BS EN 421:2010

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Protective gloves against ionizing radiation and radioactive contamination

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National foreword

This British Standard is the UK implementation of EN 421:2010. It supersedes BS EN 421:1994 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PH/3/8, Protective gloves.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Protective gloves against ionizing radiation and radioactive contamination

Gants de protection contre les rayonnements ionisants et la contamination radioactive

Schutzhandschuhe gegen ionisierende Strahlung und radioaktive Kontamination

This European Standard was approved by CEN on 22 April 2010.

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Foreword

This document (EN 421:2010) has been prepared by Technical Committee CEN/TC 162 “Protective clothing including hand and arm protection and lifejackets”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2010, and conflicting national standards shall be withdrawn at the latest by November 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 421:1994.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Annex D provides details of significant technical changes between this European Standard and the previous edition EN 421:1994.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies requirements and test methods for gloves to protect against ionizing radiation and radioactive contamination. The standard is applicable to gloves offering protection to the hand and various parts of the arm and shoulder. It applies also to gloves to be mounted in permanent containment enclosures.

This European Standard also applies to intermediary sleeves used between a glove and a permanent containment enclosure (report to 4.7.2.3).

The requirements of this European Standard do not apply to protective gloves against X-ray radiation.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 374-1:2003, *Protective gloves against chemicals and micro-organisms — Part 1: Terminology and performance requirements*

EN 374-3, *Protective gloves against chemicals and micro-organisms — Part 3: Determination of resistance to permeation by chemicals*

EN 388:2003, *Protective gloves against mechanical risks*

EN 420:2003+A1:2009, *Protective gloves — General requirements and test methods*

EN 61331-1:2002, *Protective devices against diagnostic medical X-radiation — Part 1: Determination of attenuation properties of materials (IEC 61331-1:1994)*

ISO 1431-1, *Rubber, vulcanised or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 7000:2004, *Graphical symbols for use on equipment — Index and synopsis*

ISO 11933-1, *Components for containment enclosures — Part 1: Glove/bag ports, bungs for glove/bag ports, enclosure rings and interchangeable units*

ISO 11933-2, *Components for containment enclosures — Part 2: Gloves, welded bags, gaiters for remote - handling tongs and for manipulators*

CEN ISO/TR 11610:2004, *Protective clothing — Vocabulary (ISO/TR 11610:2004)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CEN ISO/TR 11610:2004 and the following apply.

3.1
radioactive contamination
presence of radioactive substances in or on a material or in a place where they are undesirable or could be harmful

3.2
ionizing radiation
radiation constituted by particles directly or indirectly ionizing (photons included) or by a mixture of both

3.3
irradiation
exposure of a living being or matter to ionizing radiation by external sources (X, Alpha, Beta, Gamma or Neutron radiations)

3.4
water vapour permeability
weight of water vapour in grams transmitted through a material per square metre per 24 h time, under specified conditions of temperature and humidity ($gm^{-2}d^{-1}$)

3.5
containment enclosure
enclosure that prevent from the spreading of products contained in the inside medium towards the outside medium, or the penetration of outside atmosphere towards the inside medium or both

3.6
glove box
containment enclosure in which material or products can be manipulated being isolated from the operator, which is realized thanks to gloves fixed in a tightness way to openings that are designed in walls of the enclosure (glove port or cell ring)

3.7
glove for glove box or for containment enclosure
glove with a long cuff constituted in flexible elastomeric material, intended to enable a tight clamping on the circumference or the extremity of a glove port or on any other component and enabling at the same time a good mechanical resistance

3.8
glove port
cylindrical collar fitted with a bead or a groove, fixed on the wall of a glove box or a containment enclosure in order to receive a glove or any other flexible accessory finished with a bead of same diameter

3.9
cell ring
sectional ring in plastic or metal fixed on the enclosure, that receive interchangeable tightness accessories by pushing and which can be replaced without breaking the containment

3.10
support ring
interchangeable tightness ring, in metallic alloy or plastic, fitted with grooves, fixed on a cell ring and equipped with a glove or other plastic component, finished by a bead, a toric joint or a lip joint of same diameter

3.11
protective glove material
material or combination of materials used in a glove for the purpose of preventing the user from direct contact with radioactive contamination or of minimizing the radiation dose to the user from external radiation sources

4 Requirements

4.1 General

Table 1 gives the requirements for gloves and gloves for containment enclosures for protection against radioactive contamination and protection against ionizing radiation.

Table 1 — Requirements for gloves and gloves for containment enclosures

		Gloves		Gloves for containment enclosures	
		Protection against radioactive contamination	Protection against radioactive contamination and protection against ionizing radiation	Protection against radioactive contamination	Protection against radioactive contamination and protection against ionizing radiation
Requirements	4.2.1	X	X	X	X
	4.2.2	X	X		
	4.3		X		X
	4.4	X	X		
	4.5	X	X	X	X
	4.6	✶	✶	✶	✶
	4.7.2			X	X
	4.7.3			X	X
	4.7.4			♦	♦

✶ : optional requirement

♦ : mandatory if the gloves are used in an atmosphere containing ozone

4.2 Design principles

4.2.1 General principles

The glove shall comply with the relevant requirements defined in EN 420, with the following specific additions.

