INTERNATIONAL STANDARD

ISO 10648-1

First edition
1997-05-15

Containment enclosures —

Part 1:
Design principles

Enceintes de confinement —

Partie 1: Principes de conception

Reference number
ISO 10648-1:1997(E)

Contents

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X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland/Imprimé en Suisse

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.

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.

International Standard ISO 10648-1 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

ISO 10648 consists of the following parts, under the general title *Containment enclosures*:

— *Part 1: Design principles*

— *Part 2: Classification according to leak tightness and associated checking methods*

Annexes A, B and C of this part of ISO 10648 are for information only.

Introduction

This part of ISO 10648 provides guidance and recommendations for the design, mounting and assembly of containment enclosures. It gives general requirements on the materials to be used, the construction of the different types of containment enclosure: plastic enclosures, metal profile enclosures or hot-worked metal enclosures which can be used either alone or placed behind a shielding wall and, finally, standard dimensions for these different categories of containment enclosure.

Other requirements and important design and safety features, such as operating conditions, internal atmosphere, ventilation, illumination, electrical grounding and shock prevention, ergonomic considerations, etc., will be addressed in other International Standards. The risk of fire, explosion, or violent chemical reaction should also be considered when applying the design principles of this part of ISO 10648.

It is not intended to describe here a systematic procedure for risk assessment in order to select adequate and consistent construction measures. The risk assessment should consider the following different stages, including design, manufacture, construction, assembly, operation, maintenance, decommissioning of containment enclosures and waste management or disposal, as appropriate. This task should be undertaken by every designer, with respect to the exact intended use of the containment enclosure and in order to comply, if required, with relevant safety standards or regulations.

Containment enclosures —

Part 1:
Design principles

1 Scope

This part of ISO 10648 applies to enclosures or enclosure lines intended to be used for work on:

— radioactive and/or toxic products where containment is required for protection of personnel and environment,

— sensitive products requiring a special atmosphere and/or a sterile medium.

This part of ISO 10648 deals with three types of containment enclosure:

— glove boxes,

— tong boxes, and

— containment enclosures with larger dimensions, used with remote manipulators mounted behind independent shielding.

Some dimensions of the last two types will be given in a subsequent International Standard dealing with the mounting of tongs and manipulators.

The following enclosures have been deliberately excluded from the scope of this part of ISO 10648:

— pressurized vessels,

— ventilated hoods,

— shielded enclosures, manufactured from concrete only, with or without cladding, or from lead only,

— sealed sources,

— transport packaging for radioactive materials,

— enclosures, primary circuits and vessels of nuclear reactors.

This part of ISO 10648 describes the use and principles of design for containment enclosures chosen as reference examples of the three following types:

— plastic enclosures,

— metal-framed enclosures,

— hot-worked metal enclosures.

The last two types can be mounted behind shielding or can have directly attached shielding.

Where standard dimensions are not suitable, other dimensions may be chosen but the containment enclosure shall comply with this part of ISO 10648 in design principles, mounting and assembly. It shall also comply with relevant safety standards and regulations.

Examples of various seals available and the assembly of containment enclosures are shown in annexes A and B. ISO 10648-2 gives the classification of containment enclosures according to their leak tightness and associated checking methods.

Associated equipment will be detailed in future International Standards.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 10648. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 10648 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 468:1982, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 1302:1992, *Technical drawings — Method of indicating surface texture.*

ISO 7212:1986, *Enclosures for protection against ionizing radiation — Lead shielding units for 50 mm and 100 mm thick walls.*

ISO 9404-1:1991, *Enclosures for protection against ionizing radiation — Lead shielding units for 150 mm, 200 mm and 250 mm thick walls — Part 1: Chevron units of 150 mm and 200 mm thickness.*

ISO 10648-2:1994, *Containment enclosures — Part 2: Classification according to leak tightness and associated checking methods.*

3 Definitions

For the purposes of this part of ISO 10648, the following definitions apply.

3.1 enclosure: System which ensures the separation between a specified work volume (or internal environment) and a surrounding space (or external environment) in which the human operators are generally to be found.

3.2 containment enclosure: Enclosure designed to prevent the leakage of the products contained in the internal concerned environment into the external environment, or the penetration of substances of the external environment into the internal environment, or both simultaneously.

NOTE — This is the generic term to designate all kinds of enclosures, including glove boxes or boxes equipped with remote handling devices.

3.3 glove box: Containment enclosure that permits the operator to safely handle toxic or radioactive materials or products from outside the enclosure using gloves tightly sealed onto glove ports fitted into the panels of the enclosure.

4 Characteristics of materials used

4.1 Choice of materials for the containment enclosure

The choice of constituent materials is always a compromise between various requirements. The designer shall take into account the requirements for mounting and fitting. The constituent materials of the containment enclosure can be classified into three groups:

— plastics,
— glass,
— metal alloys (painted carbon steel, stainless steel, light alloys).

The general characteristics of each of these groups are given in 4.2 to 4.4.

4.2 Plastics

The main characteristics of plastics are:

— light weight and generally low cost,
— transparency for some types of viewing panels,
— good resistance to chemical agents except certain aggressive solvents, e.g. tributyl phosphate (TBP),
— variable mechanical strength according to material quality and working temperature,
— poor resistance to UV radiation,
— limited resistance to gamma radiation,
— poor ease of decontamination,
— high fire load[1)],
— permeability to water vapour.

4.3 Glass

The main characteristics of glass are:

— good resistance to chemical agents except hydrochloric acid and hydrogen fluoride,
— good temperature resistance,
— poor resistance to mechanical and thermal shock (except laminated glass),
— difficult to work, store, handle, particularly laminated glass,
— impermeability to water vapour,
— poor radiation resistance (except stabilized glass),
— ease of decontamination,
— low fire load.

1) When using plastics, the effect of the increase in calorific potential per unit mass should be taken into account.

For these reasons, only special types of toughened, laminated and stabilized glass shall be used as structural material in containment enclosures. Special precautions are required when being handled, stored or modified (adding new ports, for example).

4.4 Metal alloys

4.4.1 Carbon or stainless steels

The main characteristics of carbon or stainless steels are:

— good temperature resistance,
— possibility of modular construction,
— ease of decontamination (stainless steel),
— good mechanical strength,
— good radiation resistance,
— no fire load,
— not transparent,
— more expensive than plastics,
— high weight.

Carbon steels require surface treatment to protect them against corrosion and to simplify the decontamination procedure. Some types of stainless steel exhibit good chemical resistance.

4.4.2 Light alloys

The main characteristics of light alloys are:

— good rigidity and ease of machining,
— structures lighter than steels,
— possibility of modular construction,
— difficult to weld,
— low fire load,
— possibility of mechanical damage by sharp objects

Their temperature resistance are limited (not above 800 °C).

5 Plastic containment enclosures

This type of containment enclosure is produced in many different designs, shapes and sizes. Several models are standardized.

5.1 Use

These containment enclosures can belong to class 1, 2 or 3 (see ISO 10648-2) but shall not be used with dry air or neutral gases because of their permeability to water vapour.

They are recommended for the handling of corrosive chemical products, with the exclusion of certain solvents (TBP) (see 4.2).

Their use is not recommended for the handling of aerosols (or material easily forming aerosols) having a high specific activity, due to the destruction of the molecular structure of the plastic under radiation emitted by deposited materials and problems associated with static electricity.

