.2.2 Pipework junctions inside and outside enclosures

When selecting the type of junction, the following shall be taken into account:

- type of pipe (flexible or rigid),
- operating pressure,

— type of fluid (inert, corrosive, etc.),

— atmosphere in the containment enclosure, and

— ease of intervention.

For low-pressure pipes, either clamps on the relevant grooves, or double-cone fittings should be used.

For medium-pressure pipes, three-part metallic fittings suitable for the operating pressure should be used.

6.2.3 Sealing rings

6.2.3.1 General selection criteria

Two types of leaktightness shall first be distinguished:

— static leaktightness;

— kinetic leaktightness (translation or rotation).

When selecting seals, the following shall be taken into account:

— nature of the medium (viscosity, corrosion, temperature, pressure);

— area covered by the seal (surface condition, tolerance);

— ageing (irradiation, etc.);

— rotation velocity (if relevant);

— quality (hardness, etc.).

The constituent material of seals shall also be taken into consideration:

— metallic,

— plastic,

— metallic–plastic.

6.2.3.2 Shape

The shape shall be taken into account:

— braid,

— flat seal,

— O-ring seals,

— seals with lips.

6.2.3.3 Storage

Plastic seals shall be stored protected from heat and light.

NOTE Refer to manufacturer’s documents for details of the constituent materials of seals.

6.2.4 Precautions for effluent circuit pipes

In general, fixed pipes for conveying liquid effluent should be designed to limit the retention of suspended particles and allow rinsing or even rodding in the event of internal deposits or blockages.

For this purpose, the following precautions should be adopted in respect of pipes:

— good internal surface;

— adequate fall and large diameter;

— wide radius elbows (~5 diameters).

Junctions should be welded and fittings selected to reduce the number of obstacles to the flow of fluids, and located wherever possible on vertical sections of pipe.

The constituent materials shall be selected depending on the aggressiveness of the solution.

If effluent is to be removed from the containment enclosure, pressure shall be avoided for obvious safety reasons. To this end, pressure-reducing equipment (e.g. vacuum pump) or equipment that uses gravity should be used. This will restrict the spread of fluids in the event of a breach in leaktightness. For connecting flexible pipes, self-plugging fittings shall be used.

Foolproof systems and, if applicable, non-return valves should be located on fittings and waste pipes.

For transfer of fluids with heavy particle loads, easily-accessible decanting chambers should be located at the start of the pipeline. Links between the rinsing circuits and the circuits to be rinsed shall be equipped with suitable air outlets.

Finally, depending on the transfer activities, the pipework shall be shielded and equipped with recovery chambers at points where leaks could occur, or at junctions.

For highly or very highly active liquids, a double or triple enclosure with suitable monitoring resources shall be used.

All connections to the general effluent circuit shall be equipped with hydraulic guards.

6.2.5 Fastening of pipes inside enclosures

Pipes shall be fastened using clamps (see Figure 21) with fixed feet on rails or flat rails (stainless steel, steel) previously installed on the side walls of the enclosure. This system has the advantage of simplicity, but has the disadvantage of trapping contamination, thus the number of clamp fastening points and internal pipe runs shall be kept to a minimum.

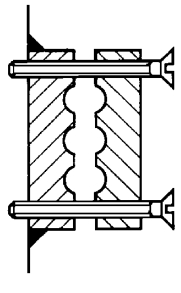


Figure 21 — Clamps for fitting pipes on fixed support

6.2.6 Grouping of fluid pipes on ejectable plugs

Fluid pipes on the containment enclosures walls can be grouped together on ejectable plugs (see Figure 22), thus making possible the rapid modification or replacement of fluid supply circuits.

It is an important requirement that an arrangement compatible with the plug-assembly ejection device be used.

This device is suitable for a group of electrical cables or a mixed group of fluid pipes and electrical cables.

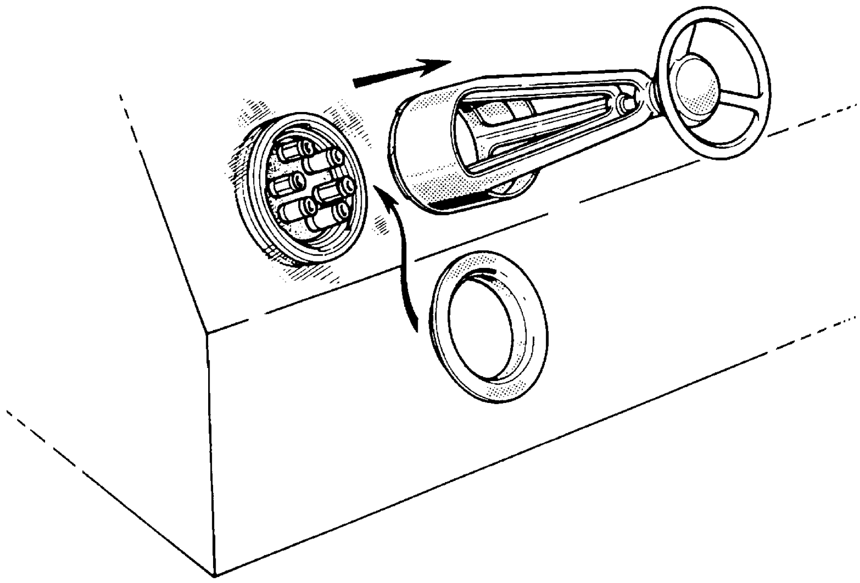


Figure 22 — Example of fluid penetration using an ejectable rigid plug

6.3 Specific component requirements and recommendations

6.3.1 Pipe fittings

6.3.1.1 Types

Pipe fittings are intended to join pipes, permanently or temporarily. There are two main types:

a) Fittings for rigid pipes, including:

- butt joint fittings for pipes,
- fittings for joints between pipes and appliances.

These joints may be made with or without preparation of the pipe (flared-flange principle, welding, soldering or applying pressure to a seal or double cone outside the pipe).

b) Fittings for flexible pipes, including:

- external joints,
- internal joints,
- joints achieved by tightening a nut on the end of the pipe.

These joints require the use of fittings such as clamps, rings, sleeves, etc.

6.3.1.2 Selection

At the design stage, the stresses arising from the fluid to be conveyed shall be reviewed in logical fashion in order to be able to select the type of pipe to be used, depending on the geometry of the system, and suitable fittings for the pipework. The quality, ease of use and durability of the system are dependent on selecting the most appropriate "fluid–pipework–pipe fittings" combination.

Thus selection of a connection depends on the reconciliation a number of criteria linked to these requirements.

6.3.1.3 Installation

For installation of pipe fittings inside the containment enclosure, the following shall be taken into account:

— the nature of the fluid conveyed (pressure, temperature, corrosion, etc.) and the nature of the medium (temperature, corrosion, etc.);

— the ease of intervention (access, method of tightening, frequency of use, etc.) and of assembly (grouped on a single panel, etc.);

— safety regulations (fittings installed in the most aggressive fluids located in the lower area with foolproof devices to prevent connecting up incompatible fluid lines, etc.), and the supplier's recommendations.