The glove may be constructed from a single or multiple material layers. The choice of material is defined by the end use requirements.

In the case of protection against external ionizing radiation the glove may contain lead (PbO, Pb_3O_4) or other heavy metallic elements to act as attenuation medium in one or more of the layers. Metallic element distribution may be uniform or designed.

4.2.2 Glove sizing and dimensions

Gloves shall be sized following prescriptions of EN 420:2003+A1:2009, 5.1.

NOTE In case where specific use identified, special tests can be identified according to Annex B.

4.3 Attenuation efficiency and uniformity of distribution of protective material

The lead equivalent thickness shall be measured by one of the methods described in 5.1. The test methods give equivalent results.

The efficiency of the glove material to absorb radiation is quoted as lead equivalent thickness. The gloves shall have at least a lead equivalence thickness of 0,05 mm.

Except for special design (see 4.7.2) the uniformity shall be such that no single measurement shall be below the specified value of the stated lead equivalent thickness. A minimum of four measurements shall be taken for each test condition (see 5.1.3) and the minimum value obtained is taken as the lead equivalence in millimetres.

The lead equivalent thickness shall always be linked with the nature and energy of the radiation used during tests (see Clauses 6 and 7).

4.4 Glove integrity

The purpose of the glove to protect against ionizing radiation or radioactive contamination is to isolate the user from the potential hazard. This is only possible if the integrity of the glove is proven.

Gloves shall pass an integrity test: the integrity shall comply with the requirements of EN 374-1:2003, 5.2.

4.5 Mechanical requirements

For each protective glove against radioactive contamination and/or ionizing radiation, the obtained performance level shall be indicated in the information supplied by the manufacturer for the following mechanical tests:

— abrasion resistance;

— blade cut resistance;

— tearing resistance;

— puncture resistance.

According to the test methods described in EN 388:2003, at least level 1 shall be reached for one of the four mechanical properties. For special purposes, dexterity is the most important parameter, in this case no level of protection of EN 388 has to be reached, but the following sentence shall be written in the user notice of the gloves: “This gloves does not protect against mechanical risks."

4.6 Chemical requirements

If required, the chemicals properties of the gloves shall be determined following the requirements defined in EN 374-1:2003, 5.3.1. The test method for permeation is described in EN 374-3.

Two possibilities are acceptable:

— The glove fulfills EN 374-1:2003, 5.3.2; In this case the pictogram of EN 374-1:2003, Figure 1 shall be used.

— The chemicals to be tested are defined taking into account the use of the glove at the work place. In this case the pictogram of EN 374-1:2003, Figure 2 shall be used.

4.7 Specific requirements for gloves for containment enclosures

4.7.1 General requirement for gloves for containment enclosures

Gloves for containment enclosures shall comply with 4.1, 4.2, 4.3 and 4.4.

NOTE Annex A provides an optional test method for water vapour permeability.

4.7.2 Design for gloves for containment enclosures

4.7.2.1 General

The glove shall comply with the relevant requirements defined in ISO 11933-2.

When the metallic element distribution is not uniform over the glove, the manufacturer shall mark the equipment and provide the information accordingly (see Clauses 6 and 7).

4.7.2.2 Glove sizing and dimensions

In the case of gloves to be mounted in containment enclosures, prescriptions of ISO 11933-1 and ISO 11933-2 shall be followed.

Gloves used in containment enclosures are often used with under gloves. The user will have to take into account this parameter for the choice of an adapted size of equipment.

NOTE ISO 11933-1 and ISO 11933-2 detail a list of characteristics of standardized gloves, glove ports, support rings, cell rings, etc.

4.7.2.3 Accessories used with gloves

4.7.2.3.1 Gloves equipped with a support ring

In a few permanent containment enclosures, gloves can be equipped with a support ring. The support ring is considered as an integral part of the glove, and the whole equipment shall be tested according to the air leak test using a test bench equipped with a cell ring (see 4.7.3).

4.7.2.3.2 Sleeve

Gloves mounted in permanent containment enclosures can be used with an intermediary sleeve, fixed between the glove and the containment enclosure. This sleeve is not considered as an integral part of the glove. It shall fulfill all requirements of this European Standard and shall be compatible with the glove used.

The way of fixation between the glove and the sleeve and between the sleeve and the containment enclosure shall be detailed in the information supplied by the manufacturers.

The sleeve shall be tested with one compatible glove as regards the integrity using the air leak test (see 4.7.3)

Such an assemblage shall resist to a tensile strength test of 100 N according to 5.4.

4.7.3 Specific integrity test for gloves for containment enclosures

The integrity of gloves used in containment enclosures shall be tested by the air leak test described in 5.2. The pressure shall not decrease by more than half the initial pressure. The initial pressure shall be mentioned in the instructions supplied by the manufacturer if it is different from 3 000 Pa.

4.7.4 Resistance to ozone cracking (static strain)

When gloves can be exposed to ozone, the resistance to ozone cracking shall be determined.

NOTE Powders emitting alpha particles can generate ozone containment enclosures.