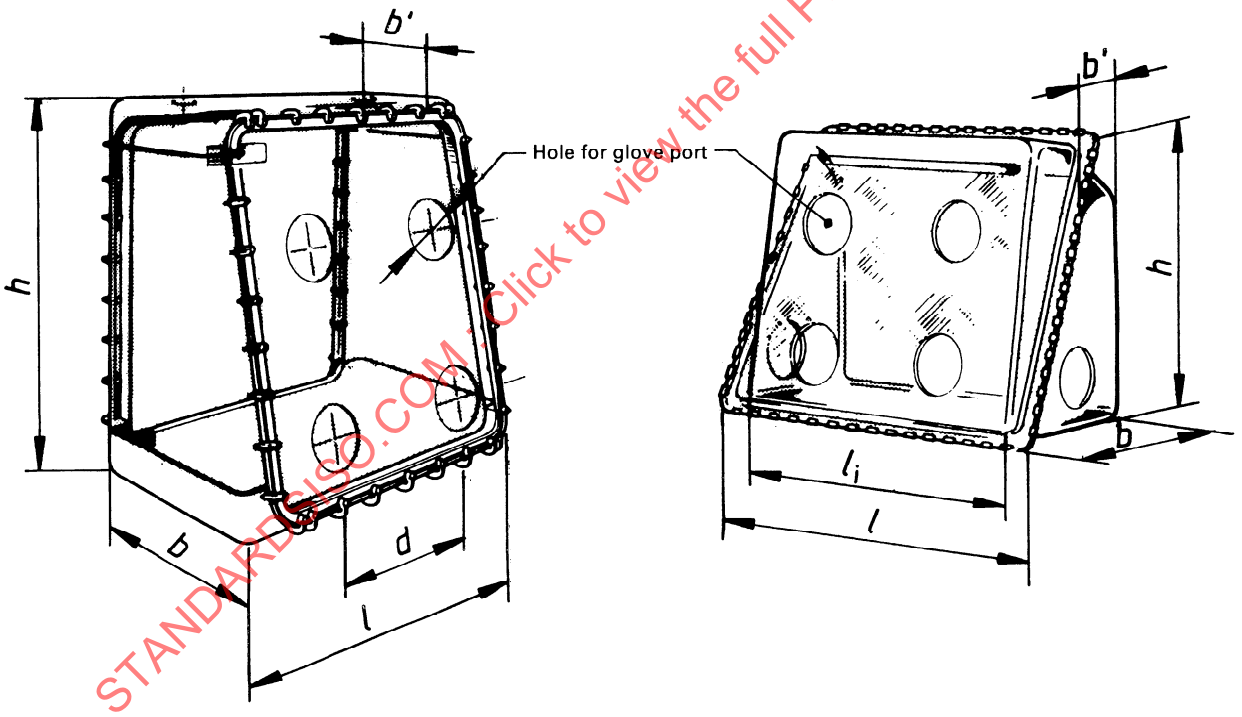
They generate a fire load higher than hot-worked metal enclosures having the same dimensions.

5.2 Description

Containment enclosures are manufactured from two plastics: polyvinylchloride (PVC) or polymethylmethacrylate (PMMA). See figure 1.

Plastic material may be transparent or opaque. The enclosure may be totally or partially transparent, but the front panel should use transparent material.

The enclosure should provide one or two workplaces equipped with glove ports.



a) In PVC (model 1)

b) In PMMA (model 2)

Figure 1 — Plastic containment enclosures

5.3 Design

Containment enclosures in PVC or PMMA can be bonded or thermoformed.

These containment enclosures can be placed directly on a laboratory benchtop or, more usually, on an appropriate support.

The front and back, which are removable, are fixed on by clamps or by flexible clips. All corners are rounded for ease of decontamination. The bottom is flat and is press-formed in the shape of a tray.

5.4 Dimensions

Standard dimensions of plastic containment enclosures are given in table 1.

Table 1 — Dimensions of plastic containment enclosures

Dimensions in millimetres

Model	Length		Width		Height	Recommended interaxial distance, d (glove/bag port spacing)
	overall l	inner l_i	base b	upper part b'	h	
1	1 000	–	630	390	1 000	460
1 (variation)	1 080	–	600	500	1 000	450
2	1 180	1 080	730	620	1 020	470

6 Metal-framed containment enclosures

6.1 Use

The enclosures can be used in conditions of either negative or positive pressure, thus complying with the requirements for nuclear (protection against contamination), biological or medical applications.

These containment enclosures can achieve a high degree of leak tightness (class 1 or 2, see ISO 10648-2).

When handling of aerosols (or material easily forming aerosols) having a high specific activity, or in the presence of corrosive or reactive substances, the seals should be protected with an appropriate mastic.

Because of their modular design, they:

— allow a workplace on each side,

— can be easily adapted for special processes,

— are suitable for heavy machines or complex operations.

They can also be manufactured in larger sizes because of their rigid construction.

NOTE — Contaminated or damaged panels can be replaced using special procedures in accordance with local regulations applicable in the establishment concerned.

6.2 Description

These containment enclosures comprise a metallic framework onto which are mounted transparent panels equipped with glove ports.

These containment enclosures are generally parallelepipeds (see figures 2 and 3) with one (or two) vertical working face(s) each having two, three or four glove ports.

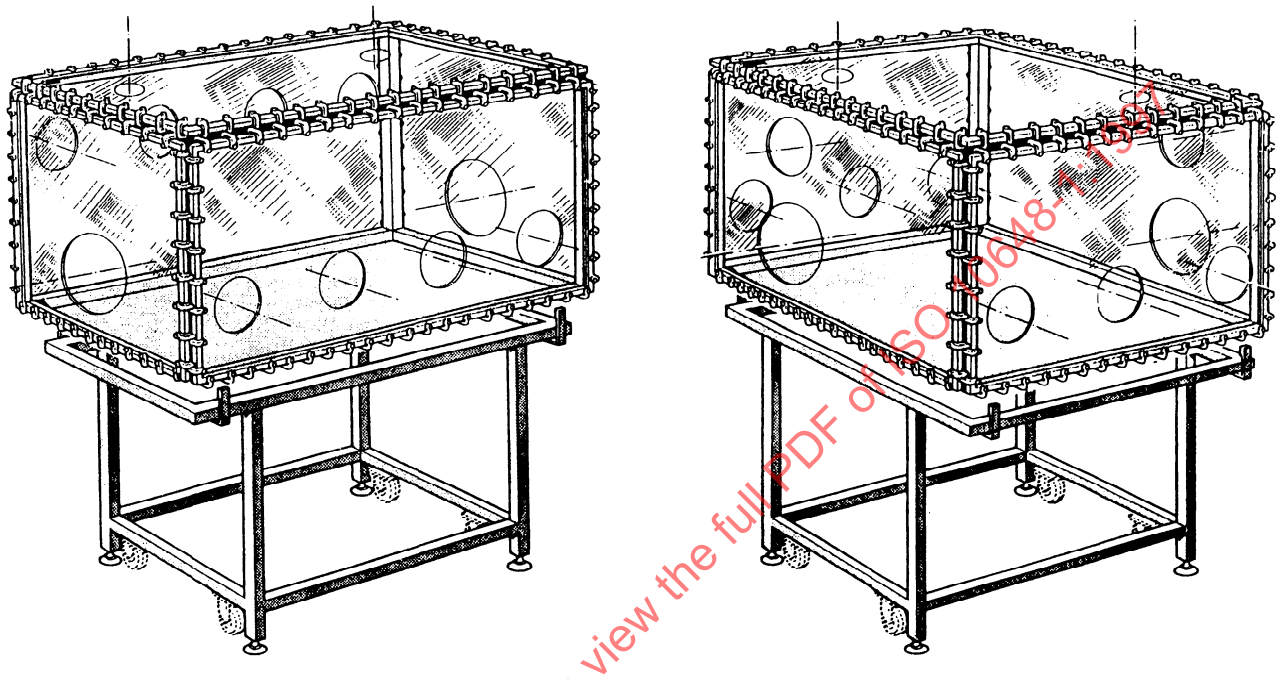


Figure 2 — Metal-framed containment enclosures (examples)

6.3 Design

The framework of the enclosure shall be made of painted carbon steel or stainless steel. The transparent panels are mounted on the framework with clamps or flexible clisp (see figure 4).

Leak tightness is ensured by seals which are compressed between the framework and the panel. When clamps are used, an external frame is required to tighten the panels onto the framework.

Various types of the most usual seals, with their main characteristics, are given in annex A.

6.3.1 Framework

The framework is made of stainless steel or painted carbon steel.

