INTERNATIONAL STANDARD

ISO 10648-2

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Containment enclosures —

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

Enceintes de confinement —

Partie 2: Classification selon leur étanchéité et méthodes de contrôle associées

Reference number
ISO 10648-2:1994(E)

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Foreword

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

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 10648-2 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 to F of this part of ISO 10648 are for information only.

Introduction

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 the environment,
- sensitive products requiring a special atmosphere and/or a sterile medium.

It does not apply

- to pressurized vessels,
- to sealed sources,
- to transport packagings for radioactive materials,
- to enclosures, primary circuits and vessels of nuclear reactors.

Containment enclosures —

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

1 Scope

This part of ISO 10648 gives a classification of containment enclosures according to leak tightness and specifies methods for checking this tightness for the following tests:

— manufacturing test at the factory,

— acceptance test at the laboratory,

— test before commissioning,

— periodical tests during operation.

These last two tests shall comply with relevant standards and local regulations.

The object of this part of ISO 10648 is to provide manufacturers, suppliers, users and the competent authorities with uniform principles in test procedures for testing the leak tightness of containment enclosures and for ascertaining the leak rate.

The tests cover the containment enclosures equipped with the basic components (see ISO 10648-1:—, annex B). All openings (for example glove ports and ventilation openings) are sealed with tight-fitting or sealable covers.

If additional equipments are to be used, a new control test taking into account these equipments should be performed.

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 6144:1981, *Gas analysis preparation of calibration gas mixtures — Static volumetric methods.*

ISO 10648-1:—[1)], *Containment enclosures — Part 1: Design principles.*

3 Definitions

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

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

3.2 hourly leak rate, T_f**:** Ratio between the hourly leakage F of the containment enclosure under normal working conditions (pressure and temperature) and the volume V of the said containment enclosure.

$$T_f = \frac{F}{V}$$

It is expressed in reciprocal hours.

4 Classification of containment enclosures according to their leak tightness

The classification of containment enclosures according to their hourly leak rate, T_f, is given in table 1.

The leak rate is measured at the normal operating pressure (usually about 250 Pa) for checking during operational use, and 1 000 Pa for the acceptance test.

1) To be published.

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

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

*) The classification of leak tightness required for a particular application under classes 1 and 2 shall be decided by the designer and user and licensing authorities. Normally, class 1 will be applied for technical reasons when higher gas purity is required.

Containment enclosures with a leak rate exceeding that of class 4 are outside the scope of this part of ISO 10648.

5 Leak testing methods for containment enclosures

There are three methods of leak testing for containment enclosures:

a) oxygen method (see 5.1);

b) pressure change method (see 5.2);

c) constant pressure method (see 5.3).

Except for special specifications (large dimensions, complex shape or installed equipment), the method of leak testing will be determined by the selected class of leak tightness as follows:

a) for class 1, the oxygen method (5.1) shall be used;

b) for classes 2 and 3, either the oxygen method (5.1) or the pressure change method (5.2) may be used, in accordance with relevant standards, local regulations and feasibility;

c) for classes 3 and 4, the constant pressure method (5.3) may be used.

For acceptance, it is usual to carry out a more stringent leak test (with a pressure difference about 4 times greater than the working conditions).

If sealing systems are not readily available, the test shall be carried out with dummy closures (gaiters, bags, etc.).

If the containment enclosure is constructed of painted carbon steel, the leak test shall be carried out before and after painting.

It the containment enclosure is contaminated, special care shall be taken to avoid radiological difficulties. The use of HEPA filters may prevent the spread of contamination.

5.1 Oxygen method (see ref. [1])

5.1.1 Principle

This method can be performed only if the containment enclosure is maintained at a negative pressure.

The method consists of measuring the increase in the oxygen concentration as a function of time inside a containment enclosure which has been previously purged by an inert gas. The purpose of this purging is to bring the residual oxygen concentration down to a level compatible with the leak rate to be measured.