The performance level shall be determined by the method described in 5.3; at least level 1 of Table 2 shall be achieved.

Table 2 — Performance level: Resistance to ozone cracking

Performance level	State of the material
1	cracks apparent at 10 % elongation
2	no cracks apparent at 10 % elongation
3	no cracks apparent at 20 % elongation
4	no cracks apparent at 100 % elongation

5 Test methods

5.1 Determination of lead equivalent thickness and uniformity of distribution

5.1.1 Introduction

This European Standard specifies several methods by which lead equivalent thickness may be measured. Either method may be used for determination. The determination of lead equivalent thickness does not lead to an absolute answer but will depend upon the source and energy spectrum of the radiation and hence should always be used as a relative measure.

In addition, due to its toxicity, Lead is today more and more substituted by other materials and therefore the lead equivalent thickness shall be checked at different conditions (see 5.1.3). These conditions have been selected because they give a good correlation with the behaviour of the material of the gloves exposed to commonly used radionuclides such as Americium and Plutonium.

NOTE The user should be warned that if other radionuclides are used, the behaviour of the gloves could be different.

Several detectors can be used for the detection of the X-rays. The corresponding test methods are developed hereafter. Either of them can be used for the determination of the lead equivalence thickness.

5.1.2 Sampling

The sampling does not depend on the test method used.

A minimum of two samples shall be tested.

On each sample, a minimum of four measurements shall be done. The definition of the surface of a measurement point is developed in each specific test method. These points are placed:

— on the centre line of the palm side of the glove, at the centre of the palm;

— on the centre line of the palm side of the glove, at a distance of 10 cm from the cuff;

— on the centre line of the back side of the glove, at the centre of the back;

— when possible, on one finger (the thumb for example);

— when the measurement on the finger is impossible (due for example to the shape of the equipment or to the test method used), and for long dimensions gloves, another measurement point is placed on the centre line of the palm side of the glove, at the mid point between the palm and the cuff.

5.1.3 Test conditions

The test method used for determination of lead equivalent thickness and uniformity of distribution (see 5.1.5, 5.1.6 and 5.1.7) shall be performed with a test bench of EN 61331-1, at the following X-ray beam qualities:

— X-ray tube voltage of 70 kV with a copper filtration of 0,10 mm;

— X-ray tube voltage of 100 kV with a copper filtration of 0,25 mm;

— X-ray tube voltage of 120 kV with a copper filtration of 0,40 mm;

— X-ray tube voltage of 150 kV with a copper filtration of 0,70 mm.

5.1.4 Expression of results

The minimum value obtained for the measurement points and for the different test conditions is taken as the lead equivalence in millimetres.

5.1.5 Detection with an X-ray film

5.1.5.1 Principle

Lead equivalence thickness shall be determined by a standard X-ray tube source. The gloves shall be compared with calibrated lead step wedges.

The method consists of placing an X-ray film under different parts of the glove placed next to calibrated lead step wedges. The whole system is then exposed using an x-ray tube with the specified x-ray tube voltage and filtration. The X-ray film is then developed and read on a densitometer.

The test bench of EN 61331-1:2002, Figure 1 shall be used (large beam geometry test bench).

5.1.5.2 Apparatus and consumable

5.1.5.2.1 Generator delivering a continuous X-ray beam at 70 kV, 100 kV, 120 kV and 150 kV.

5.1.5.2.2 Appropriate Copper filter (respectively 0,10 mm Cu, 0,25 mm Cu, 0,40 mm Cu and 0,70 mm Cu).

5.1.5.2.3 Calibrated step wedges in lead.

5.1.5.2.4 Elements of the test bench: collimation of the generator, supports of the test bench.

5.1.5.2.5 Appropriate X-ray films.

5.1.5.2.6 Densitometer.

5.1.5.2.7 Necessary laboratory apparatus for the developing of X-ray films.

5.1.5.3 Procedure

5.1.5.3.1 General

The measurement points are identified on the samples. Each measurement point can be considered as a circular surface of approximately 5 cm² (diameter of approximately 2,5 cm). Then, the glove is cut in sections perpendicular to the longitudinal axis of the glove, around the measurement points.

The section of material to test is placed on an X-ray film placed in an appropriate test bench. Calibrated lead step wedges of adapted thicknesses are placed beside the section of the glove, on the X-ray film. The system is then exposed to the radiation of a continuous X-ray generator at one specified test condition (see 5.1.3). Exposure times will be dependant on both the intensity of the X-ray source and the attenuation efficiency of the glove. Exposure times and current are chosen such that a readable optical density is obtained on the X-ray film. Then, the films are developed in a developing laboratory.

The images on the X-ray films are read by an optical density measure using a densitometer. In each measurement point, proceed to five optic density measurements and consider the average value as the point result. On each calibrated lead step wedge, proceed to a minimum of three optical density measurements and consider the average value as the result. This procedure is repeated for each measurement point of each sample.

The continuous X-ray generator has to be sufficiently stabilized before used for the measurements. This can be achieved by carrying out several blank expositions.

5.1.5.3.2 Important remarks

Special attention has to be brought on the support on which the X-ray film is placed. The support will be made or covered with a material of high atomic number (Lead for example) so as to reduce the backscatter as much as possible.