Different types of metal shapes are in use; the most common are:

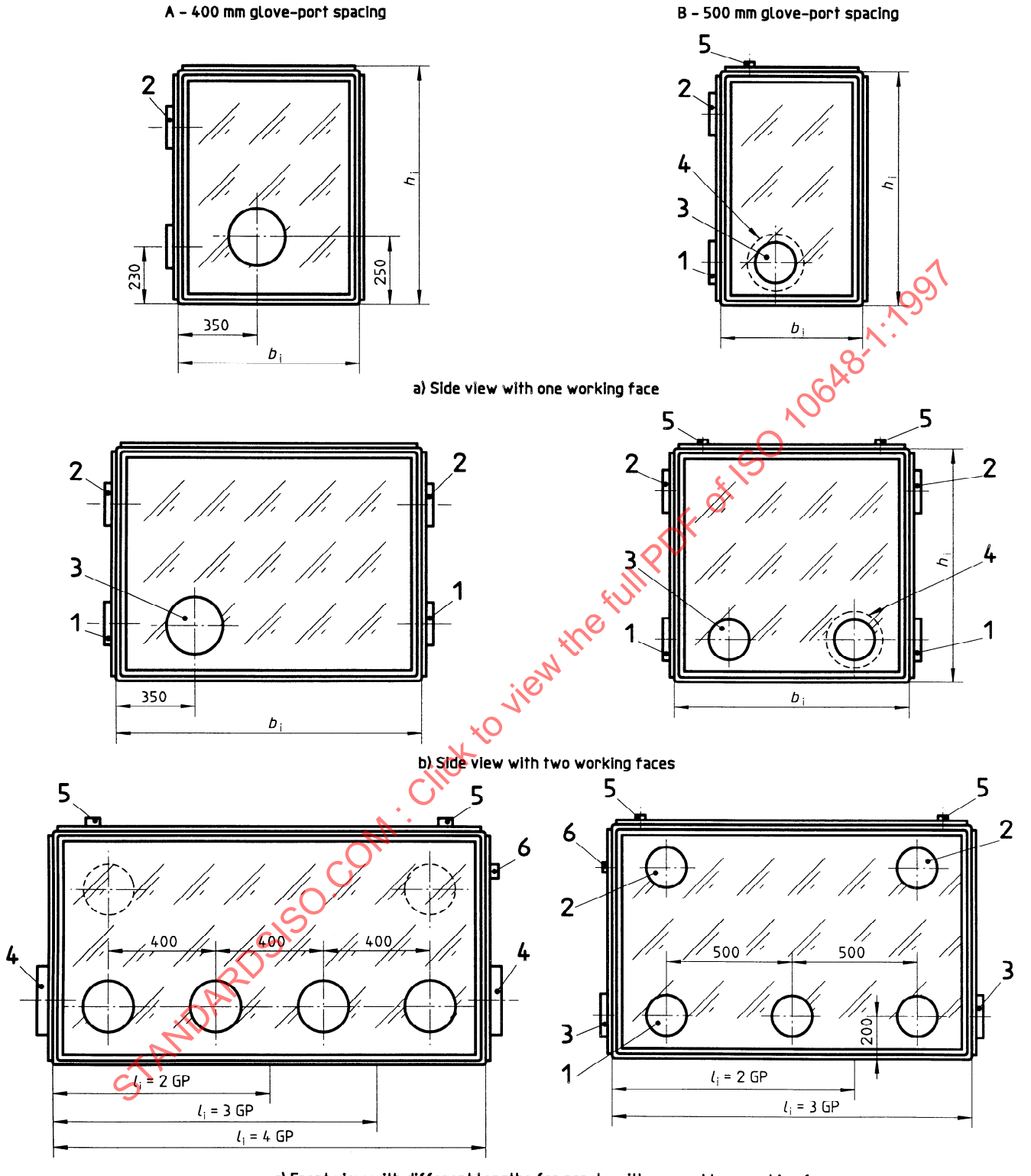
— 2,5 mm thick bent sheet metal (also called omega profile) (see figure 4, column A),

— 2 mm thick square tubing (see figure 4, column B),

— angle profile tubing (also called L-profile tubing) (see figure 5).

Two or more frames can be mounted together, as shown in figure 6, in order to extend the length and/or the height of the containment enclosure. Care should be taken to provide sufficient stiffness to prevent a loss of sealing.

Dimensions in millimetres

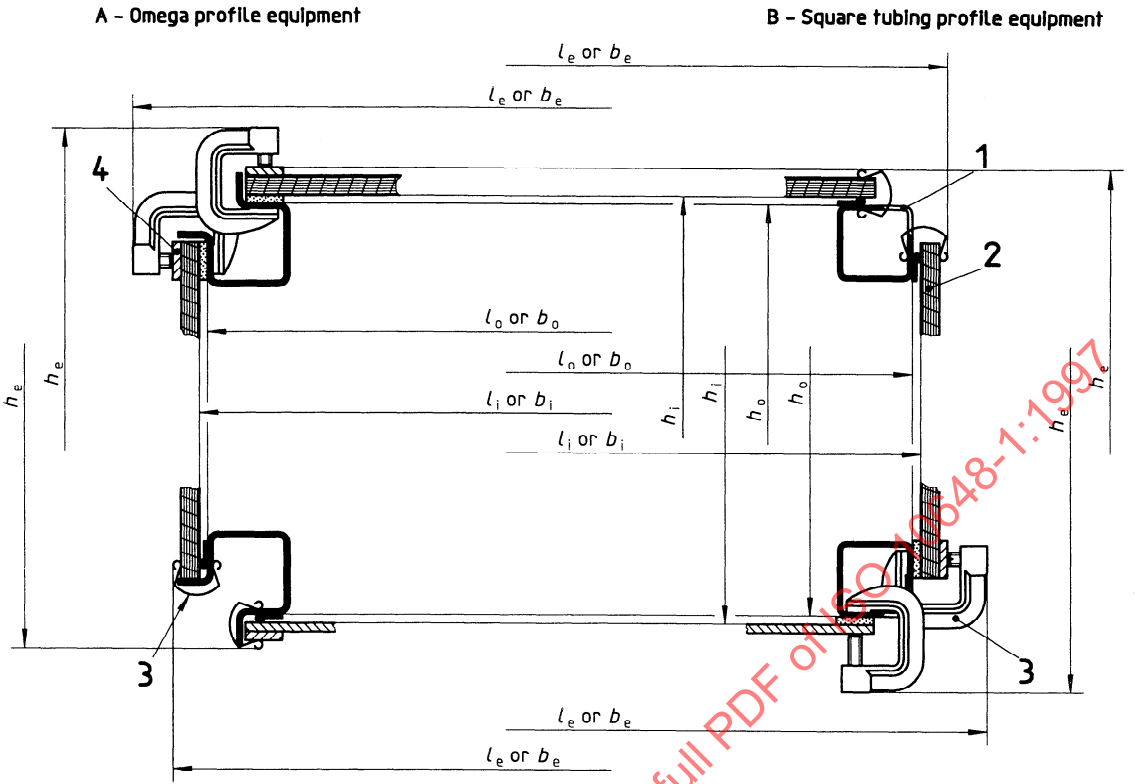


Key

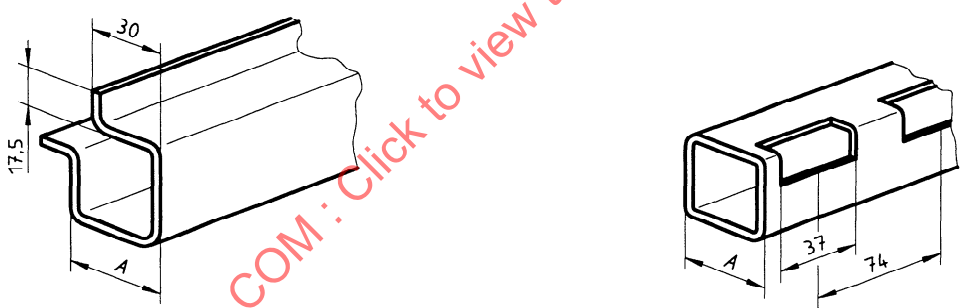
1 Glove port (GP)
2 Port for filter handling
3 Small interlock port
4 Large interlock port (transfer system)
5 Connection for ventilation
6 Connection for pressure differential measuring unit