6.3.2 Wall penetrations

6.3.2.1 General

Wall penetrations allow fluids to pass through a wall of the containment enclosure. They can also be installed on vacuum pipelines. Penetrations that can be disassembled generally comprise four parts, the leaktightness of which is ensured by the use of one or more O-ring seals. Welded penetrations are welded through the wall.

6.3.2.2 Types

There are four types of wall penetration.

a) Feed-through pipe, including:

   1) single or double-stuffing box type;

   2) screw type;

   3) screw-bolt type tightened against an O-ring seal:

      — with double stuffing box,

      — with stuffing box and double enclosure,

      — able to be isolated,

      — of special design.

b) Discontinuous pipe with screw-bolt tightened against an O-ring seal:

   1) threaded for all connections or with double enclosure;

   2) with threaded end fittings;

   3) welded on bonded pipe;

   4) with tightening of flexible pipe.

c) Penetrations bonded or welded to the wall.

d) Penetrations grouped on an ejectable plug.

6.3.2.3 Selection criteria

The choice of the type of penetration shall depend on:

a) the characteristics of the fluid (nature, temperature, pressure, flow rate, etc.);

b) the type of pipe to be connected (flexible or rigid);

c) the required degree of leaktightness at the wall;

d) the method of fastening to the wall, which depends on the type of wall and the anticipated disassembly frequency:

   — bonding,

   — welding,

   — screwing;

e) the type of coupling to the pipework:

   — bonded couplings,

   — welded couplings,

   — click-on couplings (ball, O-ring, push-button), which are manually or remotely operated,

   — screw couplings, manually operated (or defined as manual plug-in couplings),

   — bayonet-locking couplings, manually operated (or defined as manual plug-in couplings).

6.3.2.4 Installation

On both enclosure walls and ejectable plugs:

— penetrations equipped with O-ring seals should be used;

— the wall opening shall be of the smallest diameter possible to allow correct positioning of the seal;

— the surface condition of the area covered by the seal should be checked;

— the recommended tightening torque shall be complied with.

If the penetrations are not located on ejectable plugs, they shall be accessible using the handling equipment available inside the enclosure.

6.3.2.5 Location

The location of penetrations shall take into account the requirement of accessibility from both inside and outside the enclosure. There shall be no risk of siphoning (backflow of hazardous or contaminated liquid).

6.3.2.6 Examples of typical fluid-circuit wall penetrations

6.3.2.6.1 Non-continuous, threaded wall penetration with internal threaded end fittings for double plug-in couplings

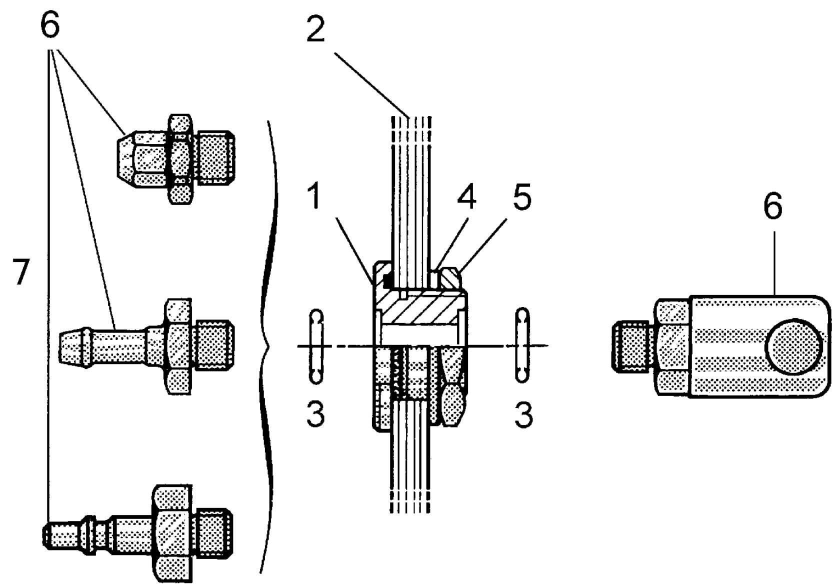
This leaktight wall penetration, with internal threaded end fittings for double plug-in couplings, usually made of metal, is suitable for containment enclosures of all classes of leaktightness, all kinds of liquids or gaseous fluids and all kinds of threaded plug-in couplings. It comprises:

- a body of metallic (brass, stainless steel or other), or plastic (PVC, PE or PTFE), material, with threaded internal end fittings;
- leaktight elastomer O-ring seals and plastic slice;
- a threaded ring in the same material as the body.

Leaktightness is achieved:

- on the enclosure wall, using an O-ring seal and a slice;
- on the couplings, using two O-ring seals.

The following different configurations are available.

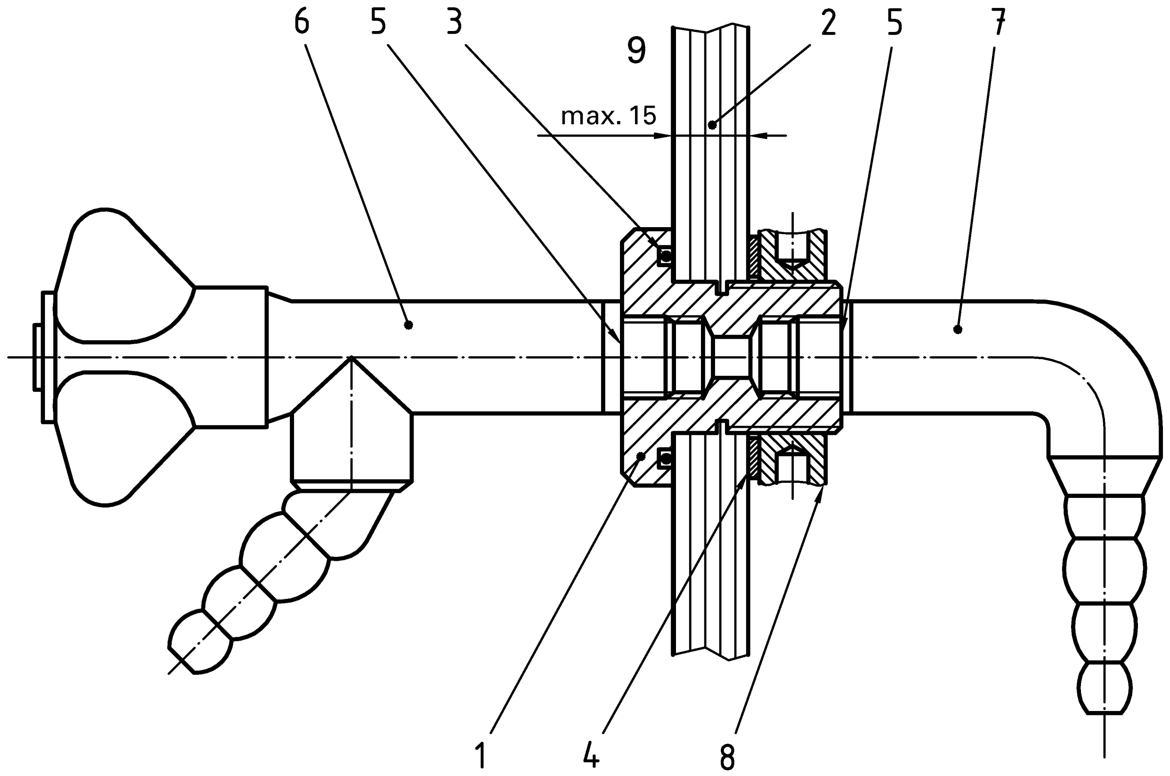


Key

1 Body
2 Enclosure wall
3 Elastomer O-ring seals
4 Plastic slice
5 Threaded ring
6 Threaded couplings
7 Inside of enclosure