The difference in the oxygen concentration in the containment enclosure between the end and the beginning of the test, calculated on an hourly basis, gives the hourly leak rate, T_f, of the containment enclosure:

$$T_f = 300 \frac{O_{2f} - O_{2i}}{t \times 10^6}$$

where

O_{2f} is the final oxygen concentration by volume, in volume per million (vpm);

O_{2i} is the initial oxygen concentration by volume, in volume per million (vpm);

t is the duration of the test, in minutes;

300 = 60 × 100/20 where 60 represents the 60 minutes in an hour and 100/20 represents 20 % oxygen in normal air.

5.1.2 Apparatus (see figure 1)

5.1.2.1 Oxygen analyser, insensitive to solvent and hydrocarbon vapours and having a resolution compatible with the leak rate measurement corresponding to classes 1, 2 and 3 containment enclosures or to those with an hourly leak rate on acceptance less than 10^{-2} h^{-1} (recommended measuring range: 0 to 1 000 vpm, see refs. [1], [2] and [3]).

5.1.2.2 Hermetically sealed circulating pump, insensitive to hydrocarbons and solvents.

5.1.2.3 Pressure-regulating device, capable of maintaining the relative pressure inside the limiting enclosure within a tolerance of 100 Pa, throughout the verification procedure.

5.1.2.4 Calibrating device, to enable the oxygen analyser to be regulated and calibrated by introducing a known quantity of oxygen into the circuit (see, for example, ISO 6144).

5.1.2.5 Filtration equipment, to prevent pollution of the measuring system.

5.1.3 Procedure

Purge the enclosure by allowing an inert gas (high purity nitrogen gas or argon gas) to flow through the enclosure for a sufficient time. The oxygen concentration is continuously monitored. If necessary, a mixing device (for example a fan inside the enclosure) may be used.

When the oxygen content decreasing rate and the oxygen concentration are sufficiently low (about 100 vpm), stop the purging procedure and turn off the extract valve of the containment enclosure.

Start the pressure regulating device at the working relative pressure (at least 250 Pa or 1 000 Pa for the acceptance test case), while at the same time keeping the circulation operating in the measuring system and then in the containment enclosure.

After the oxygen analyser reading has stabilized, record the initial oxygen concentration, O_{2i}, atmospheric pressure, temperature and relative pressure in the containment enclosure.

After a time, *t*, compatible with the hourly leak rate to be measured (usually 30 min), record the final oxygen concentration, O_{2f}, atmospheric pressure, temperature and relative pressure in the containment enclosure.

5.1.4 Characteristics of the method

This method is particularly suitable for containment enclosures filled with inert gas. It is also capable of measuring very low leak rates. It has the advantage of being not very sensitive to temperature and atmospheric pressure variations. However, it needs a thorough mixing of the containment enclosure atmosphere, particularly in the case of large volumes.

5.1.5 Validity range

During the test, the following conditions should be fulfilled:

a) internal temperature variations should be lower than 3 °C;

b) atmospheric pressure variations should be lower than 1 000 Pa;

c) internal enclosure relative pressure variations should be lower than 50 Pa.

If these conditions are not entirely satisfied the test shall be repeated. However, within these limits, no corrections due to these variations are necessary.

5.1.6 Evaluation and test report

The test report shall include the following particulars:

a) reference to this part of ISO 10648;

b) the hourly leak rate obtained;

c) the conditions in which the measurement was made, namely,

   — the volumes of the installed equipment of the containment enclosure which were taken into account,

   — the equilibrium conditions of the system at the time of the measurement (internal and external temperature, internal pressure, atmospheric pressure, leak rate),

