INTERNATIONAL STANDARD

ISO 15080

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Nuclear facilities — Ventilation penetrations for shielded enclosures

Installations nucléaires — Traversées de ventilation pour enceintes blindées

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Foreword

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

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

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

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

International Standard ISO 15080 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

Annex A forms an integral part of this International Standard. Annexes B and C are for information only.

Introduction

This International Standard provides guidance and recommendations for the design, mounting and assembly of static penetration systems used for ventilation purposes in shielded enclosures. It gives general requirements on the material to be used, the construction of the different types of penetrations which can be used, the way of mounting and assembling and, finally, standard dimensions for some typical equipment.

Nuclear facilities — Ventilation penetrations for shielded enclosures

1 Scope

This International Standard specifies the requirements for the construction and the installation of radiobiological shielding devices used as ventilation passages through shielded enclosures with concrete or leaded walls to protect against gamma radiation.

This International Standard applies to all shielded containment enclosures used for handling radioactive products or material emitting penetrating radiation (gamma or neutrons) in such quantities and of such emission rate that these products must be handled remotely behind a shielding wall. Typically, the enclosures considered cover all types of nuclear fuel cycle installations: reprocessing plants, hot activity laboratories, plutonium solution handling facilities, shielded cells, waste storage installations, etc.

It could eventually be applied to particle accelerators, primary containment of research reactors, fusion research reactors, radiographic installations, neutron generators, etc.

However, pressurized vessels, sealed sources, transport packaging for radioactive materials, as well as enclosures, primary circuits and vessels of nuclear power plants have been deliberately excluded from the scope of this International Standard.

This International Standard specifies general and detailed principles which shall be respected when designing ventilation penetrations for shielded enclosures. These specifications can be divided more generally into two categories of guidance, which apply to the two following systems of ventilation penetrations for shielded enclosures already in use:

— the first corresponding to the most important conventional systems used worldwide, and

— the second corresponding to an alternative method, called the “cast iron helix technique”.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3452, *Non-destructive testing — Penetrant inspection — General principles.*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
containment enclosure
enclosure designed to prevent leakage of products contained in the internal environment under consideration into the external environment, or the penetration of substances of the external environment into the internal environment, or both simultaneously

NOTE This is a generic term to designate all kinds of enclosures, including glove boxes, or cells of different dimensions used for handling or storing radioactive materials by means of handling devices.

3.2
shielded enclosure
containment enclosed by an additional shielding wall intended to provide complementary shielding against penetrating radiation

NOTE This additional shielding wall can be integral with, mounted on, or independent of the containment enclosure wall. The choice and thickness of the protection material depend on the type of radiation (beta, gamma or neutron) and the type of handling required.

3.3
static service penetration
(for a shielded enclosure)
device used in a containment enclosure wall for the introduction or the extraction of fluids such as air, water, gas, water vapour, or the transmission of energy

3.4
ventilation penetration
(for a shielded enclosure)
device installed on a ventilation network and mounted on a shielded enclosure wall, intended to ensure the shielding continuity of the enclosure wall and the required passage of the air or gas through this enclosure wall

4 Design of ventilation penetrations

4.1 General principles

The general and detailed design principles for ventilation penetrations for shielded enclosures, specified in this International Standard, can be divided more generally into two categories of guidance, which apply to the two following systems of ventilation penetrations for shielded enclosures already in use:

— the first corresponding to the most important conventional systems, which are used worldwide, and

— the second corresponding to an alternative method, which is called the “cast iron helix technique”.

Ventilation penetrations for shielded enclosures shall be designed to maintain the quality of the containment and the efficiency of the shielding of the shielded enclosure, in order to protect the operators against ionizing radiation and radioactive contamination.

The quality of the containment shall be particularly good where the level of internal radioactive contamination of the shielded enclosure is high. In this last case, the junction between the wall penetrations and the inner line of the shielded enclosure shall be leaktight.

Static penetrations shall be carried out in order to reproduce the shielding efficiency ensured by the structure of the shielded enclosure. When a local lessening of the shielding is unavoidable, additional shielding shall be placed on the radiation leakage line, inside, outside or directly included in the enclosure wall.

This additional shielding shall ensure that the cross-section of the shielding efficiency of the wall penetration taken in all directions provides the same level of shielding in units of mass as the shielding wall.

The design of the additional shielding is dependent upon:

— the intensity and the position of the source (or sources) of radiation;

— the diameter of the wall penetrations;

— the thickness of the shielding wall.

The design of the additional protection shall be conducted on a case-by-case basis.

When neutrons are simultaneously emitted with gamma radiation, it is necessary, depending on the neutron energy, to add an additional shielding material more effective for neutrons. Special calculations shall be made for the dimensioning of the systems ensuring the wall penetrations.

The designer could refer to the manual on safety aspects of the design and equipment of Hot Laboratories (see reference [3] in the Bibliography).

4.2 Conventional ventilation penetrations

Where the ventilation duct crosses the wall directly, it is necessary to add shielding in order to minimize radiation leakage (see Figure 1).

Shielding shall be designed to prevent direct streaming through the ventilation penetration. The duct shall not be located on the direct path of the radiation compared to the position of the operators.

Where the ventilation duct penetrates the wall in a zigzag, the duct-mounting appliance shall be enclosed in a material providing the same level of protection as the shielding wall. In general, the material shall be at least three times more dense than the wall, if it is made in concrete with a density of 2,2 t/m^3 (see Figure 2).

Annex C gives other examples of conventional duct penetrations for shielded enclosures.

4.3 Cast iron helix technique

4.3.1 General considerations

In this solution (see Figure 3), the ventilation duct consists of a helix mounted on a metallic housing. The minimum density of the helix shall be approximately three times greater than that of the wall in order to maintain the same level of protection as the shielding wall. In general, this solution does not require additional shielding.

The helixes are made from a metallic material (e.g. cast iron, stainless steel, lead). For neutron shielding, the helix can be eventually made from a plastic material (e.g. propylene, polyethylene).