Figure 23 — Threaded wall penetration — Model A

Dimensions in millimetres



Key

1 Body
2 Enclosure wall
3 Elastomer O-ring seal
4 Plastic slice
5 Threaded couplings
6 Threaded end fitting with a command valve
7 Threaded end fitting (angle piece)
8 Threaded ring
9 Inside of enclosure

Figure 24 — Threaded wall penetration — Model B

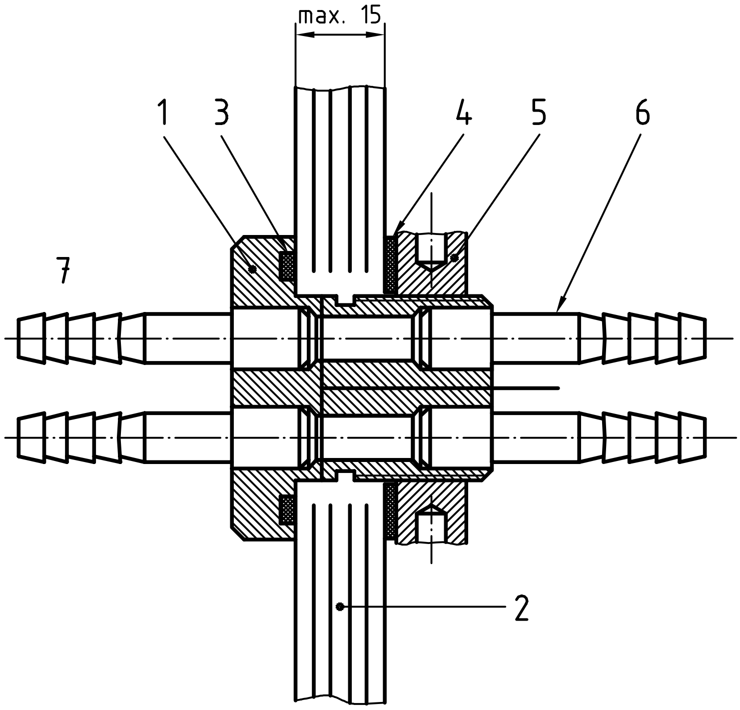
a) Standard models (models A and B, see Figures 23 and 24).

b) Grouped pipe systems on the same wall penetration. In this configuration, several end-fitting pipes are threaded on the same wall-penetration assembly (models C and D, see Figures 25 and 26). The principle of the fittings is the same as that of a).

c) Threaded penetration models, for double enclosure pipes. In this configuration, mounting of the double casing system is achieved by using additional threaded rings (model E, see Figure 27). It is suitable for the transfer of special gaseous fluids (e.g. hydrogen, fluorine, nitrogen oxide).

d) Special shaped devices, such as those of models F and G (see Figures 28 and 29).