In the case of a film that can be irradiated on both sides, the support described above has to be covered by a material of low atomic number (Plexiglas for example) in order to avoid the influence of electrons pulled out of the support in Lead.

When placing the section of material on the X-ray film, special attention has to be brought on placing the material in a way as flat as possible in order to avoid folds that may cause heterogeneities, with as low tension as possible.

5.1.5.3.3 Report and calculation

Determine the regression curve obtained with the calibrated lead step wedges (the lead equivalent thickness being a function of the optical density) and calculate the thickness of the measurement point using this curve. The lead equivalent thickness obtained shall be given with its expanded uncertainty of measurement.

This test method also enables to check defects in the material (for examples tears, bubbles and so on). If such defects are observed, the testing report will precise place, nature and if possible, lead equivalent thickness.

5.1.6 Detection with numeric films

The method is identical with the one described in 5.1.5, except that a numeric film such as a photostimulable film or equivalent system can be used for the detection instead of an X-ray film. The reading of the film is then carried out using an adapted numeric treatment.

5.1.7 Detection with an ionising chamber

5.1.7.1 Principle

The method used is that of EN 61331-1. It consists to carry out successive expositions of calibrated lead step wedges and of sections of the glove to measure with a continuous X-ray generator which deliver a collimated beam and to measure successively the attenuation that arises. Geometric conditions of the X-ray tube are fixed by EN 61331-1. The attenuation is measured using an ionizing chamber which gives a measurement in terms of air kerma rate.

The measurement point is a circular surface of approximately 3,5 cm² (diameter of (2,0 ± 0,1) cm).

5.1.7.2 Procedure

The test procedure shall be that described in EN 61331-1 as regards the measurement of the lead equivalent (narrow beam geometry test bench) with test conditions as specified in 5.1.3.

5.1.7.3 Report and calculation

Determine the regression curve obtained with the calibrated lead step wedges (the lead equivalent thickness being a function of the air kerma rate) and calculate the thickness of the measurement point using this curve. The lead equivalent thickness obtained shall be given with its expanded uncertainty of measurement.

NOTE Annex C provides information regarding uncertainty of measurement and result interpretation.

5.2 Determination of glove integrity, air leak test

5.2.1 Principle

The method allows for verification of glove tightness of containment enclosure gloves in conditions similar to their use. The gloves are mounted on a vertical glove port (respectively cell ring) in conditions of fixing representative of their use and inflated with air at ambient temperature. Due to internal pressure, glove rises to the horizontal position and may be checked for leaks.

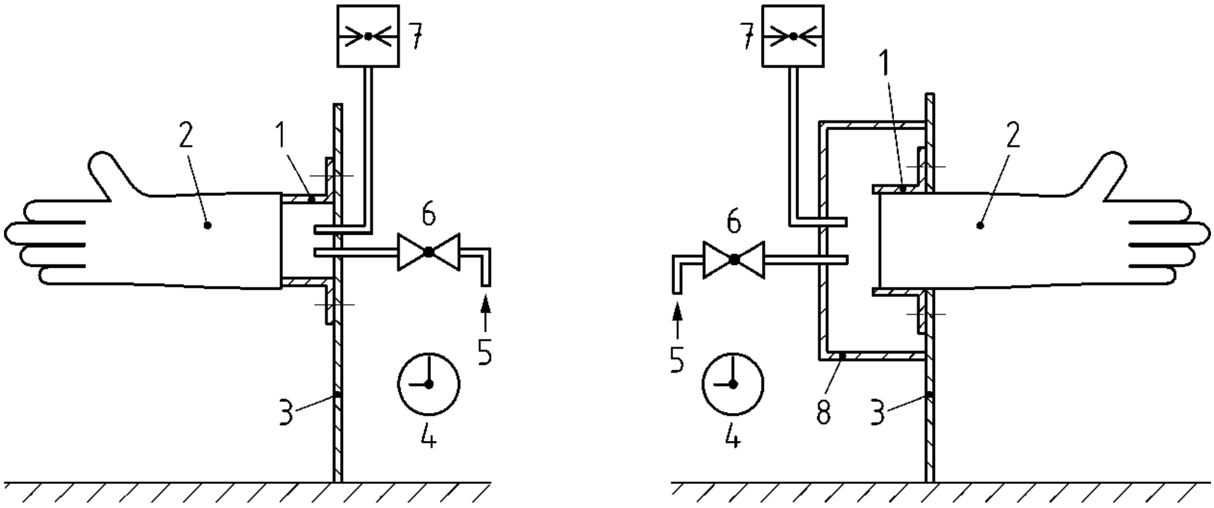
For gloves used with a sleeve, the sleeve shall also be submitted to the integrity test. The sleeve and the glove shall be tested simultaneously. Fixing conditions detailed in the information supplied by the manufacturers shall be respected.

5.2.2 Sampling

A minimum of two samples shall be tested.