4.3.2 Characteristics

Because of their helical shape, these protection helixes can ensure the following:

a) shielding continuity with an attenuation against gamma radiation equivalent to that of the wall to be penetrated;

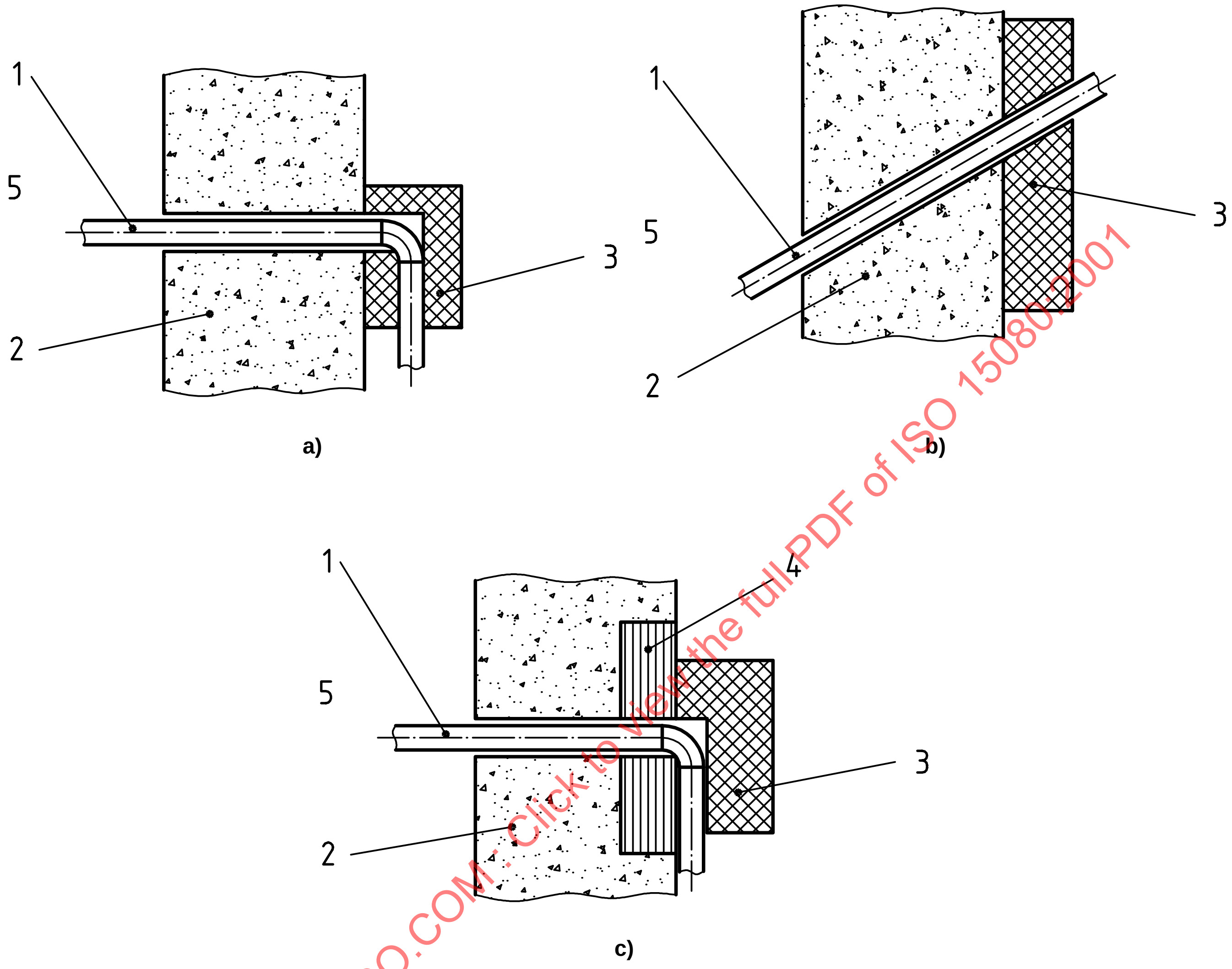
b) the passage of air or gas through the wall with the creation of a very small pressure drop.

When the walls are made of materials with a density greater than 2,2 t/m^3, the use of the helix requires adaptations to reconstitute protection equivalent to straight-through passages (see 4.3.4.2).

The design of the additional protection shall be conducted on a case-by-case basis.