Figure 3 — Metal-framed containment enclosures with vertical working face(s)

Dimensions in millimetres



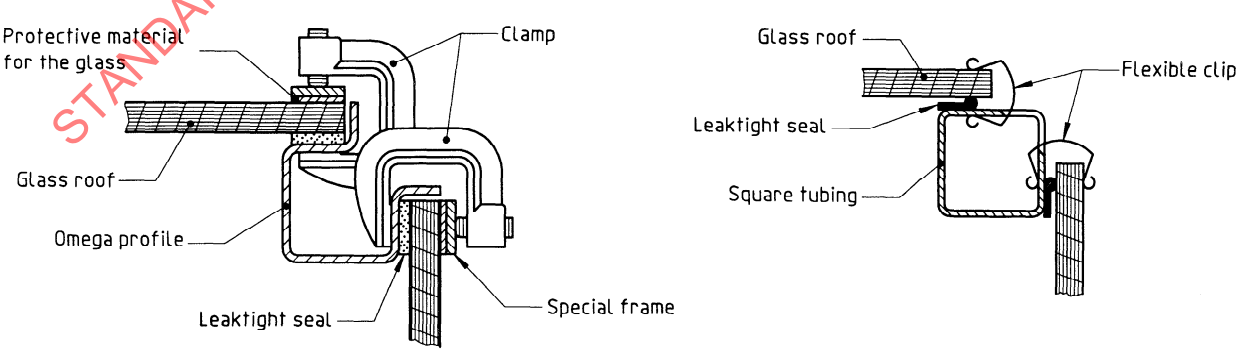
a) Description of assembly (with clamp or clip)



Omega profile 45 × 45

Square tubing profile 40 × 40
Rolled hollow section (RHS)

b) Detail of profiles (Ω or square tubing profile)



c) Detail of mounting on profile (with clamp or flexible clip)

Figure 4 — Principle of assembling and mounting of panels on metal-framed containment enclosures

6.3.2 Side panels

For normal applications, the side panels are made of PMMA or polycarbonate. The thickness is between 8 mm and 10 mm for standard enclosures and over 10 mm for the larger volume enclosures.

For containment enclosures for use with inert atmospheres, the panels are made of laminated glass.

6.3.3 Base

The base is generally metallic. It can be mounted on seals or have the form of a dished tray formed integrally with the profile to avoid contamination traps.

The base is generally flat. When a liquid is handled, the base should be appropriately formed to collect and trap the liquid.

6.3.4 Roof

The roof or top panel may be partially or totally transparent for lighting purposes.

6.4 Dimensions

Standard dimensions for metal-framed containment enclosures are given in tables 2 and 3. These dimensions are determined for glove-port spacing varying from 400 mm to 500 mm.

6.4.1 Metal-framed containment enclosures for 400 mm glove-port spacing

Table 2 gives typical dimensions of metal-framed containment enclosures with 400 mm glove-port spacing. Principles of assembly and mounting of panels on metal framework are shown in figure 4.

Table 2 — Dimensions of metal-framed containment enclosure having 400 mm glove-port spacing

Number of glove ports per working face[1)]	Number of working faces	Internal dimensions[2)] mm		
		length l_i	width b_i	height h_i
2	1	870	770	870
3	1	1 170	770	870
4	1	1 570	770	870
4	1	1 670	770	870
2	2	870	770	870
3	2	1 170	1 170	870
4	2	1 670	1 170	870

1) Other glove ports shall be added in the upper area to allow the exchange of internal filters.

2) These internal dimensions correspond to the dimensions between the seal faces. To obtain the dimensions between the panels, the thickness of the seals shall be taken into account.

6.4.2 Metal-framed containment enclosures for 500 mm glove-port spacing

Table 3 gives typical dimensions of metal-framed containment enclosures with 500 mm glove-port spacing. Principles of assembly and mounting of panels on metal framework are shown in figure 5.

Table 3 — Dimensions of metal-framed containment enclosure having 500 mm glove-port spacing

Number of ports per working face [1]	Number of working faces	Internal dimensions[2] mm		
		length l_i	width b_i	height h_i
2	1	1 010	610	1 010
3	1	1 510	610	1 010
2	2	1 010	1 010	1 010
3	2	1 510	1 010	1 010

1) Other glove ports shall be added in the upper area to allow the exchange of internal filters.

2) These internal dimensions correspond to the dimensions between the seal faces. To obtain the dimensions between the panels, the thickness of the seals shall be taken into account.

7 Hot-worked metal containment enclosures

These enclosures differ from those previously discussed in that their design is entirely based on the use of metal sheet, except for the work face(s) which is/are transparent.

7.1 Use

These containment enclosures can achieve a high degree of leak tightness (class 1 or 2, see ISO 10648-2 and are particularly well suited to operations involving inert gas or dry air.

Their use is exactly the same as metal-framed containment enclosures, but they have higher rigidity due to their metal structure and reduce the fire load in the rooms where they are installed.

Due to their strength:

— they can be made in larger sizes,

— they are well suited to accommodate a heavy or complex process.

7.2 Description

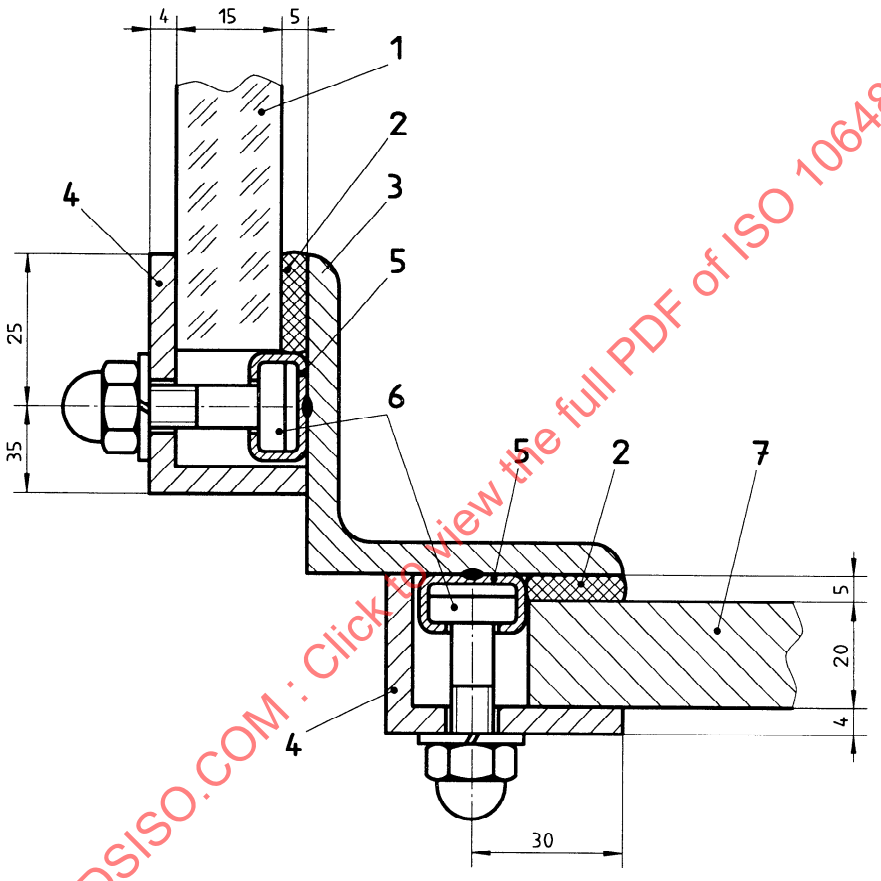
Hot-worked metal containment enclosures are boxes in stainless steel or painted carbon steel which include one or several workplaces, usually situated on one side, equipped with transparent panels having glove ports or, occasionally, tongs. They have one or two working face(s).

This part of ISO 10648 covers containment enclosures which have inclined working face(s) [see figure 7 a)].

Containment enclosures can also be built with vertical working faces [see figure 7 b)] or working faces which have a vertical lower portion containing glove ports and an inclined upper portion containing the transparent panel [see figure 7 c)].