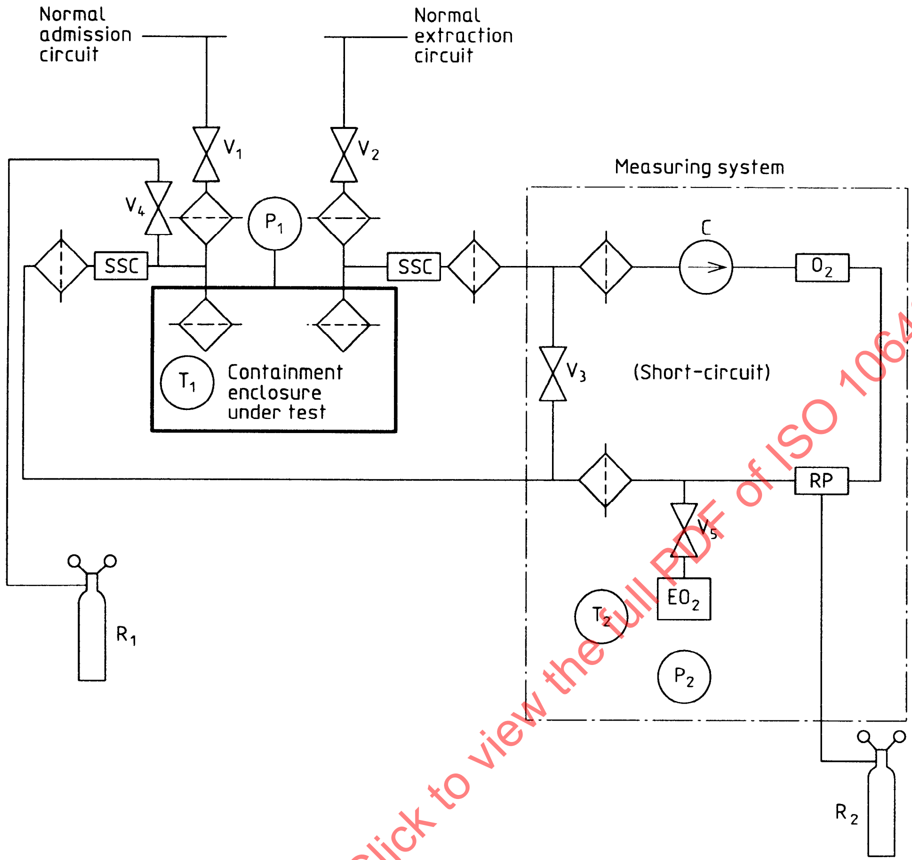
   — the duration of the measurement,

   — the units used;

d) the results obtained;

e) all operating details not specified in this part of ISO 10648, and all incidents that may have influenced the results.

An example of a report of an acceptance test according to the oxygen method is given in annex A.



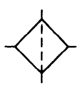
	High-efficiency (HEPA) filter
SSC	Self-sealing coupling
R_1	Inert gas cylinder for purging the containment enclosure
R_2	Inert gas cylinder for purging the measuring system
RP	Pressure regulator
V_1, V_2, V_3, V_4, V_5	Valves
C	Circulating pump
O_2	Oxygen analyser
EO_2	Oxygen calibration system
P_1	Differential pressure gauge
P_2	Barometer
T_1, T_2	Thermometers

Figure 1 — Schematic diagram of the measuring system for the oxygen method

5.2 Pressure change method

(see refs. [4] and [5])

5.2.1 Principle

The method consists of measuring the pressure rise per unit time after isolating the containment enclosure at a negative pressure.

When the containment enclosure is at a positive pressure, an equivalent method can be also used.

The requirements in relation to leak tightness are specified in clause 4.

5.2.2 Apparatus (see figure 2)

5.2.2.1 Thermometer, with an accuracy better than 0,1 °C, to measure the temperature inside the containment enclosure.

5.2.2.2 Thermometer, with an accuracy of 0,1 °C, to measure room temperature.

5.2.2.3 Barometer, with an accuracy of 10 Pa (for example mercury barometer with vernier).

5.2.2.4 Differential pressure gauge, with a scale division of 10 Pa (for example liquid-filled, inclined-tube manometer).

5.2.3 Procedure

The room temperature and barometric pressure shall be measured during the test with the thermometer and barometer set up close to the containment enclosure. The containment enclosure thermometer shall be suspended in the middle of the enclosure before the final sealing of the openings. Before starting the leak test the temperature and pressure in the containment enclosure to be tested and the test room shall be allowed to stabilise. Set up the containment enclosure negative pressure to the required value (1 000 Pa below ambient for the acceptance test, and 250 Pa for operational use checking) and then close the extract valve.