Dimension in millimetres

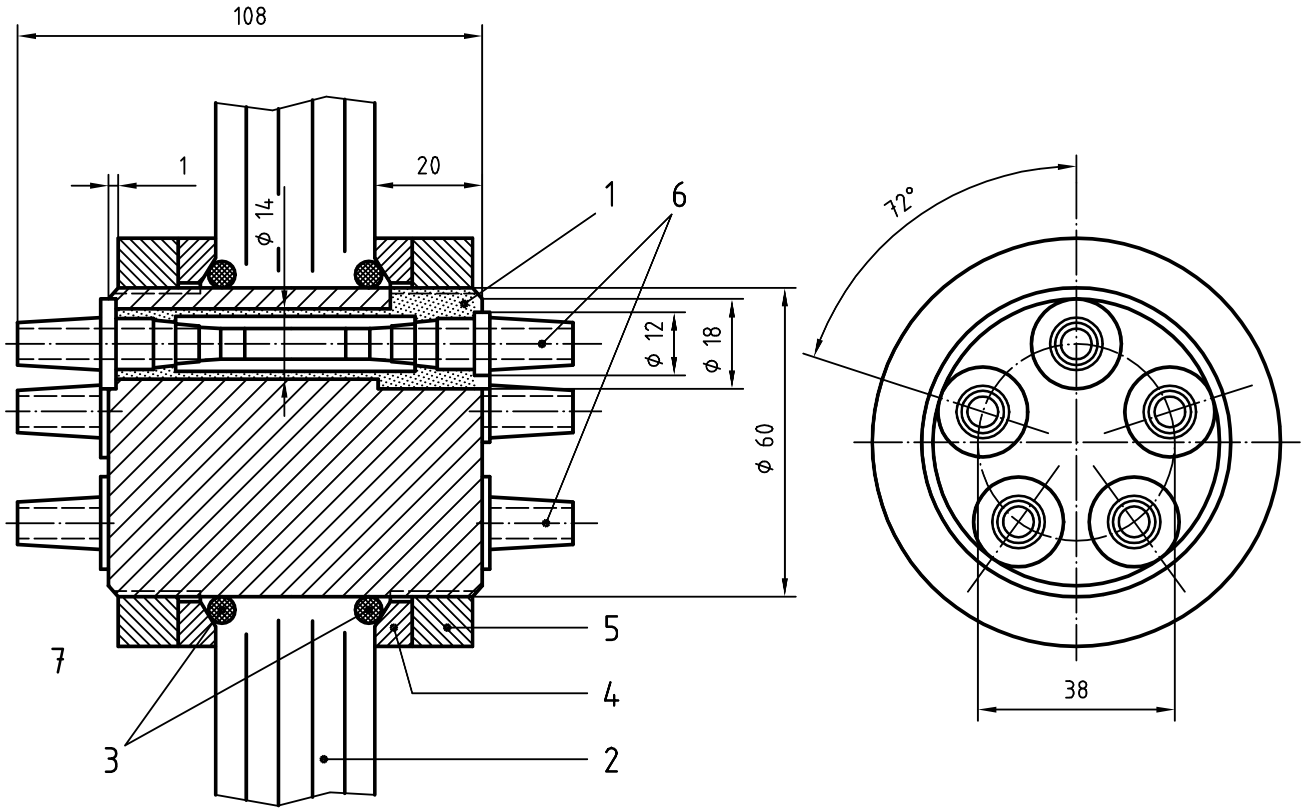


Key

1 Body
2 Enclosure wall
3 O-ring seal
4 Plastic slice
5 Threaded ring
6 Threaded end fitting
7 Inside of enclosure

Figure 25 — Threaded wall penetration — Model C

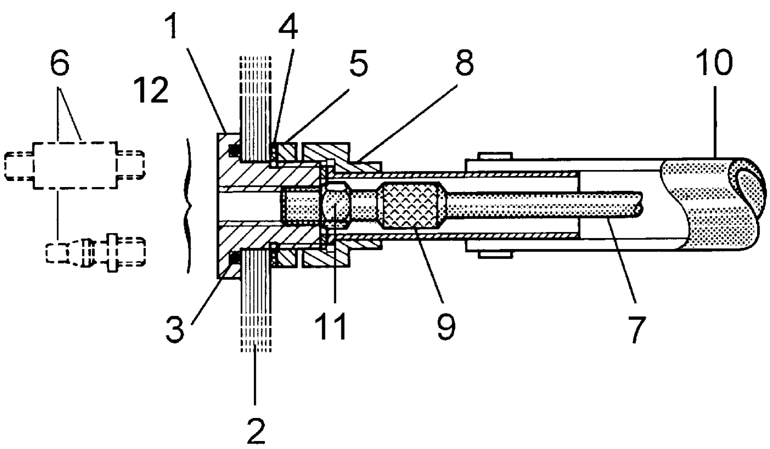
Dimensions in millimetres



Key

1 Body
2 Enclosure wall
3 O-ring seals
4 Plastic slice
5 Threaded ring
6 Threaded end fittings
7 Inside of enclosure

Figure 26 — Threaded wall penetration — Model D

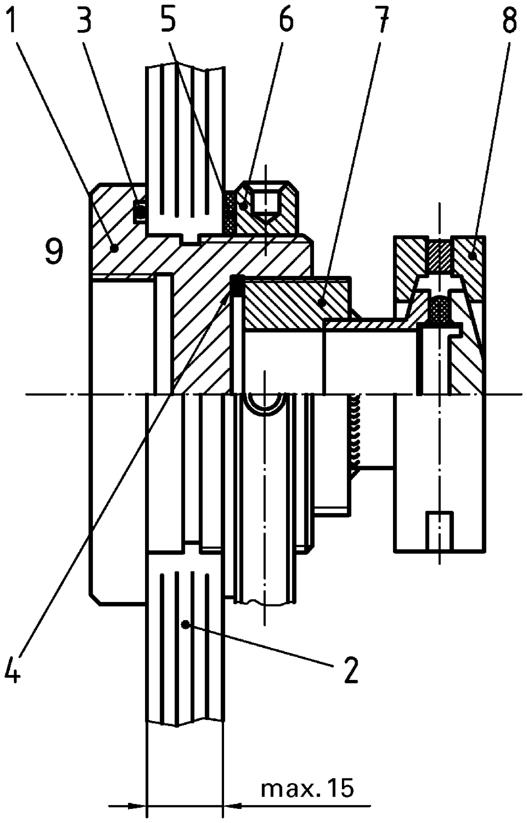


Key

1 Body
2 Enclosure wall
3 O-ring seal
4 Plastic slice
5 Threaded ring
6 Threaded end fittings
7 Main pipe
8 Double casing coupling
9 Pipe coupling
10 Double casing
11 Internal enclosure coupling
12 Inside of enclosure

Figure 27 — Threaded wall penetration — Model E

Dimensions in millimetres

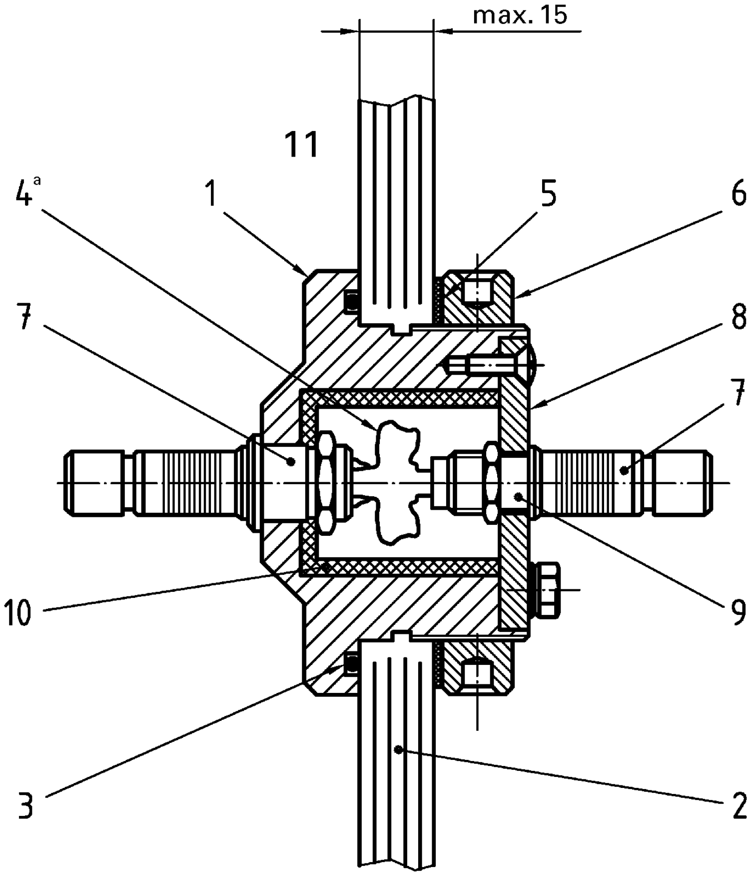


Key

1 Body
2 Enclosure wall
3 O-ring seal
4 O-ring seal
5 Plastic slice
6 Threaded ring
7 Threaded end fitting
8 Angle outlet pipe
9 Inside of enclosure

Figure 28 — Threaded wall penetration — Model F

Dimensions in millimetres



Key

1 Body
2 Enclosure wall
3 O-ring seal
4 Welded bag
5 Plastic slice
6 Threaded ring
7 Threaded end fittings
8 Cover
9 Housing penetration
10 Housing
11 Inside of enclosure

[a] The welded bag is to protect the internal couplings against dust and other environmental conditions.