However, these two last types of containment enclosure [figures 7 b) and 7 c)] are only used in special applications and are outside of the scope of this part of ISO 10648.

Dimensions in millimetres

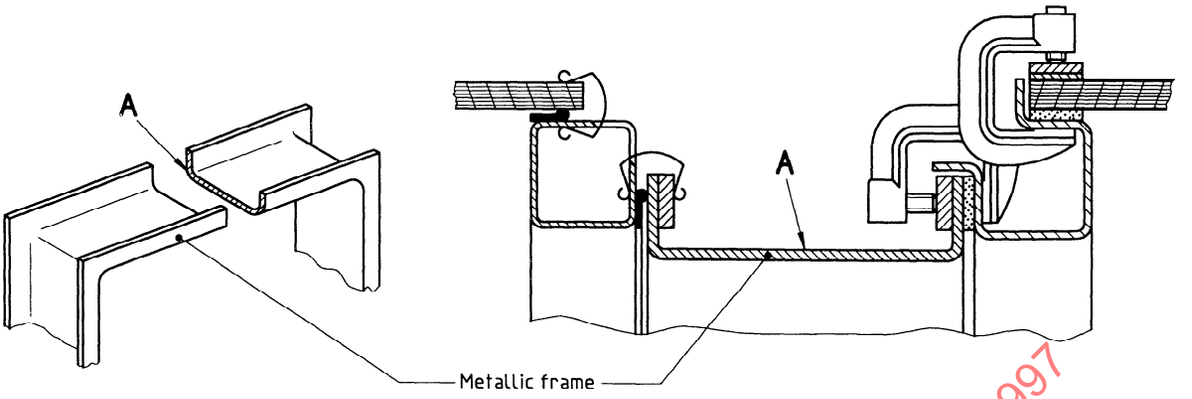


Key

1 Window panel
2 Seal
3 Steel profile
4 Special frame
5 Profile
6 Hammerbolt
7 Bottom

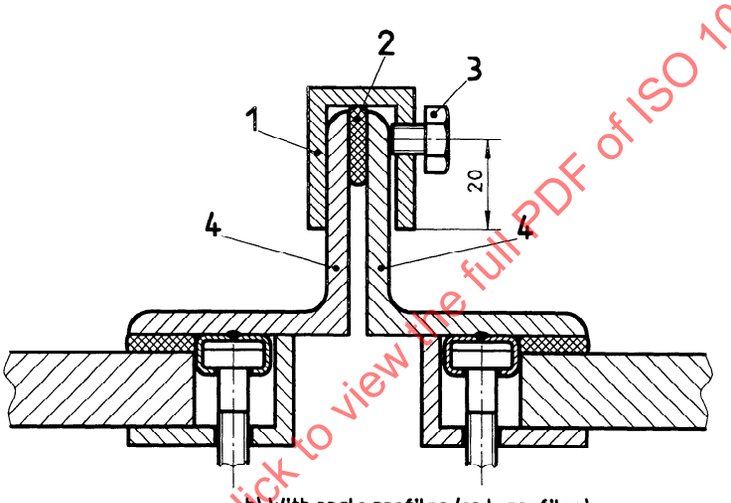
Figure 5 — Alternative principle of assembly and mounting of panels on metal-framed containment enclosures

Dimensions in millimetres



NOTE – For connecting together containment enclosures with square tubing profiles or omega profiles, a U-shaped frame is required.

a) With omega or square tubing profiles

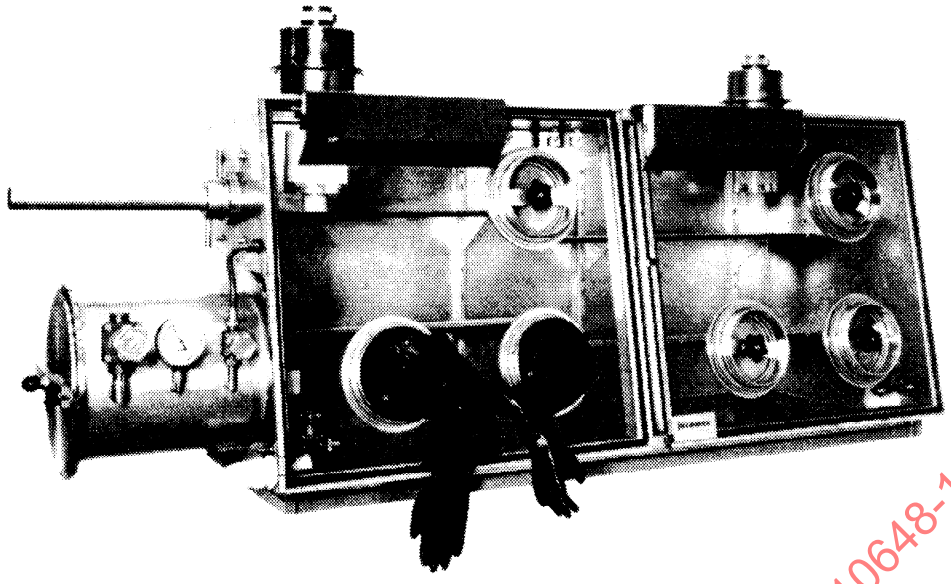


b) With angle profiles (or L-profiles)

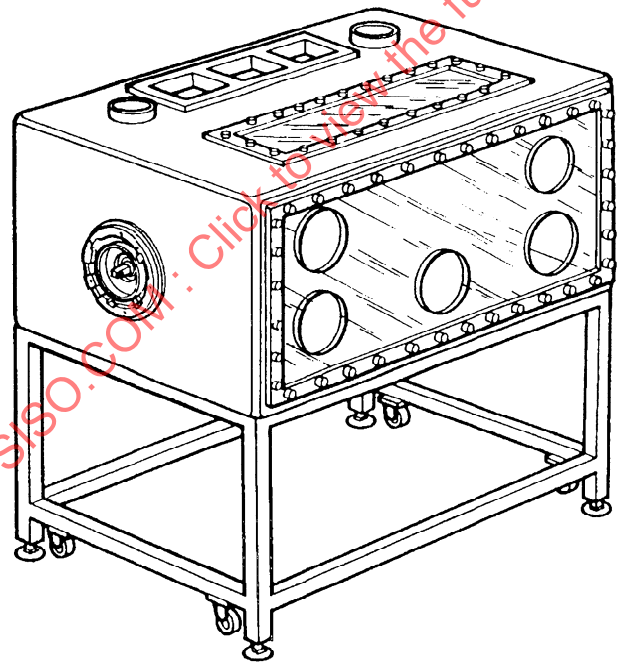
Key

1 Connecting profile
2 Seal
3 Bolt
4 Steel profile

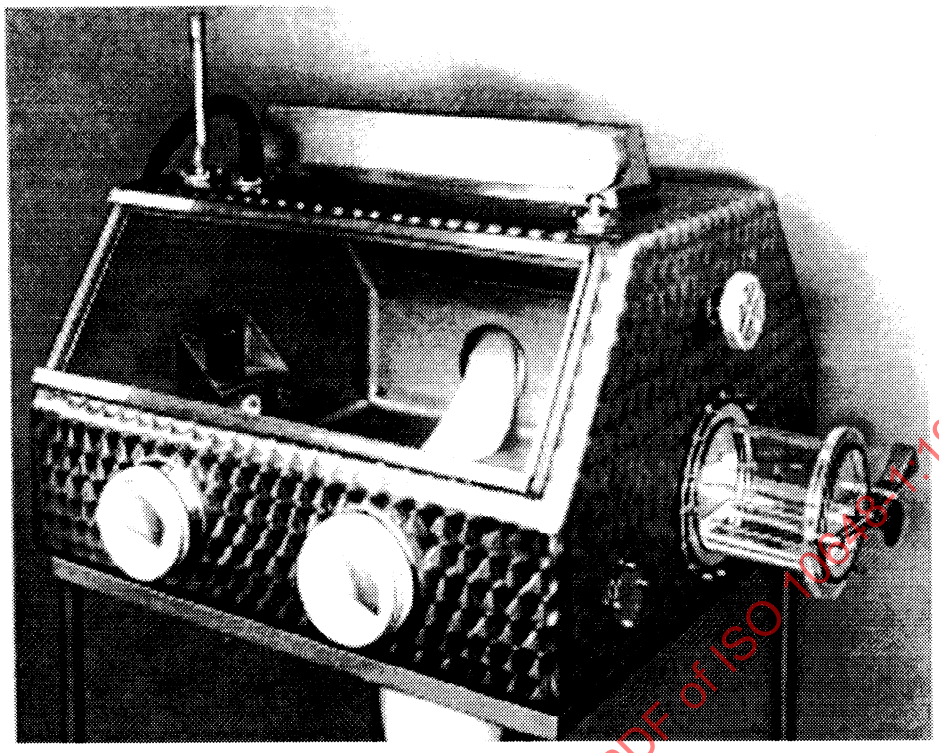
Figure 6 — Principle of joining of two or more metal-framed containment enclosures



a) With inclined working face



b) With vertical working face



c) With partially inclined working face

Figure 7 — Examples of hot-worked metal containment enclosures

7.3 Design

7.3.1 General

Hot-worked metal enclosures are constructed in stainless steel or painted carbon steel. One (or two) side(s) should be equipped to hold transparent panels.

