Technical Specification

ISO/TS 22359-2

First edition
2026-03

Security and resilience — Hardened protective shelters —

Part 2: Requirements for shelter protective equipment

Securité et résilience — Abris durcis —

Partie 2: Exigences pour les équipements de protection des abris

Reference number
ISO/TS 22359-2:2026(en)

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Published in Switzerland

Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 292, *Security and resilience*.

A list of all parts in the ISO 22359 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is a part of the ISO 22359 series on hardened protective shelters, which comprises:

— ISO 22359: the document gives an overview of hardened protective shelters and presents guidelines for their design, construction, use and maintenance;

— ISO/TS 22359-2 (this document): this document presents the minimum requirements for shelter protective equipment, i.e. various equipment that makes a shelter safe and secure to maximize the chances that the occupants stay alive and unharmed during their time in the shelter during a crisis.

A hardened protective shelter is a purpose-built structure, which is blast resistant (designed to withstand the effects of a blast with a predefined force) and gastight (so completely closed that no gases can get in or out), and which protects occupants against the effects of disasters by isolating them from the hazardous environment. A shelter can sustain the lives of the occupants even for an extended period of time if the anticipated threat so requires, by maintaining a sufficient internal overpressure and using purified filtered air to prevent entry of all possible toxic substances that the ambient air can contain.

Completely isolated from the surrounding environment during a crisis, a shelter is expected to be well equipped to protect occupants against hazards and to keep them alive and unharmed until it is safe to leave the shelter. For these purposes, a shelter is outfitted with several types of shelter protective equipment, which are devices specifically designed to shield and protect the enclosed shelter space, the ventilation and air conditioning systems, as well as other installations against the effects of hazards to the shelter and its occupants.

Security and resilience — Hardened protective shelters —

Part 2:
Requirements for shelter protective equipment

1 Scope

This document provides functional requirements and methods for verification of performance for protective equipment and systems necessary to guarantee a desired protection level of hardened protective shelters.

The document covers six functional categories of protective equipment available for the protection of a hardened protective shelter:

— blast protection;

— gas tightness;

— tightness of penetrations;

— ground shock isolation;

— CBRN (chemical, biological, radiological, nuclear) protection; and

— carbon dioxide (CO_2) removal and oxygen (O_2) addition.

The document is intended for use by the owners of the hardened protective shelters, architects and engineers designing them, industries producing the targeted equipment, and procurement organizations in the construction industry sourcing such equipment.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 22300, *Security and resilience — Vocabulary*

ISO 22359:2024, *Security and resilience — Guidelines for hardened protective shelters*

ISO 12944-2, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 16890-1, *Air filters for general ventilation — Part 1: Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)*

ISO 2135:2024, *Anodizing of aluminium and its alloys — Accelerated test of light fastness of coloured anodic oxidation coatings using artificial light*

ISO 29463-1, *High efficiency filters and filter media for removing particles in air — Part 1: Classification, performance, testing and marking*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22300, ISO 22359 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
design service life
anticipated period of time during which the equipment is expected to perform its intended function with acceptable performance and reliability, under specified conditions, without requiring major overhaul or replacement

3.2
shelter protective equipment
special devices designed to enclose the shelter space, ensure the supply of breathing air, maintain overpressure, and protect the ventilation systems and other installations against the effects of hazards

4 Common requirements for shelter protective equipment

4.1 Background

The requirements outlined in Clause 4 apply to all shelter protective equipment presented in this document unless specifically limited to concern particular group(s) of equipment. The manufacturer of the shelter protective equipment is responsible for demonstrating the conformity of the products to these common requirements.

4.2 Design service life

The shelter protective equipment shall have a design service life of at least 30 years; equipment embedded in concrete shall have a design service life of at least 50 years.

4.3 Quality of protective equipment

The quality of the protective equipment shall be assured by the manufacturer.

NOTE The manufacturer can align the protective equipment with a quality management system, such as ISO 9001.

4.4 User manual

A user manual containing the necessary instructions for safe handling, use and disposal of the equipment shall be a part of the delivery.

4.5 Equipment markings

The shelter protective equipment (excluding wall sleeves, wall frames, prefilter material and ducting) shall be provided with permanent markings, indicating at least the following:

— name and type code of the equipment;

— name of the manufacturer;

— month and year of manufacture;

— manufacturer's serial number.

4.6 Corrosion protection

The shelter protective equipment made of steel materials shall comply with the requirements for resistance against environmental conditions in accordance with ISO 12944-2 applying the resistance classes given in Table 1.