4.3.3 Design of the helix systems

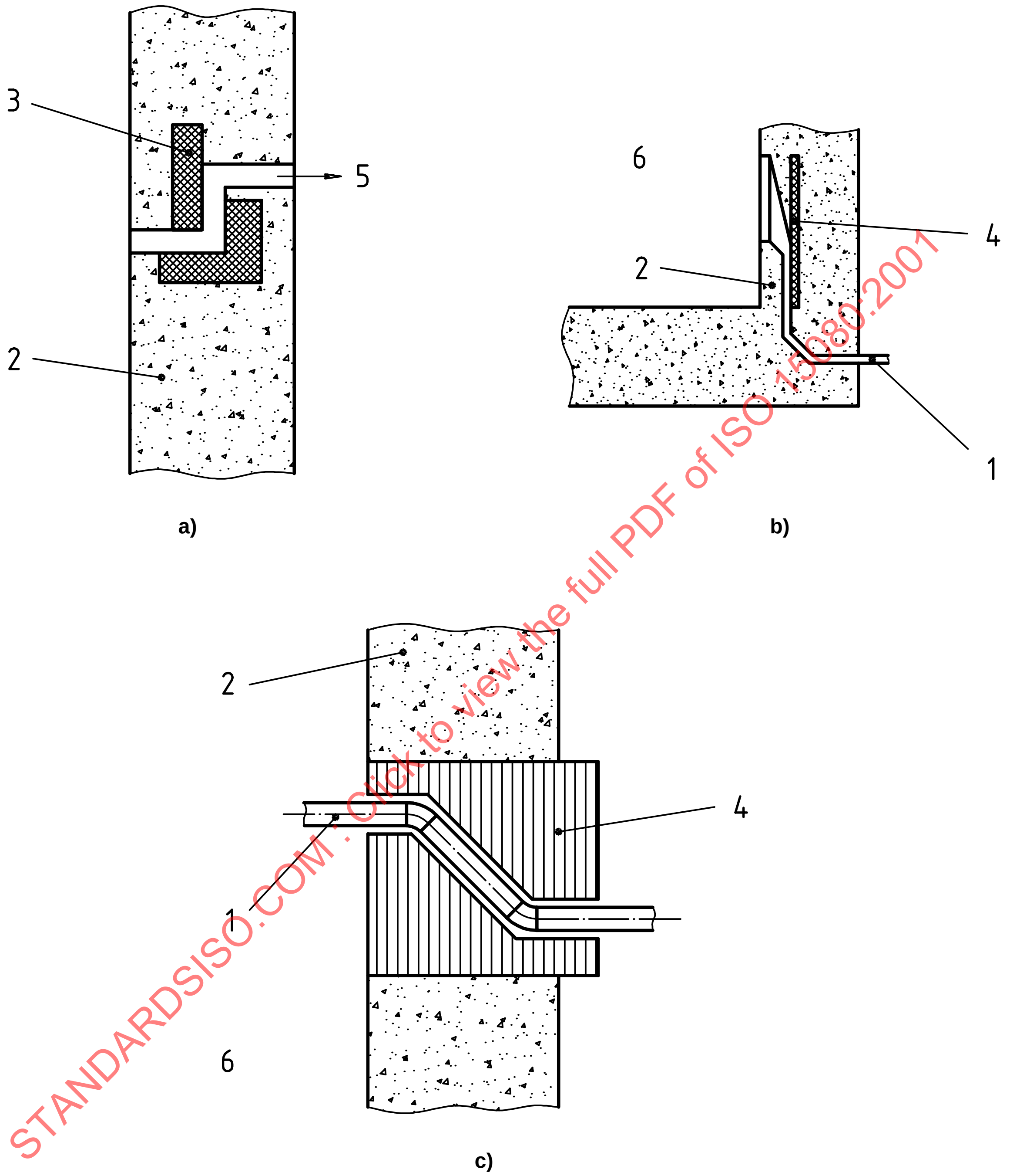
The protection helix contains one or several elements assembled into a steel housing forged and generally ended by connection flanges [see Figures 3b) and 4)].



Key

1 Ventilation duct
2 Concrete wall
3 Additional shielding
4 Additional shielding (cast iron or lead)
5 Inside enclosure

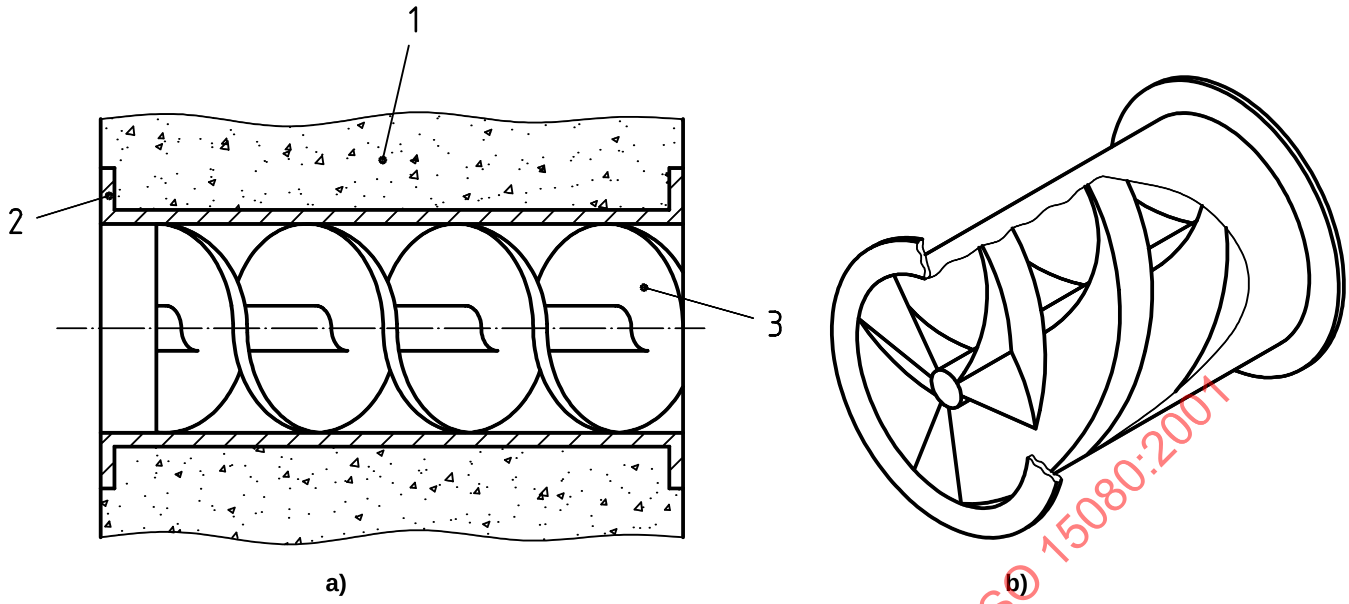
Figure 1 — Examples of conventional ventilation penetrations with additional shielding placed outside the shielding wall



Key

1 Ventilation duct
2 Concrete wall
3 Additional shielding
4 Additional shielding (lead or steel)
5 Outside enclosure
6 Inside enclosure

Figure 2 — Examples of conventional ventilation penetrations with additional shielding placed inside the shielding wall