When the pressure and the temperature are stabilised isolate the containment enclosure by shutting the valves, and measure the temperature and negative pressure in the containment enclosure for an hour at 15-minute intervals, together with the ambient pressure. The first and last readings are used for the evaluation; the intermediate readings are used to control the test conditions.

5.2.4 Characteristics of the method

This method is simple to operate and needs only widely available test equipment. It is widely used.

However, the method is very sensitive to changes in internal temperature, which can lead to internal pressure changes. Special care should be taken that doors and windows of the test room are kept closed and heating by the sun, lighting or heating equipment should be avoided.

This method is also sensitive to changes in atmospheric pressure, which can deform the enclosure walls. It cannot be used to measure very low leak rates.

5.2.5 Validity range

During the test (duration 1 h) the following conditions should be fulfilled:

a) internal enclosure relative pressure variation shall be lower than 30 % of the initial value;

b) internal temperature variations shall be lower than ± 0,3 °C;

c) atmospheric pressure variations shall be lower than 100 Pa;

d) if possible, temperature variations of the test room should be lower than 1 °C.

If these conditions are not entirely satisfied, the test shall be repeated or an alternative method used.

NOTE 1 The influence of temperature and pressure may be summarized as: a change of 1 °C in internal temperature corresponds to a change in internal pressure of 350 Pa.

5.2.6 Test report (see annexes B, C and D)

The test report shall include the temperature and pressure measurements at the specified time intervals.

The measured values, the calculated leak rate, and the assessment, shall be entered in the test report as shown in annex B, C or D.

The hourly leak rate, T_f, as defined in 3.2, is equal to:

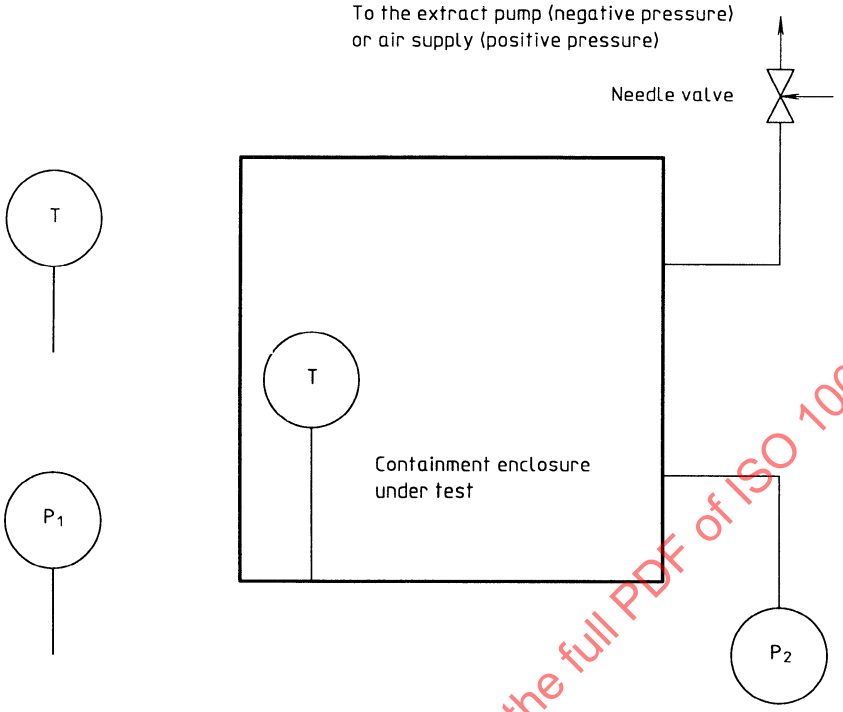
$$T_f = \frac{60}{t} \times \left(\frac{p_n \, T_1}{p_1 \, T_n} - 1 \right)$$

where

t is the duration of the test, in minutes;

p_1 is the absolute pressure (ambient pressure minus underpressure) at the first reading, in pascals;

p_n is the absolute pressure at the last reading, in pascals;



T Thermometer

P_1 Mercury or aneroid barometer

P_2 Precision inclined manometer or electronic micromanometer

Figure 2 — Schematic diagram of the measuring system for the pressure change method

T_1 is the temperature at the first reading, in kelvins;

T_n is the temperature at the last reading, in kelvins;

60 represents the 60 minutes in an hour.