Table 1 — Corrosion protection classes for steel components

Type of equipment	Class in accordance with ISO 12944-2
Doors and hatches	C2-C4
Blast valves	C2-C4
Blast valves for exhaust systems of power generators	C4-C5
Gastight valves and shut-off devices	C1-C3
CBRN filtration systems	C1-C3

4.7 Gaskets and other rubber or polymer parts

Gaskets and other rubber or polymer parts shall be resistant to acids and bases such as chemical warfare agents according to the operational requirements.

NOTE Whenever available, MIL-STD 282 (method 204.1)[7] can be used for the verification.

4.8 Temperature and humidity resistance

The range for the operational temperature of protective equipment installed inside the shelter shall be 0 °C to 40 °C and the minimum requirement for the operational humidity range RH 40 % to RH 80 %.

The minimum range for protective equipment exposed to the outside environment shall be selected according to the local climate conditions, covering the expected combined minimum and maximum values of temperature and humidity.

4.9 Fire resistance

Blast doors and hatches, blast valves, overpressure blast valves and wall sleeves exposed to the outside environment shall be designed to resist a temperature load of at least 100 °C for 10 min. This can be verified through calculations or tests based on generally accepted and scientifically correct methods.

4.10 Maintenance

Shelter protective equipment shall be maintained regularly for their entire design service life by a competent service provider; preferably one authorized by the manufacturer.

4.11 Operational requirements

The operational requirements referred to in this document define the specific conditions under which a hardened protective shelter is operated, encompassing aspects such as expected threats and scenarios, required capacities, environmental factors, necessary infrastructure, logistics, maintenance and responsible parties. The operational requirements can be set forth, for example, in the technical specifications of the end user or in the building contract.

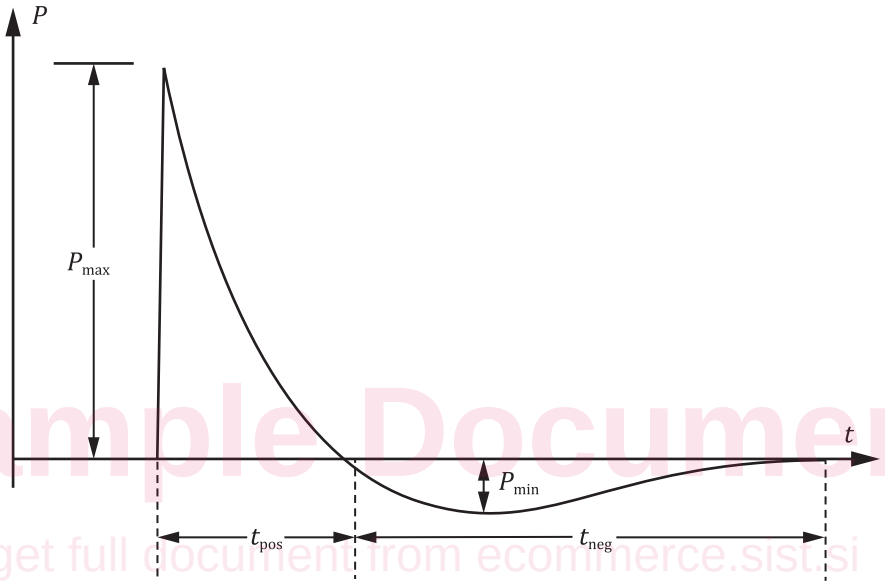
5 Blast protection

5.1 General information

An explosion (such as a weapon detonation) creates an oncoming blast wave front (also called shock front), which, when it encounters structures or other objects, generates a blast pressure uniformly distributed on the object's surface. This pressure causes a blast load on the object; the protective equipment is designed and dimensioned to protect against the effects of this load.

The blast load considered in the design can be positive or negative. The positive load is the load acting against the frame where the object is fixed, and the negative load is the load acting away from the frame.

A blast event creates a rapidly rising positive pressure that decreases steadily, reaching the surrounding atmospheric pressure, and then dropping below it, reaching a negative phase of the blast. See Figure 1.



Key

P	pressure
P_0	atmospheric pressure
P_{max}	maximum positive pressure
P_{min}	minimum negative pressure
t_{pos}	duration of the positive load
t_{neg}	duration of the negative load
t	time

Figure 1 — Blast wave parameters

A hardened protective shelter is protected from a blast wave front by constructing a blast protection barrier (see ISO 22359:2024, 4.3) around the shelter, which is able to resist the blast effects without breaking or leaking the blast pressure into the shelter.

The blast protection barrier consists of:

— the shell of the shelter (e.g. bedrock or reinforced concrete);

— the shelter protective equipment such as blast doors, hatches, valves or wall sleeves at all apertures (e.g. entries and exits) and penetrations (e.g. for tubes, pipes and cables) in the blast protection barrier.