Key

1 Concrete wall
2 Housing
3 Helix

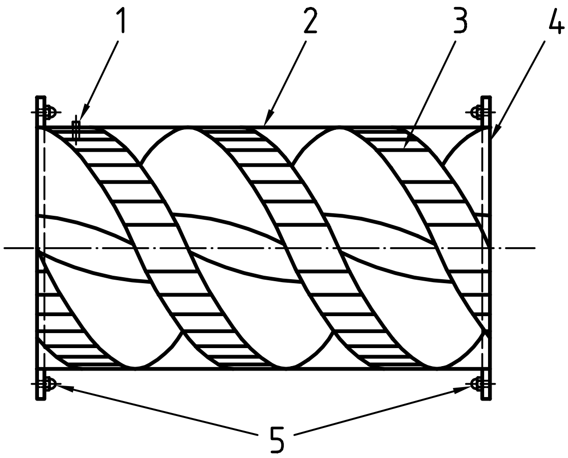
Figure 3 — Helix system

The helix elements are cast with three, four or five threads of trapezoidal cross section, with a conventional external diameter of 300 mm, 500 mm or 750 mm. Other diameters can be fabricated.

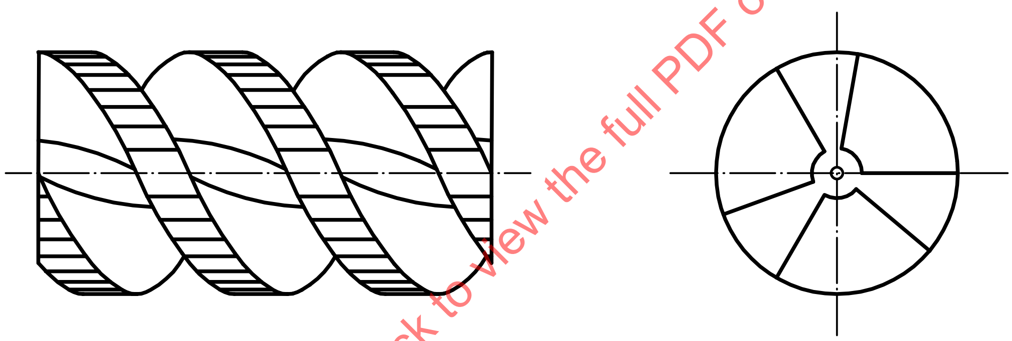
The housings made of sheet steel constitute the shell of the helix. The housings can have treaded flanges used for connecting air ducts.

The helix is fastened to the housing with pins or by mechanical means (threaded fastenings).

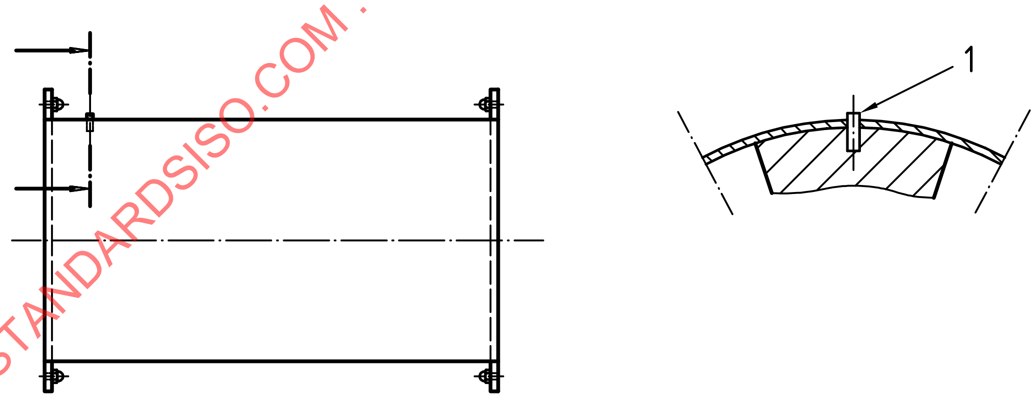
The design elements are described in annexes A and B.



a) Cross-section of a helix set in its housing



b) Helix



c) Housing

Key

1 Pin
2 Housing
3 Helix
4 Flange
5 Blind nuts

Figure 4 — Helix elements (example with 3 threads)

4.3.4 Principles of installation

4.3.4.1 General

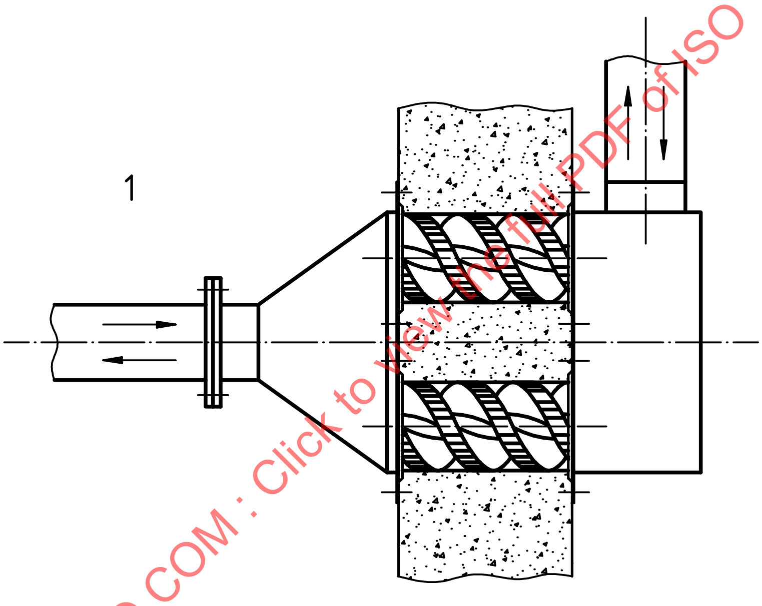
The protection helixes shall be installed horizontally or vertically. In certain special cases, the helix can be inclined.