Figure 29 — Threaded wall penetration — Model G

6.3.2.6.2 Non-continuous threaded wall penetration with external threaded end fittings for double plug-in coupling

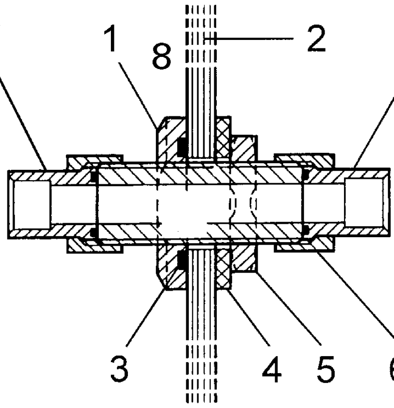
This leaktight wall penetration, with external threaded end fittings for double plug-in couplings, usually made of metal, is suitable for containment enclosures of all classes of leaktightness, all kinds of liquids or gaseous fluids, and all kinds of threaded end fittings and mechanical mounting pipes. It comprises:

— a body, realized in metallic (brass, stainless steel or other) or plastic (PVC, PE or PTFE) material and equipped with external threaded end fittings;

— a leaktight O-ring elastomer seal, and a plastic slice;

— a threaded ring of the same material as the body;

— on option, two threaded couplings, available in the same material as the body (model H, see Figure 30).

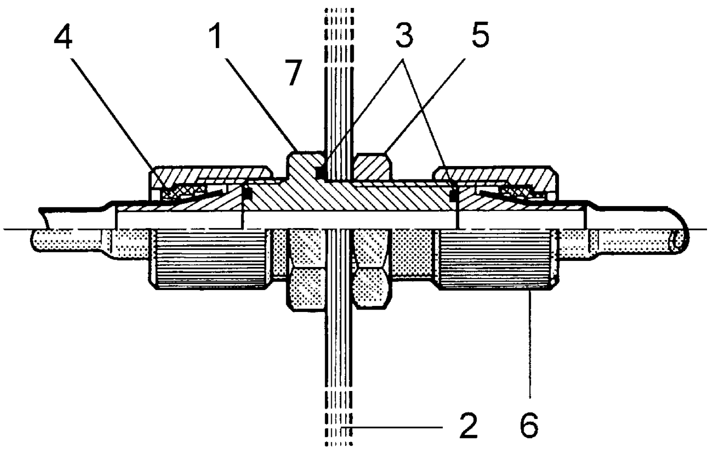


Key

1 Body
2 Enclosure wall
3 O-ring seal
4 Plastic slice
5 Threaded ring
6 Threaded end fitting pipe
7 Couplings
8 Inside of enclosure

Figure 30 — Threaded wall penetration — Model H

In the configuration of model H, fitting between the wall penetration and the removable couplings is achieved by threading an additional ring and O-ring sealing system. The connection on the pipes is realized, on both sides, by welding or brazing in the case of a metallic assembly, or by mechanical fitting or gluing in the case of a plastic assembly (model I, see Figure 31).



Key

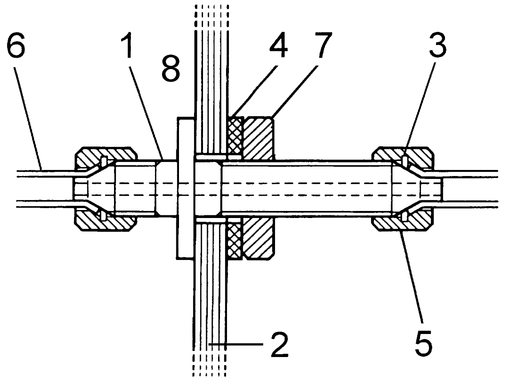
1 Body
2 Enclosure wall
3 O-ring seals
4 Furnishing
5 Threaded ring
6 Assembly screw
7 Inside of enclosure

Figure 31 — Threaded wall penetration — Model I

Leaktightness is achieved on the enclosure wall using an O-ring seal and a slice, and on the couplings using two O-ring seals and auxiliary threaded rings.

The following configurations are available.

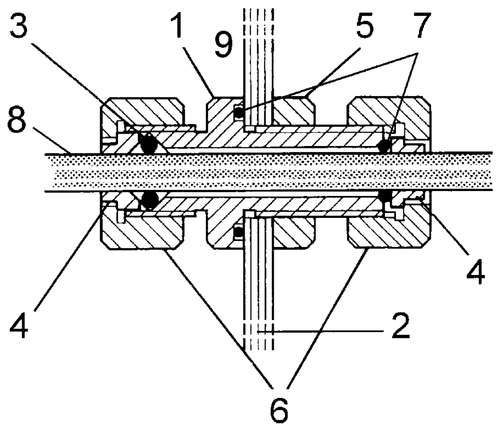
a) For connection on standard plastic threaded end couplings, conically shaped (models J and K, see Figures 32 and 33).



Key

1 Body
2 Enclosure wall
3 O-ring seal
4 Plastic slice
5 Assembly screw
6 Coupling
7 Threaded ring
8 Inside of enclosure

Figure 32 — Threaded wall penetration — Model J



Key

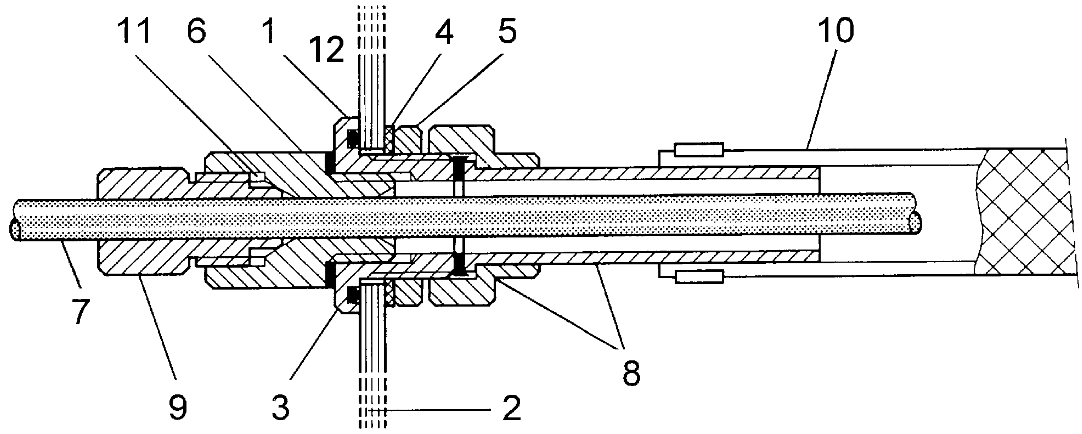
1 Body
2 Enclosure wall
3 O-ring seal
4 Plastic slice
5 Threaded ring
6 Assembly screws
7 O-ring seals
8 Main pipe
9 Inside of enclosure

Figure 33 — Threaded wall penetration — Model K

b) For connection on standard metallic threaded-end couplings, cylindrically shaped (see Figure 30).

c) For continuous pipe, with double-stuffing box base. In this configuration, the mounting principle is the same as that of b). Additional double stuffing is used in order to achieve the leaktightness between the wall penetration and the continuous pipe (see Figure 34, internal containment enclosure side).

d) For continuous pipe, with double enclosure system. In this configuration, the same basic wall penetration is used in order to allow passage of a continuous metallic or plastic pipe through the containment enclosure wall (see Figure 34, external containment enclosure side). This equipment is suitable for low activity effluent circuits or for the transfer of hydrofluoric acid.