5.2.3 Test apparatus

The test apparatus consists of a vertical panel equipped with all diameters of glove ports (respectively cell rings) used on containment enclosures. The vertical panel closes the opening of the gloves and is equipped, for each port size (respectively cell ring size) with an inflation valve and a manometer. For pressure testing the manometer is graduated for high pressure from 0 Pa to 10 000 Pa. The equipment is completed by a clock. Examples of diagrams of the apparatus are given in Figure 1.



Key

1 glove port or cell ring

2 test glove

3 backing panel

4 stop clock

5 closure value

6 input air (10 000 Pa)

7 manometer (0 Pa to 10 000 Pa)

8 closure panel

Figure 1 — Examples of glove integrity test apparatus for the air leak test

5.2.4 Test procedure

The glove (or the glove mounted with its sleeve) to be tested is fitted on the glove port (respectively the cell ring) having the same diameter as the glove opening (respectively the support ring opening). The glove (or the glove mounted with its sleeve) is inflated with air to 3 000 Pa high pressure at ambient temperature. The pressure is high enough to maintain the glove (or the glove mounted with its sleeve) in a horizontal position (this pressure is higher than usage pressure). If the glove (or the glove mounted with its sleeve) cannot be maintained on the test bench thanks to the bead (because of the high pressure), an accessory (adhesive tape, clamping ring) shall be used to ensure the keeping on the test bench. In this case, the information supplied by the manufacturer shall mention that accessories shall be used and precise their nature.

The air pressure valve is then closed and the pressure inside the glove is measured after 1 h.

Certain gloves (or gloves mounted with their sleeves) cannot be inflated to 3 000 Pa due to their material, thickness or shape. In these particular cases, equipments are inflated at the highest possible pressure. The pressure of test shall be mentioned in the information supplied by the manufacturer.

5.2.5 Test report

The number of tested gloves (or gloves mounted with their sleeves), the use of additional accessories and the test conditions used are reported.

5.3 Determination of resistance to ozone cracking (Static Strain Method)

5.3.1 Procedure

The test procedure shall be according to ISO 1431-1 with the following test conditions.

5.3.2 Test conditions

The test shall be carried out at (40 ± 2) °C in an ozone concentration of (50 ± 5) pphm. The duration of the test shall be four days.

5.3.3 Sampling

A minimum of two samples shall be tested.

5.3.4 Reporting of results

The results shall be reported in the form of a performance level as shown in Table 1.

5.4 Pull test for assemblages (sleeve and glove)

Assemble the means of attachment according to the manufacturer's instructions. If the glove is not strong enough to apply a 100 N pull substitute an item that fulfills this requirement. Securely attach one member to a fixed clamp and the other to a moveable clamp. Apply a force longitudinally to the assembly up to 100 N. Record the force at which it parts or state that at 100 N it was still complete.

6 Marking

Marking of the protective glove shall be in accordance with the marking requirements for gloves of EN 420. Besides, the appropriate pictograms (Figures 2 and 3) shall be used. The pictograms shall be accompanied by the number and date of the standard. Additional marking on the gloves or the nearest possible packaging unit may be specified by the manufacturer (i.e. nature of material: Butyl).

For gloves protecting against chemicals, the pictogram of EN 374-1 shall be used.

NOTE The reference of gloves can follow information provided in ISO 11933-2.

For gloves protecting against particulate radioactive contamination, the pictogram ISO 7000-2484 of Figure 2 shall be used.

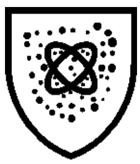


Figure 2 — Pictogram ISO 7000 – 2484
Protection against particulate radioactive contamination

For gloves protecting against ionizing radiation, the pictogram ISO 7000-2809 of Figure 3 shall be added. The marking shall specify the lead equivalence thickness in millimetres together with the test conditions used during tests (for instance, "X - 70 kV - 0,10 mm Cu ; X - 100 kV - 0,25 mm Cu ; X - 120 kV - 0,40 mm Cu ; X - 150 kV - 0,70 mm Cu"). For gloves owning different lead equivalent thicknesses depending on the part of the glove, each part shall be clearly marked by mentioning the corresponding lead equivalent thickness.

**Figure 3 — Pictogram ISO 7000 – 2809
Protection against ionizing radiation**

7 Information supplied by the manufacturer

The information supplied by the manufacturer shall be in accordance with the requirements for information as required in EN 420. In particular, following information shall be indicated:

a) Application of the gloves;

b) Limitation on use;

c) Performance level of the equipments against radioactive contamination and/or ionising radiation;

d) Mechanical levels of performance according to standard EN 388;

e) In case of chemical protection, the names and breakthrough of chemicals tested according to EN 374-1;

f) Specific information for gloves used in containment enclosures:

   1) Characteristics of the equipment:

      i) For gloves fitted with a bead: bead diameter, diameter of the cuff or useful diameter of the glove port on which the glove can be fixed;

      ii) For gloves equipped with a support ring: diameter of the support ring or useful diameter of the cell ring on which the support ring can be adapted, diameter of the groove of the support ring, bead diameter;

   2) If relevant, the water vapour permeability result (informative);

   3) If relevant, the additional accessories used during the integrity test;

   4) The test pressure of the integrity test;

g) Specific information for protective gloves against ionising radiation:

   1) A specific warning shall be added specifying that gloves containing elements of high atomic number shall not be used to protect against radioelement of high beta energy so as to avoid bremsstrahlung;

   2) For gloves owning different lead equivalent thicknesses depending on the part of the glove, the detail of the lead equivalent thicknesses depending on the parts of the glove;

h) For reusable gloves, information on checks to be carried out by the user to verify degradation or lowering of protective performances during the glove life duration.