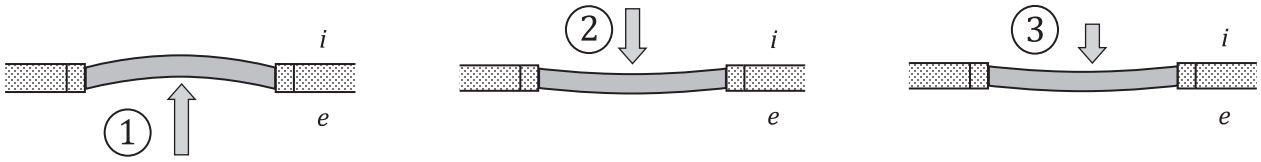
5.2 Blast doors and hatches

5.2.1 Blast resistance for positive, negative and rebound load

5.2.1.1 Background

Blast doors and hatches protect the shelter entries and exits against blast pressure. When an oncoming blast wave front hits a blast door or hatch, it first generates a positive blast load that is transmitted to the surrounding structures through the door frame into the wall structure. As depicted in Figure 1, the blast load then turns into a negative blast load acting away from the frame.

When the blast load causes the door plate to deform, it absorbs the potential energy of the blast wave front like a tensioned spring. When the external blast load decreases and ceases to push the door plate against the door frame, the potential energy stored in the door plate is released and the door plate bounces back in a phenomenon called rebound. The rebound phenomenon generates a rebound load on the door (see Figure 2). The rebound load and the required resistance depend on the basic natural vibration time of the door construction.



Key

1	positive load
2	rebound load
3	negative load
i	interior area
e	exterior area

Figure 2 — Blast doors under positive, rebound and negative loads

5.2.1.2 Functional requirements

A blast door or hatch in a shelter as well as their frames shall be dimensioned and designed so that the positive and negative loads described above can be transmitted to the surrounding wall structures through the frames.

A rebound latching system restraining the door plate structure in its place, shall be designed so that the rebound force is transmitted into the surrounding wall structure.

If the load caused by the blast is of long duration (significantly longer than the basic natural vibration time of the door construction) then:

— the static pressure in kPa (kilopascals) is used as a basis for calculating the required blast resistance of blast doors and hatches;

— the maximum value for the rebound load shall not exceed 0,5 × positive load.

If the load caused by the blast is of short duration (shorter than or equal to the basic natural vibration time of the door construction) then:

— the dynamic pressure in kPa is used as basis for the calculation of the required blast resistance of blast doors and hatches;

— the rebound load shall be determined by rigorous dynamic analysis.

The blast resistance for negative load shall not be separately calculated, as the resistance of the door against the rebound load is a governing factor in the design of a door.

5.2.1.3 Verification of performance

The blast resistance of a blast door or hatch is verified through calculations based on generally accepted and scientifically correct methods. Acceptable methods are static analysis in case of a long duration load and dynamic analysis in case of a short duration load.

5.2.2 Impact load

5.2.2.1 Background

The outer surface of a shelter and objects installed into it (such as blast doors and hatches) can be exposed to the impact of high velocity shrapnel or fragments that can penetrate unprotected objects.

5.2.2.2 Functional requirements

An exposed blast door or hatch shall be protected against the impact of shrapnel and fragments by structural steel of minimum 20 mm thickness or reinforced concrete of minimum 200 mm thickness or by another material with corresponding impact resistance.

5.2.2.3 Verification of performance

The resistance of a blast door or hatch against fragment penetration is verified by generally accepted and scientifically correct methods based on the estimated momentum of the flying object and the properties of the door material.

5.2.3 Shock load

5.2.3.1 Background

Blast doors and hatches can be subject to explosion induced in-structure ground shock loads transmitted through shelter structures to the installation location of the doors and hatches. Depending on the type of the soil, the acceleration caused by the shock load can be up to 30*g*, which can cause severe damage to the hinges and latching mechanism of the doors and hatches due to the movement of the heavy door plate. In a wall installation, the wall structure can exert vertical and horizontal shock forces tending to move the door plate in relation to the frame fixed in the wall.

5.2.3.2 Functional requirements

The resistance against a shock load exerted on a blast door shall be the same as that on the structure in which it is installed.

Sufficient shock support against the specified shock forces to the door plate shall be provided in both vertical and horizontal directions.

5.2.3.3 Verification of performance

The resistance of a blast door or hatch against shock loads is demonstrated by design and calculations indicating sufficient support of the door plate structure in both vertical and horizontal directions.

5.2.4 Additional requirements for double doors

5.2.4.1 Background

Double doors with two wings are missing the door jamb at the centre (see Figure 3). They are usually substantially heavier than single wing doors.