In this design:

— the transparent panels, made as small as possible, are for viewing. They may have openings for glove ports depending on the type of work and the panel profile,

— the metal sides are used generally for service input (fluids, electricity, lighting, transfer systems) and for internal support devices (rails, rigid angle bars).

7.3.2 Hot-worked metal structure

7.3.2.1 Box

The welded box is manufactured in stainless steel or painted carbon steel sheet having a minimum thickness of 3 mm (2,5 mm, is occasionally used for small-volume enclosures having no special requirements). The type of steel used shall be determined by the physical or chemical constraints imposed by the operations and materials handled in the box.

7.3.2.2 Welding

The welding shall be continuous; it shall be dressed to give the surface finish required for ease of decontamination. It shall not have any cavities or sharp angles.

7.3.2.3 Surface texture

The surface roughness of the walls shall be Ra = 2,8 µm or better if required (see ISO 468 and ISO 1302).

7.3.2.4 Base

The base shall have the same surface roughness as the side walls and have rounded corners to facilitate decontamination. Seals should be avoided on the lowest part of the base.

7.3.2.5 Frame for installing transparent panels

Their shape and surface roughness shall be identical to containment enclosures with metal-framed construction.

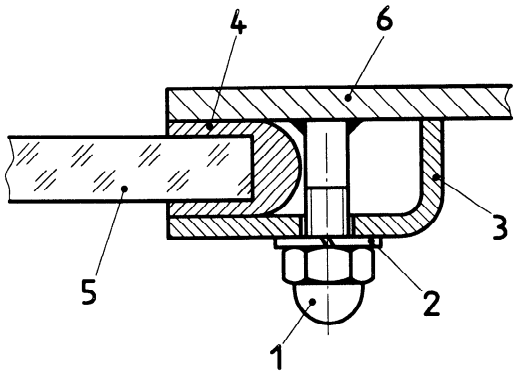
7.3.3 Transparent panels

Transparent panels can be of PMMA, polycarbonate or laminated glass.

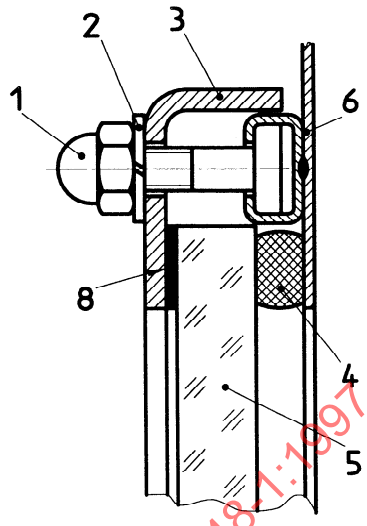
The fastening and sealing of the panels can be carried out using either the same principles as in metal framed containment enclosures or in conformity with the system shown in figure 8.

7.4 Dimensions

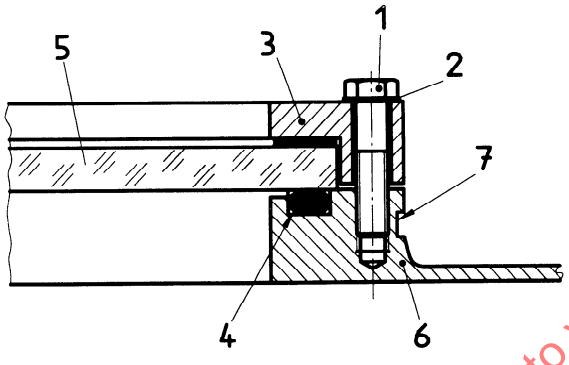
The dimensions of one-piece construction containment enclosures with inclined working faces, as shown in figure 9, are given in tables 4 and 5.



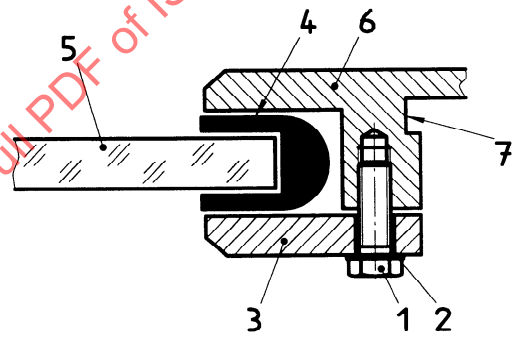
a) With U-shaped seal and fixed nuts



b) With flat seal and free nuts



c) With O-ring and angle-shaped flange (or L-shaped flange)



d) With U-shaped seal and flat flange

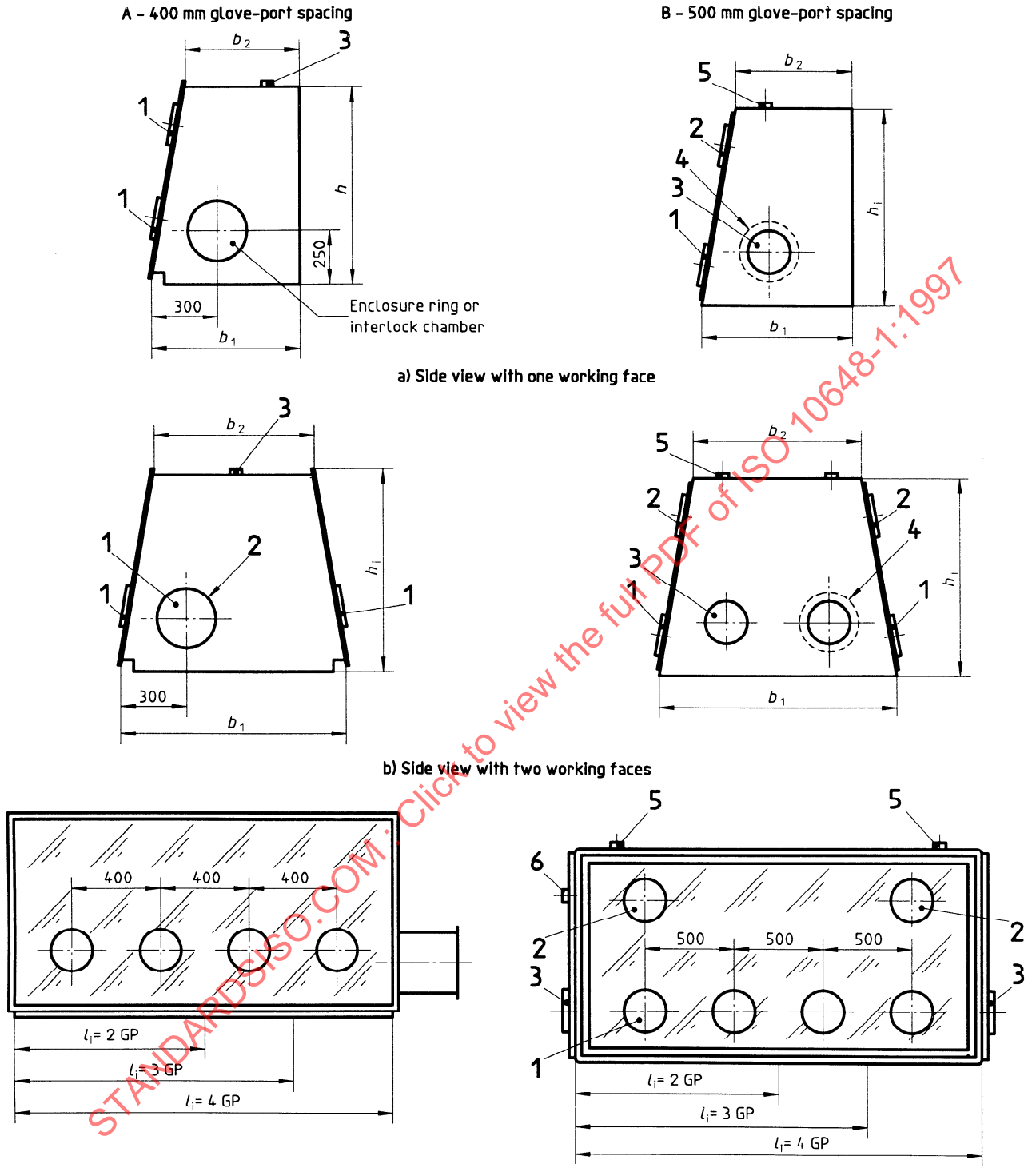
NOTE — The mounting and sealing are independent.