Key

1	Body	4	Plastic slice	7	Main pipe	10	Double casing
2	Enclosure wall	5	Threaded ring	8	Double casing couplings	11	Double staffing box device
3	O-ring seal	6	Threaded end fitting	9	Pipe coupling	12	Inside of enclosure

Figure 34 — Threaded wall penetration for double plug-in coupling (double enclosure system)

6.3.2.6.3 Special removable penetrations for shielded or unshielded enclosures

The principle of these penetrations is the same as that of the electrical penetrations described in 5.2.7.5.3, the only difference being that fluid, and not electrical, connectors are used.

6.3.2.6.4 Special remote-handling fitting device

This pipe fitting exists in two versions, a remote handling device for fitting on wall penetrations, whose mobile piece consists of a remote handling clip that is an integral part of the wall penetration (see Figure 35), and a remote handling device for fitting on pipes using a translation of the mobile clip (see Figure 36).

The device allows quick remote connection of two pipe parts or of a pipe on a wall penetration. It is suitable for the transfer of all type of corrosive fluids, under low pressure.

6.3.3 Valves

6.3.3.1 General

Valves used in the fluid circuits of containment enclosures allow the flow of a fluid in a pipe to be established or cut off, or the rate of flow to be controlled. The fluid can be a liquid or gas, including a vacuum. Valves can be operated manually (directly or using remote-handling equipment) or by remote-control (electrical, pneumatic or hydraulic). They are classified in families depending on the direction of movement of the shut-off device in relation to the direction of flow of liquid at the valve seats. There are a variety of types available, described in 6.3.3.2.

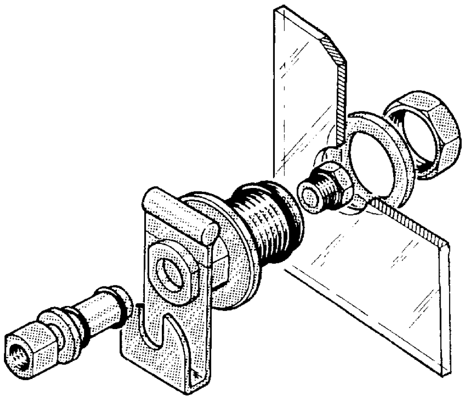
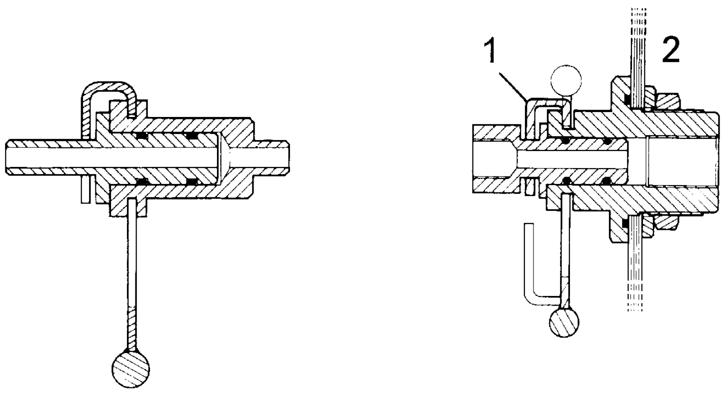


Figure 35 — Remote handling fitting device, for connection on enclosure wall penetration



Key

1 Mobile clip

2 Outside of enclosure

Figure 36 — Remote handling fitting device, for connection on pipes

6.3.3.2 Types

6.3.3.2.1 Ball or needle valve

In this type of valve (see Figure 37), the shut-off device (globe, ball membrane, flap, piston, needle, etc.) is positioned against the valve seating through a movement that is parallel to the axis along which the fluid is moving at the valve seating.

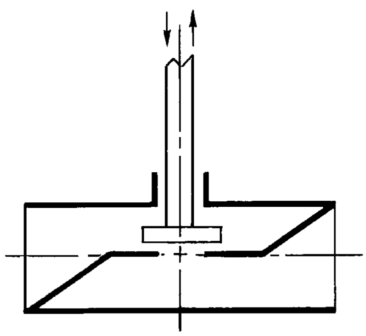


Figure 37 — Ball or needle valve

6.3.3.2.2 Gate valve

In this type of valve (see Figure 38), the shut-off device (cap or gate, single or double piston, plate etc.) slides between two valve seatings through movement in a perpendicular direction to the axis along which the fluid is moving at the valve seatings. The term "gate valve" may also be used for direct-flow valves of the same family.

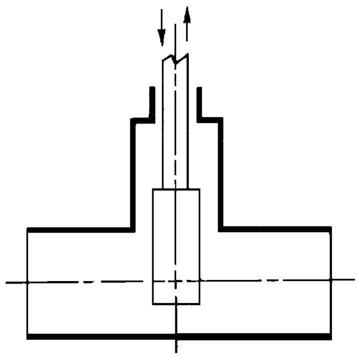


Figure 38 — Gate valve

6.3.3.2.3 Taper plug valve

In this type of valve (see Figure 39), the shut-off device, a cylindrical, spherical or conical plug cock, turns round an axis of revolution orthogonal to the axis along which the fluid flows.

Leaktightness at the closing is achieved by grinding or seals.

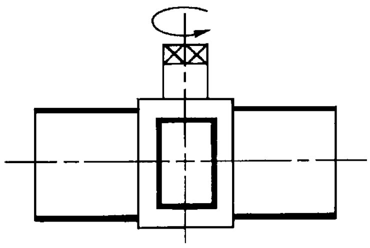


Figure 39 — Plug valve

6.3.3.2.4 Butterfly valve

In this configuration (see Figure 40), the arrangement is the same as that of the Taper plug valve (6.3.3.2.3), except that the shut-off device is a disk and not a solid rotating body. This valve is intended to control, rather than shut off completely, the flow of fluid.

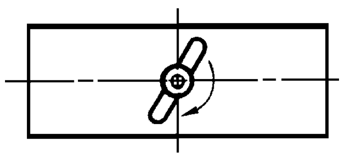


Figure 40 — Butterfly valve

6.3.3.2.5 Non-return valve

There are two types of non-return valve (see Figure 41):

a) non-return valves with guided flaps, whose shut-off device (flap or ball) moves in linear fashion along the direction of flow of the fluid at the seating, located parallel or perpendicular to the pipe;

b) swing-type check valves or tilt check valves, whose shut-off device, a shutter or swing-door, moves by rotating around an axis orthogonal to the axis along which the fluid flows.