Annex A
(informative)

Determination of water vapour permeability

A.1 Requirement for water vapour permeability

Gloves used in containment enclosures are often required to offer an impermeable barrier to water and water vapour when the enclosures are required to work under anhydrous conditions. Measurement of water vapour permeability can therefore be an important factor in glove selection.

For assessment of the permeability of a glove, report to test method given in this Annex.

NOTE The method given in this Annex is applicable to impermeable materials offering a degree of resistance to the passage of water vapour, and should not be confused with the method given in EN 420 which is designed to measure the permeability of leather.

A.2 Test method

A.2.1 Principle

The purpose of this test is to determine the permeability to water vapour of elastomeric materials. In the proposed method a quantity of desiccant is enclosed in a dish sealed by a sheet of the material. The dish assembly is stored in a conditioned atmosphere. The rate of water vapour transmission is computed from the rate of increase in weight of the dish assembly.

A.2.2 Apparatus and materials

A.2.2.1 Test dishes (see Figure A.1)

Dimensions in centimetres

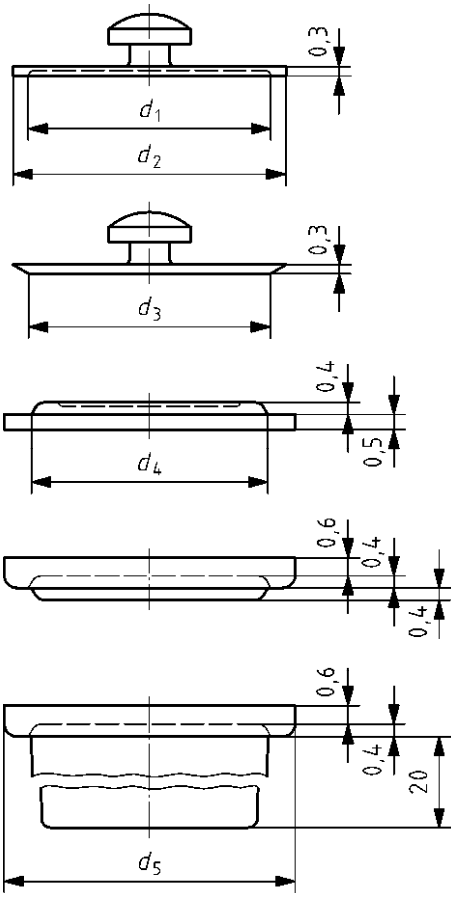


Figure A.1 — Diagram of dishes and templates (water vapour permeability test)

Shallow aluminium dishes of as large a diameter as can conveniently be accommodated on the balance shall be used.

The test dishes shall be designed so that the area of specimen under test is accurately defined and the wax seal between the sheet and dish satisfactorily prevents the transmission of water vapour at or through the edges of the sheet.

Figures for dishes and lids show inside dimensions, except the overall diameter of the dishes, which is an outside dimension.

Table A.1 — Dimensions used for test dishes

Test areas	d_1 **[cm]**	d_2 **[cm]**	d_3 **[cm]**	d_4 **[cm]**	d_5 **[cm]**
50 cm^2	8,0	9,0	7,98	7,8	9,6
25 cm^2	5,7	6,6	5,64	5,4	7,2
Dimensions are shown for test areas of 50 cm^2 and 25 cm^2.					

Recommended material: 20 standard wire gauge (0,914 mm) aluminium sheet.

A.2.2.2 Weighing covers

If the test dishes are removed from the cabinet or room for weighing, an aluminium lid shall be provided to fit each dish in order to minimise changes in weight while the specimens are out of the controlled atmosphere.

Figure A.1 shows a suitable design of dish and templates for cutting and sealing the specimens. Using the dimensions shown, test areas of 50 cm² are obtained. The dishes and their covers shall be manufactured from 20 standard wire gauge deep drawing quality, aluminium sheet.

A.2.2.3 Balance

The balance used shall be accurate ± 0,5 mg.

A.2.2.4 Equipment of testing cabinet

The testing cabinet shall have racks to support the dishes and means of circulating air conditioned at (50 ± 5) % relative humidity and (25 ± 2) °C for the temperature test.

Care should be taken to ensure that the cabinet is not loaded to such an extent that the rate of moisture up-take reduces the relative humidity below the lower limit specified.

A.2.2.5 Desiccant

The desiccant used shall be such that the relative humidity within the dish does not rise above 2 % during the determination. Anhydrous calcium chloride is suitable and should be used in the form of small lumps free from fine material, 10 to 20 mesh size is recommended.

A.2.2.6 Wax

The wax compound used for sealing shall adhere firmly both to the surface of the specimen and to the dish and shall not be brittle at room temperature. It is important that the wax be relatively stable and non-absorbent to water vapour; the weight change on an area of 50 cm² wax surface exposed for 24 h at 90 % relative humidity and 38 °C shall be less than 1 mg.