The helix-housing unit or units can be placed in the wall prior to the pouring of the concrete. Units may also be placed in channels formed in the wall and then cemented into place. Inlet and/or outlet ventilation connections as shown in Figures 5 and 6 can be mounted on the helix.

When a high ventilation flow is required, one or several units can be mounted in parallel as shown in Figure 5.

The means for supporting the protection helix for pouring the concrete shall in no case damage the materials or the coating of the helix and housings.

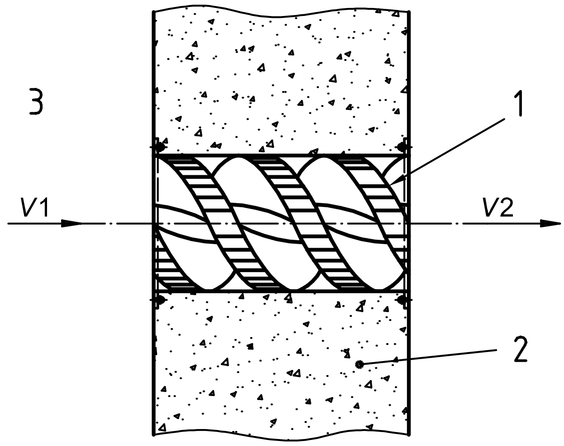
During the pouring of concrete, care shall be taken to avoid the introduction of concrete or water into the helix and the blind nuts.



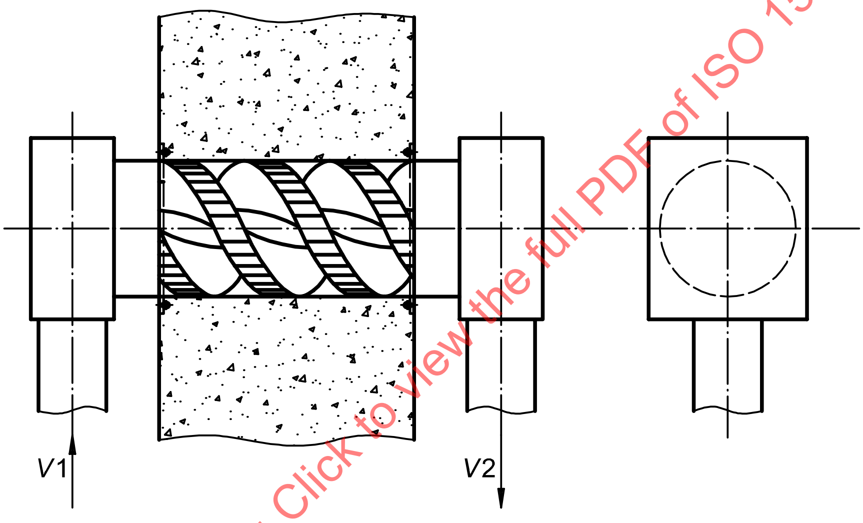
Key

1 Inside or outside the enclosure

Figure 5 — Example of an arrangement with several helix units



a) Inlet and outlet without connection



b) Inlet and outlet connection

Key

1 Helix
2 Concrete wall
3 Inside enclosure

Figure 6 — Helix examples with and without inlet and outlet connections

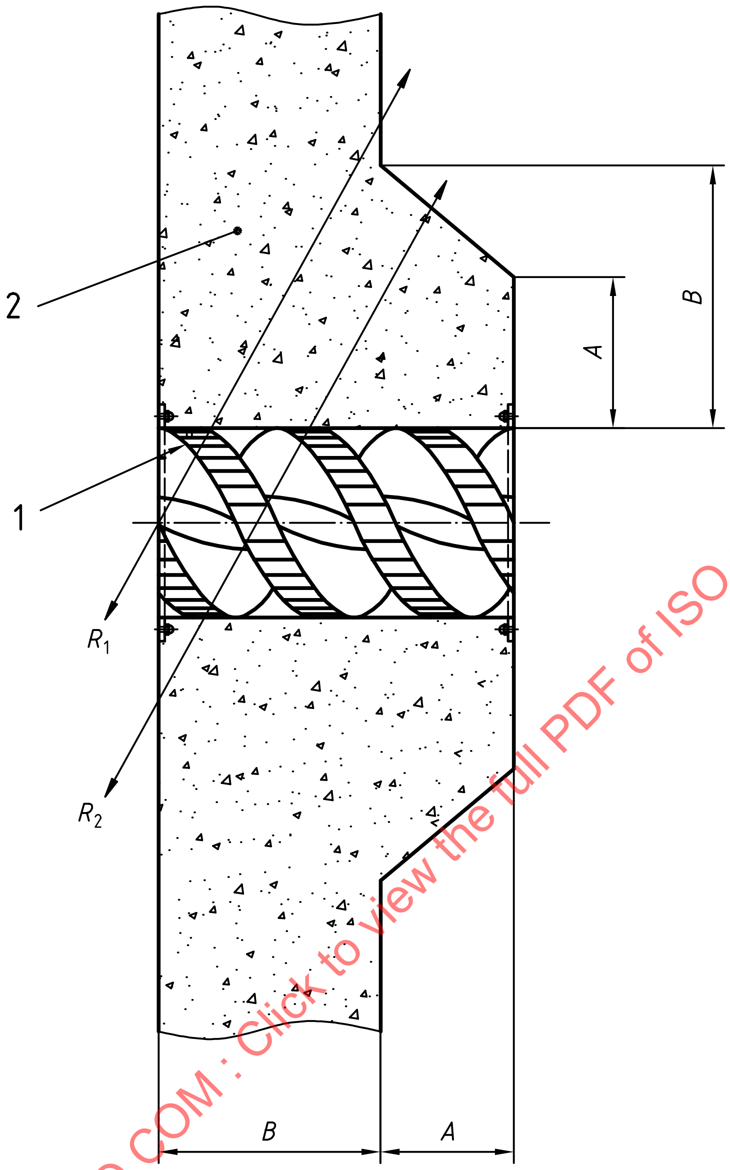
4.3.4.2 Special cases

In the following cases, an increase of the thickness of the wall in the area around the helix shall reconstitute the equivalent to R_1.