NOTE 2 Conversion of degrees Celsius to kelvins: T (K) = (θ + 273) (θ in degrees Celsius).

For example, a class 2 containment enclosure satisfies the requirements for leak tightness if the leak rate $T_f < 2{,}5 \times 10^{-3}$ per hour, at an initial negative pressure of 1 000 Pa. This is equivalent to an increase in pressure of 250 Pa per hour.

It is recommended that the graphical method shown in annex C shall be used to simplify the evaluation.

When using the algebraic evaluation method given in annex B, the differential values shall be in pascals for Δp and in kelvins for ΔT.

When using the method given in annex D, the negative pressure tests shall be entered in the way shown. If used for positive pressure tests, the appropriate changes must be made.

5.3 Constant pressure method
(see ref. [6] and [7])

5.3.1 Principle

The leak rate is evaluated by measuring the flow rate of the extract system needed to maintain the negative pressure of an isolated containment enclosure at a constant level. This flow rate, divided by the enclosure volume, corresponds to the hourly leak rate, at the specified negative pressure, as defined in 3.2.

When the containment enclosure is to be used at a positive pressure, an equivalent method can also be used by measuring the flow rate of the inlet system.

5.3.2 Apparatus (see figure 3)

The use of the normal extract system is recommended when carrying out the test, unless the introduction of the volumetric counter creates any difficulty. If it does, the installation shall be tested in accordance with local regulations.

5.3.2.1 Volumetric counter (for class 3 containment enclosures).

5.3.2.2 Flow meter (for class 4 containment enclosures).

5.3.2.3 Pressure gauge.

5.3.2.4 Thermometer.

5.3.2.5 Regulating valve.

5.3.2.6 Extract (or inlet) system.

5.3.3 Procedure

The measurement of the overall extract (or inlet) flow rate of air is carried out at the actual pressure and temperature values used in normal operation of the containment enclosure. If these pressure and temperature values vary between two limits, the test shall be performed with the set of values leading to the highest leak rate.

During the measurement, the minimum value of the pressure difference between the enclosure and the atmosphere is fixed arbitrarily at 250 Pa for checking during operational use, or 1 000 Pa for the acceptance test (see clause 4).

The installation is set up in normal operational conditions. Once the pressure and the temperature inside the containment have stabilised, the inlet valve and all the other apertures are shut, and the extract flow rate is regulated in order to maintain the negative pressure at its specified value. This extract flow rate, divided by the enclosure volume, corresponds to the hourly leak rate, at the specified negative pressure.

When performing the test at positive pressure a similar procedure shall be used.

5.3.4 Characteristics of the method

This method is simple to operate and is particularly suitable for measuring high leak rates or leak rates on large containment enclosures. It is not a sensitive method and it needs a device able to measure very low flow rates.

5.3.5 Validity range

The measurement shall be less than 10 minutes long to avoid the effect of atmospheric pressure changes in the test room, or temperature change inside the enclosure.

5.3.6 Evaluation and test report

The test report shall include the following particulars:

a) reference to this part of ISO 10648;

b) the hourly leak rate obtained;

c) the conditions in which the measurement was made, namely,

   — the volumes of the installed equipment of the containment enclosure which were taken into account,

   — the equilibrium conditions of the system at the time of the measurement (internal and external temperature, internal pressure, atmospheric pressure, leak rate),