A.2.2.7 Thickness measurement

The sample thickness in millimetres shall be measured using an apparatus complying with ISO 4648.

A.2.3 Sampling

A minimum of two samples shall be tested.

A.2.4 Procedure

The test specimen is measured using a template which is of such diameter that the edge of the specimen projects halfway over the annular recess of the dish. The thickness is measured according to ISO 4648. The dish is filled with desiccant to within 1 mm to 3 mm of the supporting ring on which the sample is then centred. In case of multi layers gloves, the external face of the glove is placed on the inside of the test dish and the internal face, on the extern part. The waxing template is placed centrally over the dish and test specimen and molten wax is run into the annular recess until the wax is level with the top surface of the template. Any air bubbles in the wax should be broken with a small air jet, the wax allowed to harden and the template removed.

The dish is inspected to ensure that the seal is satisfactory and any wax on the outside is removed. It is important that the filling and sealing of the dish is carried out as rapidly as possible so that the desiccant absorbs a minimum of water vapour from the atmosphere. Care shall be taken not to damage the test area during the operation or to allow the desiccant to come into contact with it. To facilitate the removal of the template from the wax, a thin film of petroleum jelly should be applied to the bevelled edge before sealing; any surplus on the lower surface should be removed.

The required number of dishes is prepared and placed in the humidity cabinet. Successive weighing is made at suitable intervals which shall be sufficient frequent to complete the test before the relative humidity in the dish rises above 2 %. The cumulative weight increase of each dish in milligrams is plotted against the total time of exposure in the cabinet; when at least three but preferably four points lie on a straight line, a constant rate of gain has been attained and the experiment may be discontinued. The weighing should be made to an accuracy of 1 % of the weight change between two successive weighing. Where possible the cabinet and balance should be kept in a room held at constant humidity and temperature. The following procedure is recommended. About eight dishes are removed from the cabinet at a time and immediately covered with their respective lids. The dishes should be allowed to cool until their temperature is not appreciably different from that of the room.

At the completion of the weighing the lids are removed and the samples immediately replaced in the cabinet. Precisely the same routine and time schedule shall be followed in detail at each successive weighing interval.

A.2.5 Report, calculation and result

The water vapour permeability shall be reported as grams per square meter per 24 h at 25 °C and a relative humidity of 50 %. Thickness of sample shall also be reported.

The permeability shall be calculated from the slope of the graph which has been obtained by plotting the cumulative weight increase of each dish in milligrams against the total time of exposure in the cabinet. The required slope is that of the best straight line drawn through those points which represent the constant rate of gain. If this is such that x mg is the weight increase over a period of y hours for an exposed area of A cm², the permeability is:

$$\frac{240 \times x}{A \times y}$$ in grams per square metre per 24 h exposure.

The corresponding test result is given in the information supplied by the manufacturer.

Annex B
(informative)

Warning

B.1 General

Special attention should be paid on the relation between actual conditions in the workplace and test methods.

In most cases, the degradation of the glove will be the result of a combination of several factors: exposition to chemicals, mechanical attacks, exposure to ionizing radiation. Therefore, it is extremely difficult to account for these combined exposures by testing.

To make sure that equipments are not degraded, users will have to check equipments regularly during their life duration.

Anyway, in cases where specific use was identified, special tests may be defined according to the prescriptions given in B.2 and B.3.

B.2 details specific tests for chemical resistance.

B.3 gives elements to carry out specific tests for ionizing radiation resistance. These tests are recommended when gloves are exposed to high levels of radiation. Due to the variety of glove materials and radiation nature, it is very complex to establish a general test simulating exposition to ionizing radiation. Thus the Annex reminds essential parameters that have to be defined before the beginning of such tests.

B.2 Special tests: Chemical resistance

B.2.1 This Annex gives suggestions for special chemical tests including ageing of gloves in chemicals, to be carried out where required by the user.

B.2.2 The nature of the test depends on the nature of the material of the glove and the type of hazard (acids, chlorinated solvents, aromatic solvents, ionizing agents, etc.). These tests use initial and final tensile strength and elongation at break measurements as measures of the degradation or other tests including a percentage swell as determined by the customer. Test conditions shall be defined for each category of hazard and the level of protection defined in each case.

B.3 Special tests: Radiation resistance

This requirement concerns only gloves which may be exposed to high levels of radiation (i.e. in containment enclosures) such that the mechanical properties of the material may be modified. In such cases it may be both necessary and advisable to check the radiation resistance of materials by irradiation tests, prior to glove material selection. The conditions of testing have to be determined, taking into account the:

— Nature and energy of the radiation;

— Dose rate in air;

— Testing dose;

— Environment;

— Temperature;

— Mechanical stress, etc.;

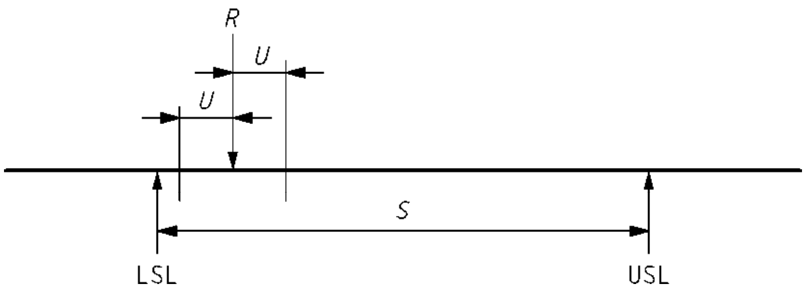
— Sample thickness.