The two cases considered in Figure 7 take into account the installation of a ventilation helix in a wall:

— whose thickness is less than the minimum length of the helix allowed by the design,

— whose average density is higher than 2,2 t/m^3 so that the helix length is greater than the wall thickness.



Key

1 Helix
2 Concrete wall

Figure 7 — Fitting of a helix of length greater than that of the wall to be penetrated

Annex A
(normative)

Specifications for the design of cast iron helixes

A.1 Material of manufacture

A.1.1 Helix

For the essential factors such as mechanical resistance, machining, homogeneity and radiation attenuation behaviour, the use of cast iron with lamellar graphite of grade FGL 200 in accordance with the standard NF A 32-101 is recommended for the helix unit.

A.1.2 Housing

The housings and flanges are generally made of non-alloy carbon steel S 235J of minimum quality 2 in accordance with to the standard NF EN 10025, or of austenitic stainless steel in accordance with standards EN 10088/2 or EN 10088/3, X2 CRNI 18,09 or ANSI 304 depending on the gamma radiation level inside the enclosure. The grade shall be resistant to the corrosive characteristics of the air or the gas carried and chosen in accordance with the internal covering of the enclosure.

The housings are produced entirely by a mechanical-welded process. The welds shall be continuous, perfectly penetrated and caulked. The welders shall be trained and qualified professionals in accordance with national standards (e.g. NF EN 287).

The assembly systems (blind nuts, devices to maintain the helix elements in the housing, etc.) shall be made of a steel grade compatible with those used in the manufacture of the housings and flanges.

A.1.3 Coating

After sanding or shot blasting, the helix can be painted.

The coating shall be resistant to the corrosive characteristics of the air or gas in contact with the helix and with the intensity of the gamma radiation inside the enclosure. If the absorbed dose by the housing-parts in contact with the gamma radiation is higher than $1,5 \times 10^6$ Gy, the housings shall be made out of austenitic stainless sheet.

A.1.4 Helix/Housing assembly

Each helix is delivered set in its housing. Assembly shall be carried out by introducing the helix in the housing.

A.2 Dimensional specifications

A.2.1 General data

The helix shall have a length

— equal to the thickness of the wall of the shielded enclosure in which it is fixed, when it is made of concrete of density 2,2 t/m^3 or less, and

— greater than the thickness of the wall when the wall is in heavy concrete or when the minimal wall thickness is less than the minimal length of the helix.

The choice is made between the three following conventional types of helix, which are available:

— Ø 300 of minimum length 450 mm,

— Ø 500 of minimum length 600 mm,

— Ø 750 of minimum length 800 mm.

The final selection shall be made taking the following factors into account:

a) the required air flow;

b) the admissible pressure drop;

c) the surface available and the thickness of the wall;

d) the space available inside and outside the wall for connecting the ventilation ducts.

These four requirements can be met by selecting one or several devices.

These rules only represent an approximate approach for the pre-dimensioning of the protection efficiency of the helix.

The second objective is to maintain the same radiation attenuation efficiency as that of the wall. To achieve this, the calculations of the final dimensions shall take into account:

a) the location of the radiation source relative to the passage and its diameter;

b) the energy spectrum of the radiation source;

c) the dimensions and volume of the enclosure;

d) the accessibility and the time of presence of the operators.

Depending on the results, these calculations will enable the protection efficiency to be determined or the additional shielding to be defined as necessary.

The protection helix shall be manufactured to meet the operating constraints of the shielded enclosure to which it belongs, particularly those concerning air or gas specifications, sealing conditions and the requirements of construction and security, etc.

The dimension data shall be noted in the characteristic boards (see annex B).

A.2.2 Standardized dimensions

The normal dimensions of cast iron helixes are given in Table A.1.

Table A.1 — Standardized dimensions of cast iron helixes

Description	Type Ø 300	Type Ø 500	Type Ø 750
Helix (in cast iron)			
Nominal diameter	300 mm	500 mm	750 mm
Standard length, multiple of	100 mm	100 mm	100 mm
Theoretical minimum length to be installed	450 mm[a]	600 mm	800 mm
Maximum length advised	2 200 mm	2 200 mm	2 200 mm
Pitch of helix	600 mm	800 mm	1000 mm
Number of threads at L_{min}	3	4	5
Thickness of a thread on axis	60 mm	60 mm	60 mm
Diameter of core	50 mm	80 mm	110 mm
Minimum weight of an element per linear metre without housing (relative density: 7)	155 kg	430 kg	880 kg
Useful cross-section for air flow	0,034 m^2	0,104 m^2	0,300 m^2
Housing (in non-alloyed carbon steel or stainless steel)			
Recommended thicknesses	2 mm	2 mm	3 mm

[a] This dimension can be obtained from an element of length 500 mm machined to 450 mm

NOTE Dimensional tolerances of helix for machining:

— for the diameter: 0 mm
−0,3 mm

— for the length: 0 mm
−2 mm

Play between helix and housing:

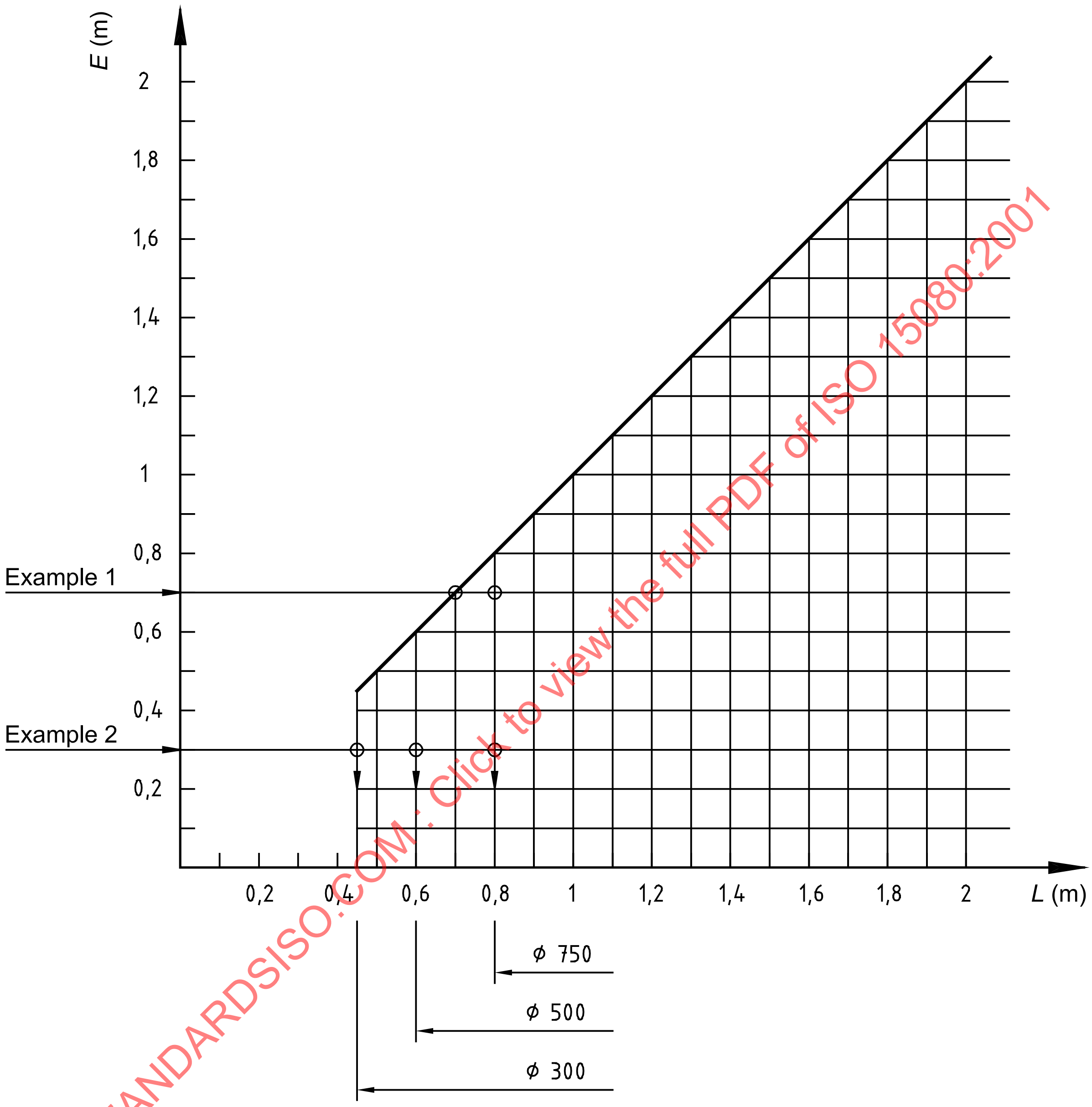
— less than 0,5 mm along the radius

Dimensional tolerances for housings:

— for the length: 0 mm
+2 mm

A.2.3 Determination of the minimum length of the helix

Figure A.1 shows the chart for calculating the helix length relative to the thickness of wall for a concrete density of 2,2 t/m^3.



L_{min} in metres, is the minimum length of the helix;

E: in metres, is the thickness of concrete wall of density 2,2 t/m^3 necessary for protection against gamma radiation;

Ø 300, Ø 500 and Ø 750 are the helix diameters, in millimetres.

Figure A.1 — Chart for calculating the helix length relative to the thickness of wall for a concrete density of 2,2 t/m^3

A.2.4 Examples of calculation of the length of the helix depending on the thickness of the wall

EXAMPLE 1: Wall thickness E = 0,7 m

Diameters of the helix Ø 300 mm and Ø 500 mm: L_{min} = 0,70 m

Diameter of the helix Ø 750 mm: L_{min} = 0,80 m

EXAMPLE 2: Wall thickness E = 0,3 m

Diameter of the helix Ø 300 mm: L_{min} = 0,45 m

Diameter of the helix Ø 500 mm: L_{min} = 0,60 m

Diameter of the helix Ø 750 mm: L_{min} = 0,80 m

A.2.5 Determination of the helix pressure drop

A.2.5.1 Evaluation of the pressure drop coefficients

The total helix pressure drop is the sum of the linear pressure drop (coefficient K_1) and the particular pressure drop (coefficient K_2) at the inlet and the outlet of the helix.

These pressure drops are linked and take into account the gyratory flow of the helix geometry.

The test results gave average values equal to:

— K_1 = 0,76L (L in metres);

— K_2 is the sum of the inlet coefficient (K_{21}) and the outlet coefficient (K_{22}), according to data given in Figure A.2 ($K_2 = K_{21} + K_{22}$)

These coefficients (K_{21} et K_{22}) are approximations for calculating the pressure drop in ventilation ducts.

$$D_p = \rho \times S \times K \times Q^2 \times 10^{-6}$$

where

D_p is the total helix pressure drop, in pascals (Pa);

ρ is the density of air, in kilograms per cubic metre (kg·m^{-3});

Q is the flow rate, in cubic metre per hour (m^3·h^{-1});

K is the sum of the coefficients of pressure drop $K_1 + K_2$;

S is the specific coefficient for the diameter of the helix, in metres to the power minus four (m^{-4});

S = 34,2 m^{-4} for a helix Ø 300 mm,

S = 5,5 m^{-4} for a helix Ø 500 mm,

S = 1,0 m^{-4} for a helix Ø 750 mm (S is determined by calculation).