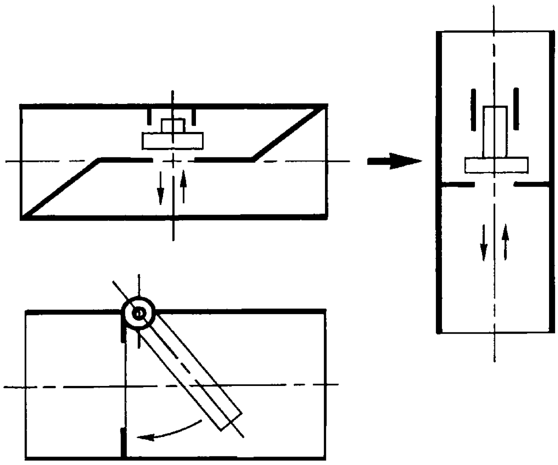


Figure 41 — Non-return valve

6.3.3.3 Selection criteria

The type of valve shall be selected depending on:

— the type of use (interruption or control of flow),

— the degree of leaktightness.

The constituent material used shall depend on:

— the nature and characteristics of the fluid to be conveyed,

— the environmental atmosphere,

— the type of pipe on which the valve is to be used.

6.3.3.4 Installation

Valves may be connected to pipes by:

— bonding,

— screwing,

— welding,

— flange fitting.

6.3.3.5 Location

Valves shall be located outside the enclosure, except in the case of a contaminated or hazardous circuit, or when otherwise unavoidable.

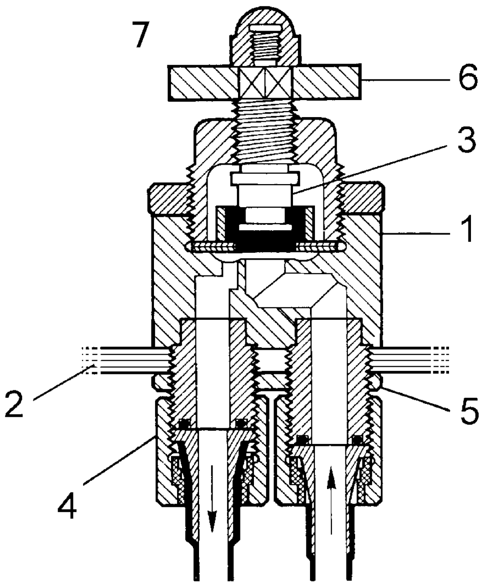
If valves are located inside the enclosure, they shall be accessible.

6.3.3.6 Examples of typical valves

6.3.3.6.1 Enclosure wall fitting valve

This threaded fitting valve for mounting on containment enclosure walls is suitable for all kinds of aggressive liquid, effluent, gaseous and process fluid. It comprises a body containing the inlet and outlet openings, and a cover equipped with the shut-off device (generally a piston). The valve is fitted onto the pipes using threaded rings and additional double-stuffing box systems. The body is screwed onto the containment enclosure wall, using a threaded ring. Both openings can be located inside the enclosure (see Figure 42), or one opening can be located inside and the other outside (models A, B and C, see Figures 43, 44 and 45).

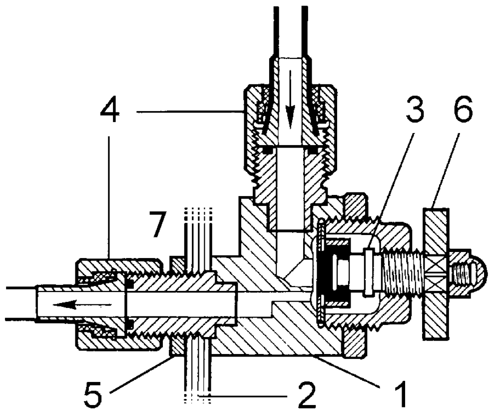
The valve or shut-off device is made of plastic (PVC or other) or metal (stainless steel) material.



Key

1 Body
2 Enclosure wall
3 Piston
4 Assembly screw with furnishing
5 Threaded ring
6 Command of valve
7 Outside of enclosure

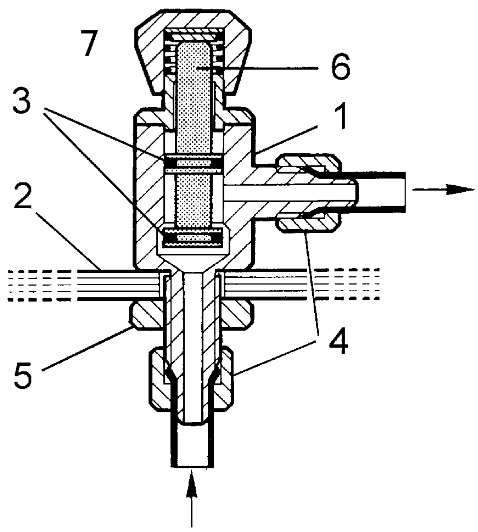
Figure 42 — Valve (with internal openings) for containment enclosure wall



Key

1 Body
2 Enclosure wall
3 Piston
4 Assembly screws with furnishing
5 Threaded ring
6 Command of valve
7 Inside of enclosure

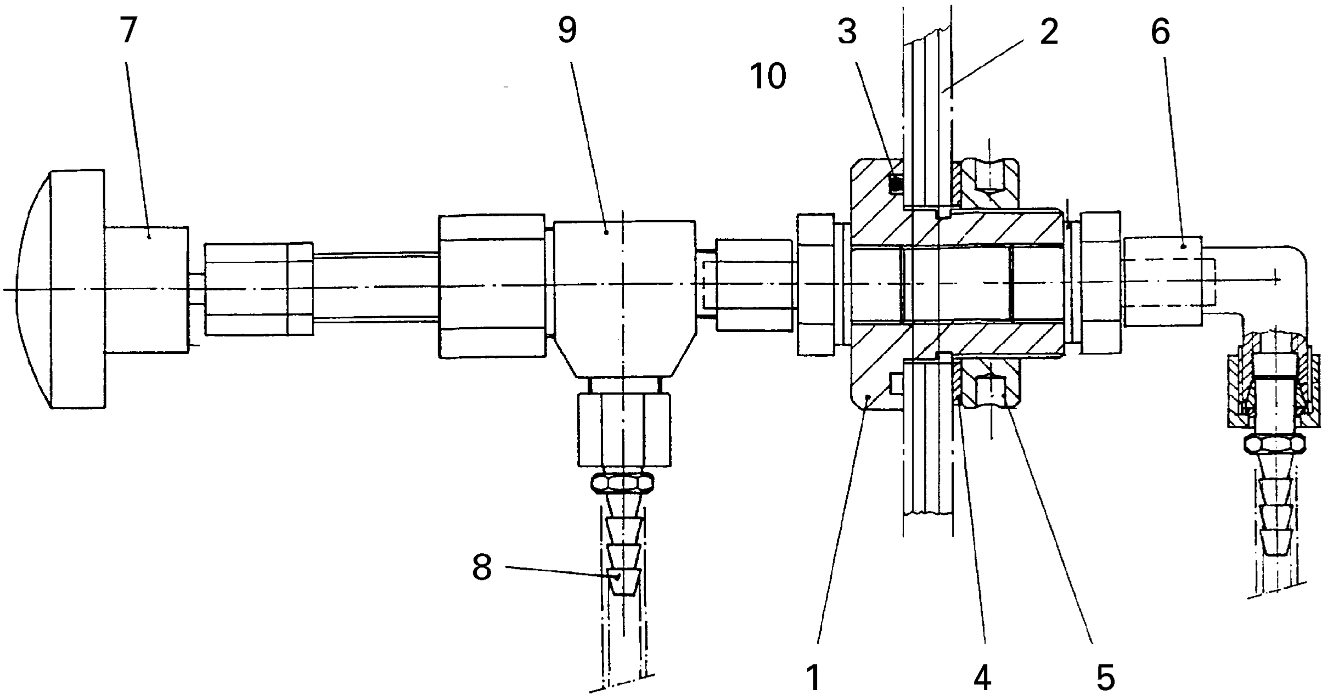
Figure 43 — Valve (with internal and external openings) for containment enclosure wall — Model A