Annex C
(informative)

Uncertainty of measurement and results interpretation

The following protocol with regard to uncertainty of measurement shall be applied to test results, where the non-consistent decision could lead to health and safety risks for the end user of the products.

If the test result plus/minus the uncertainty *U* of measurement falls between the upper and lower limiting values of the specification zone, then the result should be deemed to be a straightforward pass (see Figures C.1 and C.2).



Key

R result of a measurement

S specification zone

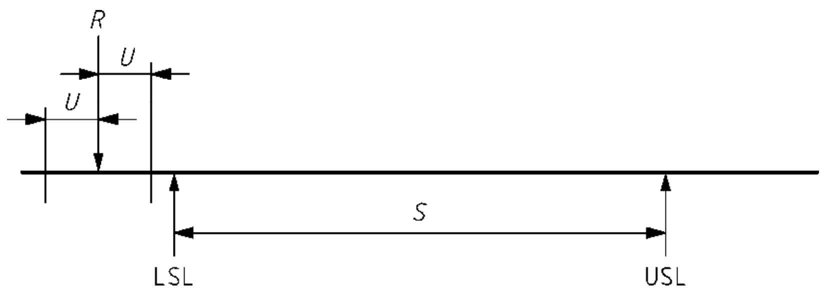
LSL lower specified limit

USL upper specified limit

U uncertainty of measurement

Figure C.1 — Result pass

If the test result from the test data plus/minus the uncertainty of measurement *U* falls outside of the upper or lower limiting values of the specification zone, then the result should be deemed to be a straightforward fail (see Figure C.2).



Key

R result of a measurement

S specification zone

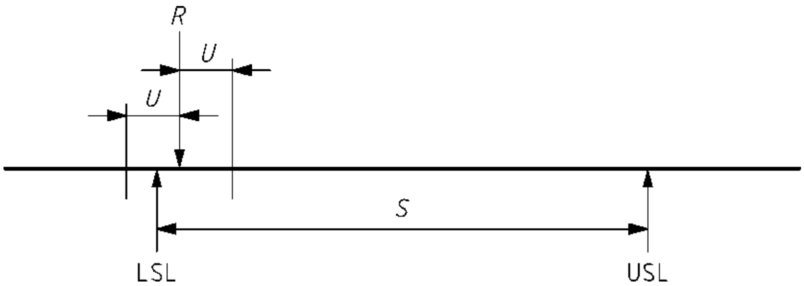
LSL lower specified limit

USL upper specified limit

U uncertainty of measurement

Figure C.2 — Result fail

If the test result falls within the specified limits of the specification zone, but the uncertainty of measurement *U* falls outside of the upper or lower limiting values, then the result should be deemed a fail (see Figure C.3).



Key

R	result of a measurement	LSL	lower specified limit
S	specification zone	USL	upper specified limit
		U	uncertainty of measurement

Figure C.3 — Result fail

Annex D
(informative)

Significant technical changes between this European Standard and the previous edition

The following list gives significant technical changes between this European Standard and its previous edition EN 421:1994:

a) Clearer structure of the standard concerning gloves / gloves for containment enclosures;

b) Additional requirements for specific accessories used with gloves for containment for enclosures (support ring, sleeve);

c) Water vapour permeability has been modified into an optional test;

d) Test method for determination of lead equivalent thickness and uniformity of distribution has been updated (new detection techniques added).

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 89/686/EEC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of the EU Directive 89/686/EEC on Personal Protective Equipment (PPE).

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and EU Directive 89/686/EEC on PPE

Clause(s)/sub-clause(s) of this EN	Essential Requirements (ERs) of Directive 89/686/EEC	Qualifying remarks/Notes
4.7.2.3.2; 4.7.4	1.3.2 Lightness and design strength	
4.7.2.3.2	1.3.3 Compatibility of different classes or types of PPE designed for simultaneous use	
7	1.4 Information supplied by the manufacturer	
4.7.2.3.1; 4.7.2.3.2	2.10 PPE for connection to another external complementary device	
4.6; 6	2.12 PPE bearing one or more dentification or recognition marks directly or indirectly relating to health and safety	
4.5; 4.7.1	3.3 Protection against physical injury (abrasion, perforation, cuts, bites)	
4.4; 4.7.1; 4.7.3	3.9.2.1 Protection against external radioactive contamination	
4.3; 4.7.1	3.9.2.2 Limited protection against external irradiation	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN 374-2:2003, *Protective gloves against chemicals and micro-organisms — Part 2: Determination of resistance to penetration*

[2] ISO 4648, *Rubber, vulcanized or thermoplastic — Determination of dimensions of test pieces and products for test purposes*

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