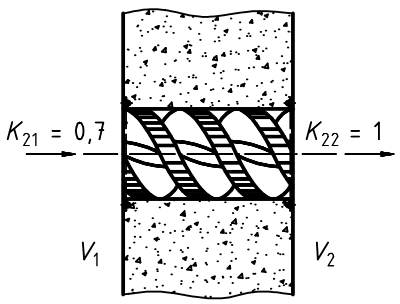
A.2.5.2 Example of pressure drop D_p (see Figure A.2)

Diameter of the helix: Ø 500 mm

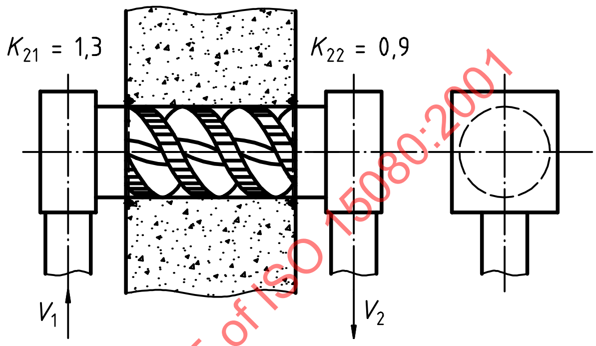
Length of the helix: 1,3 m

Air flow rate: 1 300 $m^3 \cdot h^{-1}$

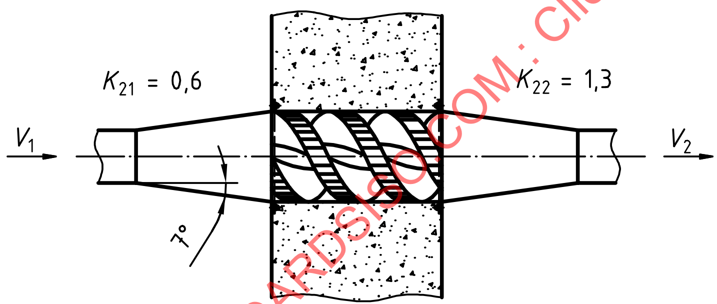
D_p = 1,8 daPa



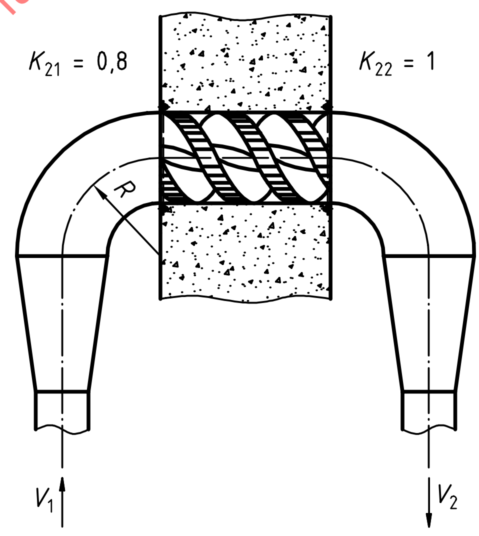
a) Inlet and outlet without connection
V_1 and $V_2 \leqslant$ 5m/s



b) Inlet and outlet connected
V_1 and $V_2 \leqslant$ 5m/s



c) Inlet and outlet connected
V_1 and $V_2 \leqslant$ 5m/s



R = 1,5 D

d) Inlet and outlet connected
V_1 and $V_2 \leqslant$ 5m/s

Figure A.2 — Diagram for calculation of coefficients of pressure drop $K_{21} + K_{22}$

Annex B
(informative)

Rules for the definition of cast iron helixes

Table B.2 gives characteristic boards. Table B.1 gives explanations of the references in Table B.2.

Table B.1 — Explanation of the references given in Table B.2

Reference	Designation
1	**General data**
11	Identification of the assembly: An assembly comprises one or several units. A unit is made up of one helix and one housing.
111	Functional reference: The reference is unique for an assembly and should appear on each unit.
112	Free.
113	Reference for embedded parts: This reference is unique and shall be placed on each unit.
121	Identification of the upstream premise: Indicate the reference of the premise.
122	Identification of the downstream premise: Indicate the reference of the premise.
13	Number of the ventilation plan: This is a guide plan of the ventilation which shows the protection helix.
2	**Specifications of the wall to be crossed**
21	Location.
211	Wall (W): put an X in the corresponding column.
212	Floor (F): put an X in the corresponding column.
221	Nature of the wall: Heavy concrete: put HC in the corresponding column and state the relative density. Ordinary concrete: put OC in the corresponding column.
222	Stainless steel coating, if present: Put an X in the corresponding column if such exists in the enclosure.
23	Minimum thickness of walls to ensure protection against gamma radiation: Elements provided by calculation: Values for ordinary concrete.
24	Thickness of the wall to be crossed: Elements given on the structural guide plans.

Reference	Designation
3	**Manufacturing specifications**
31	Number of units: State the number of units in a set.
32	Nominal diameter of each unit.
321 322 323	Ø 300 mm: put an X. Ø 500 mm: put an X. Ø 750 mm: put an X.
33	Helix part.
331	Cast iron screw. The helix is made entirely in cast iron: put an X.
332	Length: Indicate the total length of the helix in millimetres.
34	Housing parts.
341	Non-allow carbon steel; put an X in the corresponding column.
342	Stainless steel: put an X in the corresponding column.
343	Length of the housing: put an X in the corresponding column. Indicate the total length in millimetres.
35	Mass per unit in kilograms: See Table 1 for the helix and add the calculated weight of the housing.
36	Plan: A guide plan for the manufacture and installation shall be attached depending on the requests for services.
4	**Aerodynamic specifications**
41	Location in the ventilation network.
411	Blowing; put an X in the column S. Indicate the flow for an identified assembly.
412	Extraction; put an X in the column E.
413	Transfer: put an X in the column T.
42	Flow rate in cubic meters per hour.
43	Pressure drop: Indicate the pressure drop in decapascals.
5	**Observations** Complementary data (special coating, resistance to earthquakes, temperature, etc.).