Key

1 Bolt (or hammerbolt)
2 Spring washer
3 Flange
4 Seal
5 Window pane
6 Frame
7 Hole for fixing welded bags
8 Support seal

Figure 8 — Examples of mounting and sealing systems

Dimensions in millimetres



Key

1 Glove port (GP)
2 Port for filter handling
3 Small interlock port
4 Large interlock port (transfer system)
5 Connection for ventilation system
6 Connection for pressure differential measuring unit

Figure 9 — Examples of hot-worked metal containment enclosures with inclined working face(s)

Table 4 — Dimensions of hot-worked metal containment enclosure having 400 mm glove-port spacing

Number of glove ports per working face [1]	Number of working faces	Internal dimensions[2] mm			
		Length l_i	Width b_1	Width b_2	Height h_i
2	1	900	650	510	850
3	1	1 350	650	510	850
4	1	1 900	650	510	850
2	2	900	1 000	620	850
3	2	1 350	1 000	620	850
4	2	1 900	1 000	620	850

1) Other glove ports shall be added in the upper area to allow the exchange of the internal filters.

2) These internal dimensions correspond to the dimensions between the seal faces. To obtain the dimensions between the panels, the thickness of the seals have to be taken into account.

Table 5 — Dimensions of hot-worked metal containment enclosures having 500 mm glove-port spacing

Number of glove ports per working face [1]	Number of working faces	Internal dimensions[2] mm			
		Length l_i	Width b_1	Width b_2	Height h_i
2	1	1 000	600	480	700
2	1	1 000	800	620	1 000
3	1	1 500	600	480	700
3	1	1 500	800	620	1 000
4	1	2 000	600	480	700
4	1	2 000	800	620	1 000
2	2	1 000	1 000	750	700
2	2	1 000	1 000	648	1 000
3	2	1 500	1 000	750	700
3	2	1 500	1 000	648	1 000
4	2	2 000	1 000	750	700
4	2	2 000	1 000	648	1 000

1) Other glove ports shall be added in the upper area to allow the exchange of the internal filters.

2) These internal dimensions correspond to the dimensions between the seal faces. To obtain the dimensions between the panels, the thickness of the seals have to be taken into account.

8 Special case of containment enclosures with shielding

8.1 Use

This type of containment enclosure is used for the handling of beta, gamma and neutron emitters which require additional shielding.

8.2 Description

These containment enclosures shall fulfil the same containment criteria as those described in clauses 6 and 7 and shall be equipped with shielding.

For normal operation, tongs or manipulators shall be used, except that when short-time manual intervention is required (e.g. for maintenance), gloves may be used under controlled conditions.

8.3 Design

These containment enclosures consist of a box similar to those described in clauses 6 and 7 (containment enclosures of hot-worked metal, metal-framed) and enclosed by an external casing which provides additional protection. This protection can be integral with, mounted on or independent of the box.

The choice and thickness of the protective material shall be determined according to the type of radiation (beta, gamma or neutron) and the type of handling required.

8.3.1 Containment enclosures with integrated or mounted shielding

This type of containment enclosure, which is only used within thin shielding, generally allows handling of radioactive products using gloves. When not in use, continuity of protection at the glove ports is ensured by adding appropriate shutters.

The structure of the containment enclosure shall be strong enough to support the extra mass of the protective material. This assumes that the mass of the shielding is small.

The mounting and assembly of the transparent panels of the containment enclosure are carried out according to the techniques described above or as shown in figure 10. In this diagram, two types of transfer system are shown.

8.3.2 Containment enclosures with independent shielding

This design technique should be used when the mass of additional shielding cannot be supported by the containment enclosure. It conforms to the two following principles (see also figure 11).

8.3.2.1 Design of the containment enclosure

For reliability and ease of maintenance, hot-worked metal containment enclosures are recommended. It is necessary:

— to limit the dimensions of the transparent panel of the containment enclosure to the field of vision of the window in the additional protection,

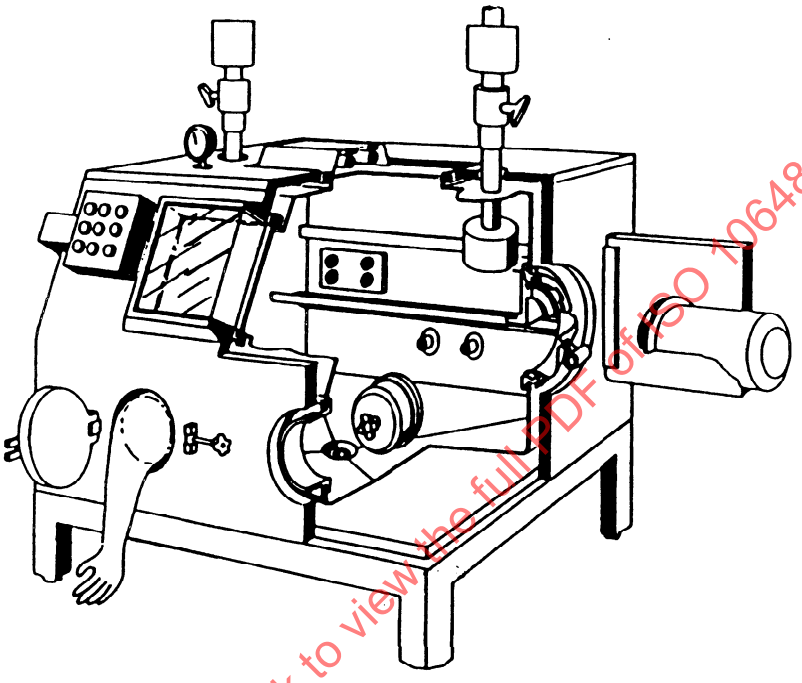
— to provide a metal wall which can accommodate all the necessary services (manipulators, transfer systems, ventilation...).

The mounting and assembly of the panels of the containment enclosure shall be accomplished by the methods recommended in clause 7. For mounting of the transparent panels, the use of clamps shall be avoided, as the seal loses its initial elasticity with time and relaxation gives rise to detective clamping which could result in clamps falling off.

Suitable systems for attachment to the containment enclosure, as shown in figure 8, are recommended.