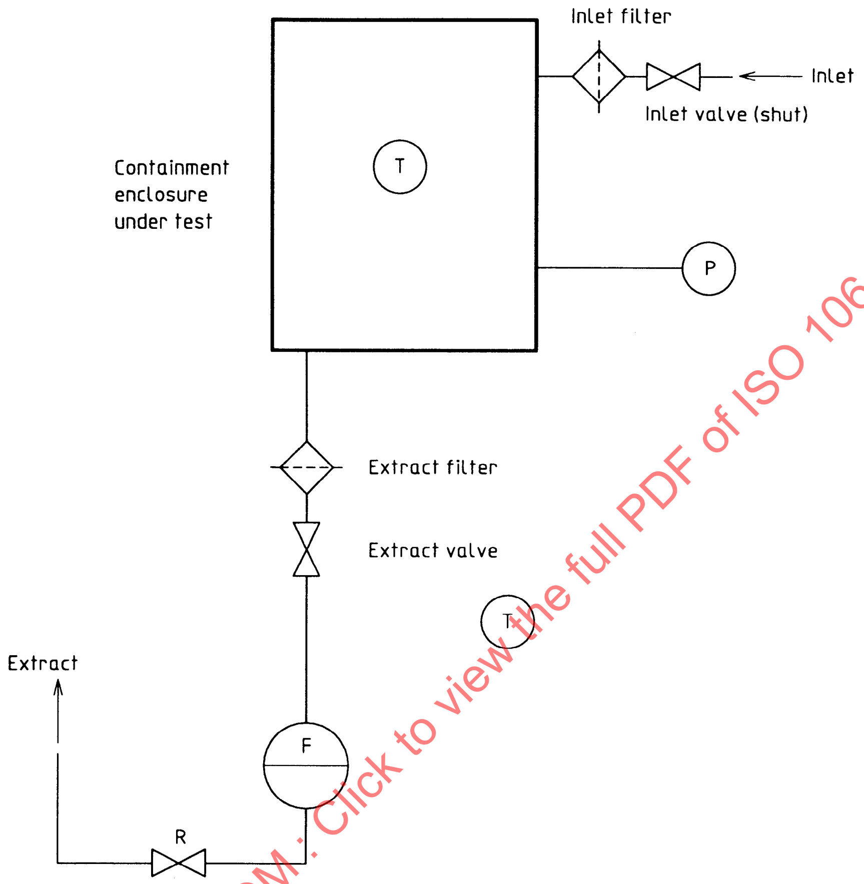
   — the duration of the measurement,

   — the units used;

d) the results obtained;

e) all operating details not specified in this part of ISO 10648, and all incidents that may have influenced the results.

An example of a report of an acceptance test according to the constant pressure is given in annex E.



T Thermometer

P Pressure gauge

F Volumetric counter (class 3) or flow meter (class 4)

R Regulating valve

Figure 3 — Schematic diagram of the measuring system for the constant pressure method (containment enclosure kept at a negative pressure)

Annex A

(informative)

Example of a report of a containment enclosure acceptance test according to the oxygen method (5.1)

1 References

Applicant: ....

Test location: ....

Test operator: ....

Equipment identification: ....

Test date: ....

2 Equipment tested

Enclosure type: ....

Material: ....

Manufacturer: ....

User: ....

Registration number: ....

Serial number: ....

Date of manufacture: ....

Location: ....

Date of entry into service: ....

Enclosure volume: 1,4 m^3

Installed equipment volume: 0,03 m^3

Total test volume including attached volumes (for example filters, ducts, etc.): 1,405 m^3

Enclosure equipment during test:

a) installed equipment: ....

b) connected equipment: ....

3 Operating conditions

Internal containment enclosure temperature:

initial: 20,7 °C final: 20,8 °C

Ambient temperature:

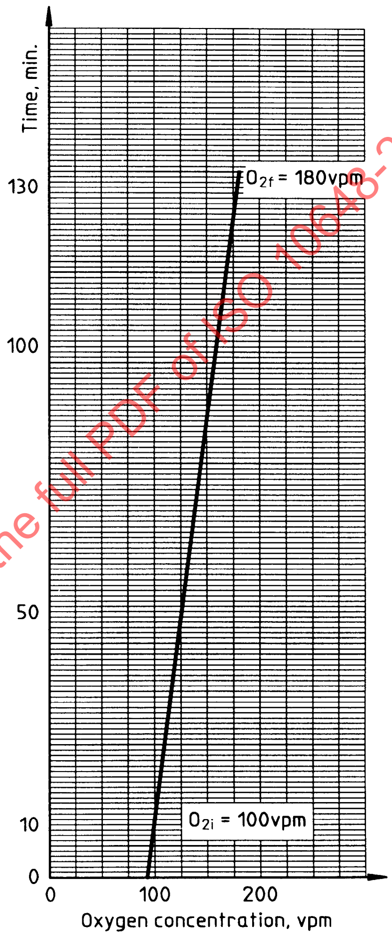
initial: 20,9 °C final: 20,8 °C

Atmospheric pressure:

initial: 101 000 Pa final: 101 000 Pa

Negative pressure in the enclosure: p = 1 000 Pa

Control duration: t = 120 min



4 Results

Initial oxygen concentration: O_{2i} = 100 vpm

Final oxygen concentration: O_{2f} = 180 vpm

Leak rate per hour in air:

$$T_f = 300 \times \frac{O_{2f} - O_{2i}}{t \times 10^6}$$

$$= 300 \times \frac{180 - 100}{120 \times 10^6}$$

$$= 2,0 \times 10^{-4}\ h^{-1}$$

5 Assessment

The leak tightness of the containment enclosure does/~~does not~~ comply with the rate of leakage of a class 1 containment enclosure, in accordance with ISO 10648-2.

Date	Signature and stamp of testing house

Annex B
(informative)

Example of a report of a containment enclosure acceptance test, according to the pressure change method (5.2) — Algebraic evaluation method

1 References

Containment enclosure No: ....
Type designation: ....
Manufacturer: ....
Test operator: ....
Equipment used: ....
Location: ....

Date	Time	Temperature K	Atmospheric pressure Pa	Negative pressure Pa	Absolute pressure Pa
	10 h 00	T_1 = 293,0	101 000	1 000	p_1 = 100 000
	11 h 00	T_n = 292,9	101 020	950	p_n = 100 070
	Duration of test t = 60 min	Temperature difference ΔT = – 0,1			Pressure difference Δp = + 70

2 Results

$$T_f = \frac{60}{t} \times \left(\frac{p_n T_1}{p_1 T_n} - 1 \right)$$

$$= \frac{60}{60} \times \left(\frac{100\ 070 \times 293{,}0}{100\ 000 \times 292{,}9} - 1 \right)$$

$$= 1{,}04 \times 10^{-3}\ \mathrm{h}^{-1}$$

3 Assessment

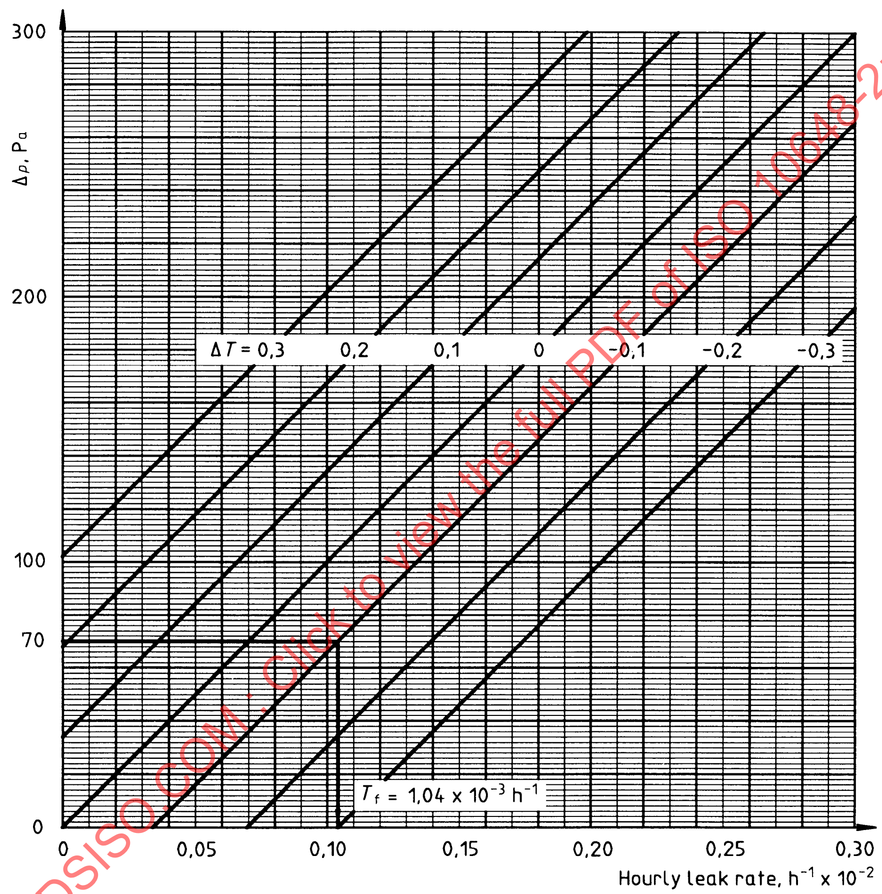
The leak tightness of the containment enclosure does/~~does not~~ comply with the rate of leakage of a class 2 containment enclosure, in accordance with ISO 10648-2.