Key

1 Body
2 Enclosure wall
3 Pistons
4 Assembly screws with furnishing
5 Threaded ring
6 Command of valve
7 Outside of enclosure

Figure 44 — Valve (with internal and external openings) for containment enclosure wall — Model B



Key

1 Body
2 Enclosure wall
3 O-ring seal
4 Plastic slice
5 Threaded ring
6 Angle end fitting
7 Command of valve
8 Coupling
9 Threaded end fitting
10 Inside of enclosure

Figure 45 — Valve (with internal and external openings) for containment enclosure wall — Model C

6.3.4 Measuring and inspection appliances

6.3.4.1 General

Measuring and inspection appliances can be fixed or mobile, depending on whether they are used intermittently or continuously.

This type of appliance should be installed outside the enclosure; only sensors and transmitters shall be located inside the enclosure. Connections between sensors and measuring instruments are by wall penetrations.

Care shall be taken to protect the electrical connections for this type of appliance, in particular, terminals. Furthermore, each sensor shall be suitable for the particular atmospheric conditions. The sensors concerned cover:

— temperature,

— pressure,

— flow rate,

— fire,

— contamination,

— flood,

— PH, etc.

They are not described in this part of ISO 11933.

6.3.4.2 Location of detectors and alarms

The following specific constraints shall be taken into account when locating detector and alarm systems:

- effects of corrosion and mechanical vibrations;
- effect of any ionizing radiation;
- nature of the handling operations performed inside or outside the enclosure;
- risk of condensation of dust deposits;
- effect of temperature and of ventilation requirements.

In particular, special attention shall be given to the possibilities of disassembling, maintaining and regularly inspecting vital equipment such as sensors, connections and alarm-transmission devices.

Although the sensitive area of the detector (sensor and transmitter) is generally located inside the enclosure, the visual or audible alarm (hooter or flashing light), or both, shall be located outside the enclosure, where it can be seen, and on the front panel or top of the enclosure.

Where necessary, alarms shall be repeated in a room where staff are permanently present and capable of taking immediate action.

Special attention shall be paid to fire extinguishers or flow sensors located on the enclosure ventilation ducts. These are subject to deterioration caused by sudden changes in the ventilation system (as specified). The detectors may be temporarily disabled while major work is carried out.

6.3.5 Functional equipment

Functional equipment is used in priority to achieve the process. This equipment includes cooling systems, heat exchangers, pumps, remote handling devices, control and regulation devices such as those described in clause 5. Due to its great diversity of use, it is not possible to describe all the equipment in this part of ISO 11933.

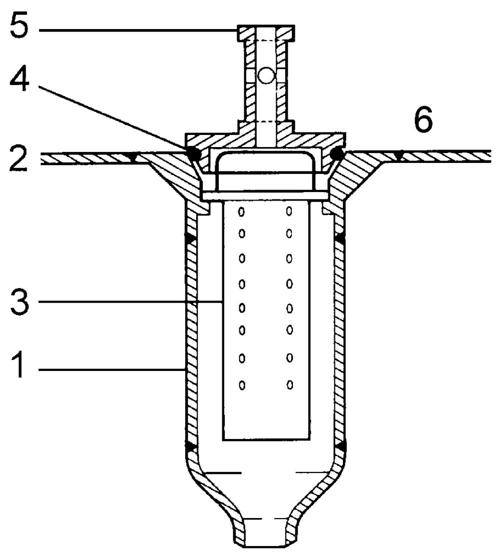
6.3.6 Safety equipment

6.3.6.1 General

The safety equipment covered by this part of ISO 11933 is generally concerned with maintaining the static containment of the enclosure.

Minimization of the risks of overpressure or underpressure is realized by using equipment such as safety guards, security valves and pressure regulators (see ISO 11933-4). Equipment used for the transfer of effluents through a containment enclosure wall is of the same category.

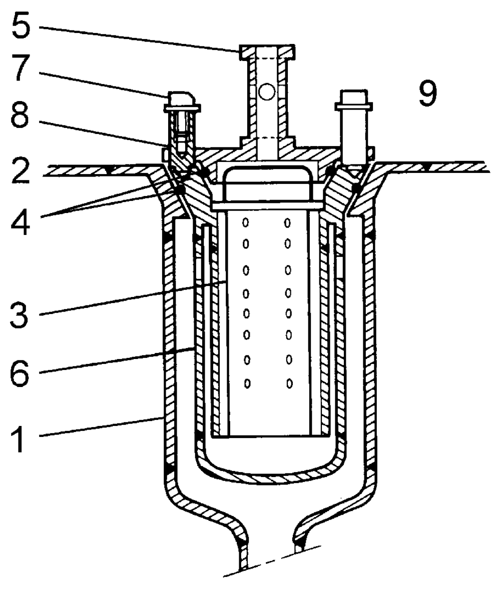
A typical safety device, suitable for shielded containment enclosures is the floor drain with remote handling basket. The floor drain is in two (see Figure 46) or three pieces (see Figure 47): a fixed part, or housing, welded on the bottom of the enclosure, a remotely handled exchangeable basket and, in the double system shown in Figure 47, a pierced body. The device allows contaminated liquid to be retained inside the containment enclosure. When the quantity of liquid is higher than a certain level, the loaded liquid will be released through the evacuation hole and filtered through the basket, pierced body or both, and collected at the outlet pipe. The basket is remotely handled so that it can be washed when needed, inside the containment enclosure.



Key

1 Housing
2 Enclosure wall
3 Basket
4 O-ring seal
5 Evacuation
6 Inside of enclosure

Figure 46 — Remote-handling floor drain (simple system)



Key

1 Housing
2 Enclosure wall
3 Basket
4 O-ring seals
5 Evacuation
6 Pierced body
7 Special screw
8 Pin
9 Inside of enclosure

Figure 47 — Remote handling floor drain (double system)

Bibliography

[1] ISO 7212, *Enclosures for protection against ionizing radiation — Lead shielding units for 50 mm and 100 mm thick walls*.

[2] ISO 9404, *Enclosures for protection against ionizing radiation — Lead shielding units for 150 mm, 200 mm and 250 mm thickness enclosures — Part 1: Chevron units of 150 mm and 200 mm thickness*.

ICS 13.280

Price based on 52 pages