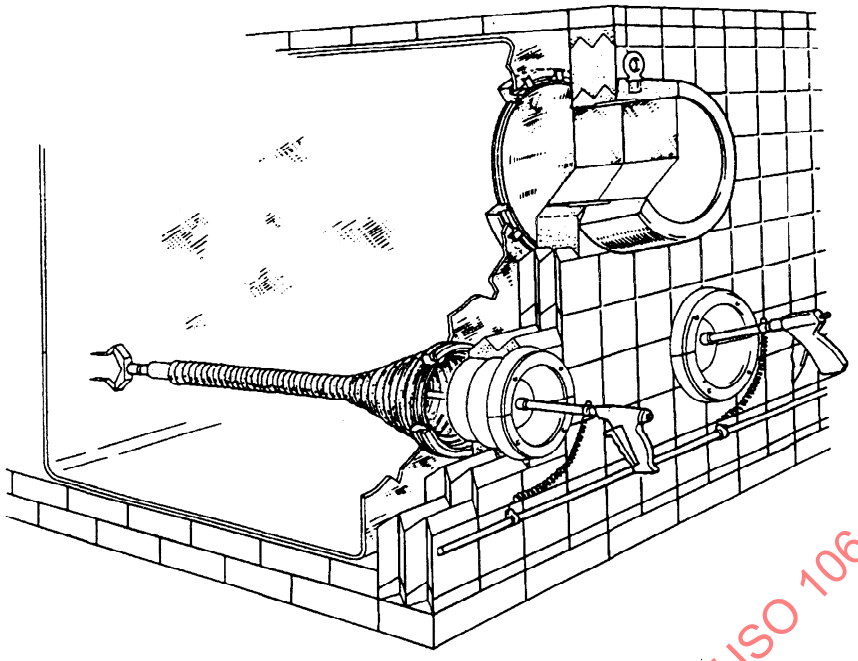
8.3.2.2 Design of additional protective shielding

Additional independent and self-supporting protective shielding is generally made up of a number of removable elements (of lead, heavy or ordinary concrete, cast iron, steel or hydrogenated materials, etc.), allowing access to the components of the containment enclosure for maintenance puposes. The design of the elements and their assembly shall be such that there are no radiation leaks at the interfaces. If lead shielding is used, it shall be in accordance with ISO 7212 and ISO 9404-1. When large lead panels are used, they shall be reinforced with suitable steel structures.

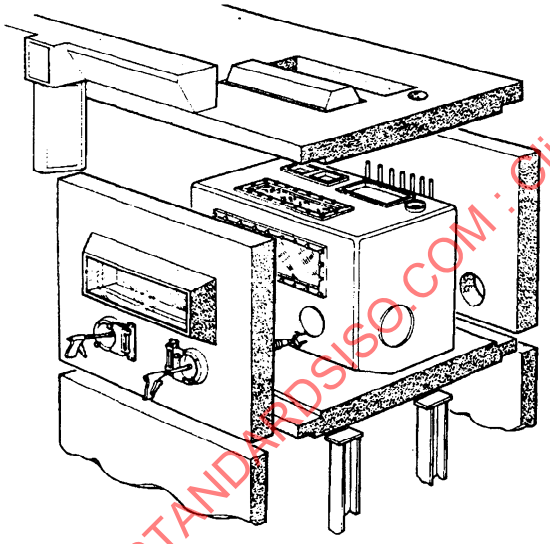


NOTE — During normal use (containment enclosure under negative pressure), the gloves are inside the containment enclosure

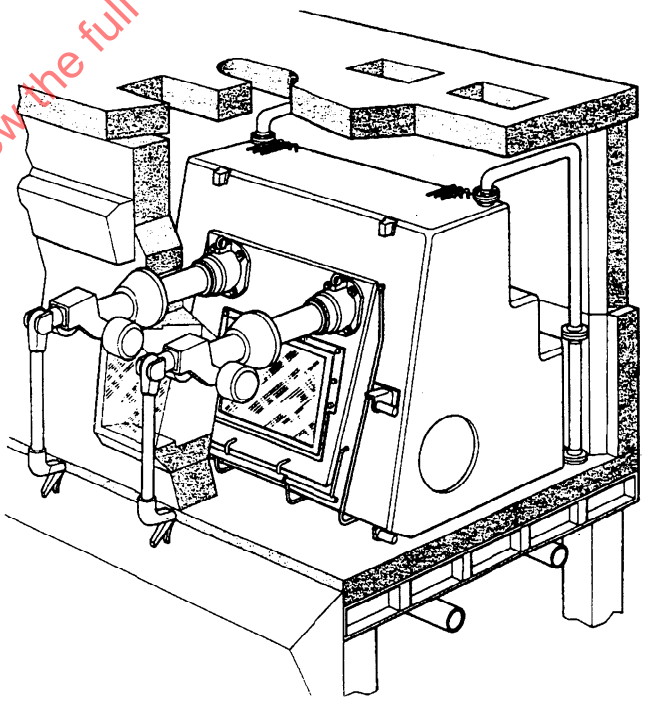
Figure 10 — Containment enclosure with integrated or mounted shielding



a) With lead bricks (see ISO 7212 and ISO 9404-1) and containment enclosure equipped with tongs.



b) With cast iron, steel or lead panels and containment enclosure equipped with tongs.



c) With cast iron, steel or lead panels and containment enclosure equipped with remote manipulators.

Figure 11 — Design of containment enclosures with independent gamma shielding

Annex A
(informative)

Seals for containment enclosures

A.1 General

This annex gives some details on materials generally used for the construction of seals (see table A.1), as well as for the selection, the principle of mounting and the characteristics of the various seals usable in conjunction with metal-framed or hot-worked metal containment enclosures.

The seals ensure leak tightness between frame and panels, and attachment of the panels to the framework of the containment enclosure.

Table A.1 — Elastomer materials usually used for the fabrication of seals

Material	Commercial name[1)]	Shore hardness	Standardized symbol
Polyvinyl chloride	PVC	70 to 90	PVC
Natural rubber	Latex	35 to 40	R
Polychloroprene	Neoprene	60 to 80	CR
Chlorosulfonated polyethylene	Hypalon	50 to 75	CSM
Fluoroelastomer	Viton A, B	50 to 90	FPM
Fluoroelastomer	Viton G, F	75	FPM
Ethylene-propylene	ETH	60	EPM
Nitrile butadiene rubber	Perbunan	50 to 85	NBR
Silicone rubber	—	—	—

1) These names are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this (these) product(s).

A.2 Use of seals

Polychloroprene, natural rubber or nitrile butadiene rubber are commonly used. In special cases the materials given in table A.2 are used.

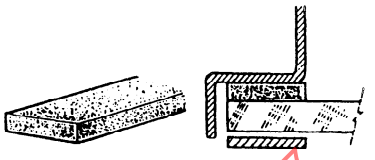
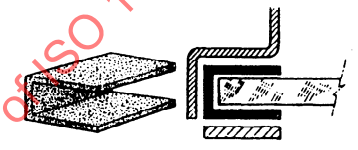
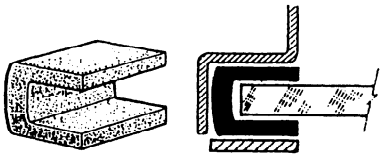
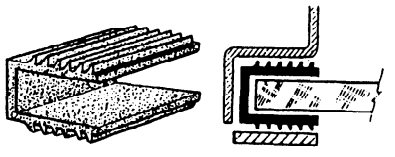
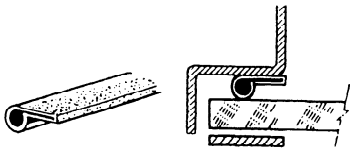
Table A.2 — Use of different seal materials

Material	Example of use
PVC-ETH	Assembly of plastic glove boxes (suitable for general chemical procedures)
Viton A, B	Gloves boxes used with: — vacuum, — ventilated inert gases, — high or low temperatures
Viton G, F	Protection against solvents (e.g. TBP) and very aggressive acids
Hypalon	Protection against radioactive products with high specific activity

A.3 Types of seal

Various types of seal are given in table A.3.

Table A.3 — Types of seal

1	Flat seal (natural rubber or Hypalon) 5 mm × 20 mm		
2	Simple U-shaped seal in neoprene or in natural rubber		
	Simple U-shaped seal in ethylene-propylene (width of sides: 4,5 mm)		
	PVC U-shaped and lipped seals (width of sides: 4 mm)		
3	O-ring seal in neoprene or neoprene covered with Viton ϕ 5 – l = 15 mm	with inner lip	
		with outer lip