Date

Signature and stamp of testing house

Annex C
(informative)

Example of a report of a containment enclosure acceptance test, according to the pressure change method (5.2) — Nomogram for graphical determination



EXAMPLE

P_1 = 100 000 Pa, P_n = 100 070 Pa, Δp = + 70 Pa

T_1 = 293,0 K; T_n = 292,9 K; ΔT = – 0,1 K

t = 60 min

T_f = 1,04 × 10^{-3} h^{-1}

Assessment

The leak tightness of the containment enclosure does/~~does not~~ comply with the rate of leakage of a class 2 containment enclosure, in accordance with ISO 10648-2.

Date

Signature and stamp of testing house

Annex D
(informative)

Example of a report of a containment enclosure acceptance test, according to the pressure change method (5.2) — Method taking into account corrections due to variations in temperature and atmospheric pressure

1 References

Test certificate No: ....
Date of test: ....
Containment enclosure references: ....
Location of test: ....
Condition (unpainted/painted):..
Manufacturer:..

2 Record chart

	Initial reading 1	Final reading 2	Change	Equivalent pressure change (Pa)
Temperature of containment enclosure (°C)	20,0	19,9	Fall 0,1 °C ~~Rise~~	− 34 ↘
Atmospheric pressure (Pa)	101 000	101 020	~~Fall~~ Rise 20 Pa	− 20 ↗
Time	10 h 00	11 h 00	60 min	
Containment enclosure negative pressure (Pa)	1 000,0	950		
Room temperature (°C) (for record only)	20,0	19,9		

A Correction of the final pressure in the containment enclosure due to variations in containment enclosure temperature and atmospheric pressure

Containment enclosure pressure = final reading 2 (Pa)		Correction (Pa) for containment enclosure temperature change			Atmospheric pressure change (Pa)		Corrected containment enclosure pressure (Pa)
950	+	Rise		+	Fall		896
	−	Fall	34	−	Rise	20	

B Correction of pressure difference in containment enclosure

Containment enclosure pressure = initial reading 1 (Pa)		Corrected containment enclosure pressure as found at "A" (Pa)		Corrected containment enclosure pressure difference (Pa)
1 000	−	896	=	104

C Containment enclosure leak rate obtained at "B" divided by the initial absolute pressure $\frac{104}{100\ 000}$

D Hourly leak rate

$$\frac{\text{Reading obtained at "C"}}{\text{Time, in hours}} = \frac{1{,}04 \times 10^{-3}}{1} = 1{,}04 \times 10^{-3}\ h^{-1}$$

Test operator: ....

3 Assessment

The leak tightness of the containment enclosure does/~~does not~~ comply with the rate of leakage of a class 2 containment enclosure, in accordance with ISO 10648-2.

Date

Signature and stamp of testing house