भारतीय मानक

Indian Standard

IS 19079 : 2024
ISO 22359 : 2024

सुरक्षा और प्रत्यास्थता — कठोर सुरक्षात्मक आश्रयों के लिए दिशानिर्देश

Security and Resilience — Guidelines for Hardened Protective Shelters

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Risk Management, Security and Resilience Sectional Committee, MSD 17

NATIONAL FOREWORD

This Indian Standard which is identical to ISO 22359 : 2024 ‘Security and resilience — Guidelines for hardened protective shelters’ issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Publication and Risk Management, Security and Resilience Sectional Committee and approval of the Management and Systems Division Council.

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions and terminologies are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words ‘International Standard’ appear referring to this standard, they should be read as ‘Indian Standard’; and

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to an International Standard for which Indian Standard also exists. The corresponding Indian Standard, which is to be substituted in its place, is listed below along with its degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 22300 Security and resilience — Vocabulary	IS/ISO 22300 : 2021 Security and Resilience — Vocabulary	Identical

Annex A and B are for information only.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Introduction

0.1 General

This document provides guidelines for hardened protective shelters used for protection of people, assets, and functions supporting critical infrastructures during a disaster through isolating them from the hazardous environment and thus protecting them against the dangerous effects of the hazard.

Protection of people is based on international treaties and protection of the civilian population when their country is at war, but also in peacetime is primordial. Article 3 of the United Nations Universal Declaration of Human Rights[2] gives everyone the right to life, liberty, and security. Furthermore, the fourth treaty of the Geneva Convention[1] proclaims the civilian populations right to be protected in armed conflicts.

0.2 Hazards and disasters

Hazards create harmful effects such as loss of life, injury or other health effects, property damage, social and economic disruption or environmental degradation. Hazards can be single, sequential or combined in their origin and effects, as hazardous events can occur alone, simultaneously, cascading or cumulatively.

If the hazard(s) cannot be mitigated, they can result in a disaster. During a disaster, citizens typically need some type of societal protection against the effects of the hazard. Most societies have planned and implemented actions to protect their citizens against hazards and their effects. These actions are sometimes referred to diversely as civil protection, civil defence, crisis management, emergency management, emergency preparedness, contingency planning, civil contingency and civil aid.

The preventive measures and protective efforts depend on the threat assessments studying the risks created by various hazards or combinations of them. The threat assessments usually address all four stages of the disaster management cycle (mitigation, preparation, response and recovery).

When a hazard occurs, it can cause effects that can affect the citizens. The citizens can be directly injured or harmed by the failure of critical infrastructure and the denial of vitally important functions of the society. This document focuses only on hazards and effects that can be mitigated through hardened protective shelters. Some other common and well-known methods to protect citizens are mass evacuations, quarantines and redundant systems.

0.3 Hardened protective shelter

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), for protection of shelter occupants against the effects of disasters by isolating them from the hazardous environment.

The shelter is hardened against the mechanical effects of disasters by means of a heavily reinforced concrete or bedrock shield. This distinguishes it from rapidly erected temporary shelters such as lightweight canvas weather shelters, other tarp tent shelters as well as metal and container shelters.

The shelter can sustain the life of the occupants for an extended period of time should the anticipated threat so require, 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.

0.4 Use of shelters

The civil protection shelter programs are managed by civilian authorities. The primary purpose of hardened protective shelters is to protect citizens against the effects of weapons during wars or warlike situations, but they can also be used for safeguarding them in case of natural hazards or industrial accidents threatening civilian life.

Military shelters are usually hardened against weapon effects, such as blast, chemical, biological, radiological and nuclear (CBRN) warfare, and in many cases also against the effects of an electromagnetic pulse (EMP). They are used as command-and-control centres, for protection of troops and as fortified hangars for aircraft and other military assets.

There are several industry branches with a potential risk of accidents involving of flammable, explosive, poisonous or radiating materials. The accident is often caused by an explosion, but also natural effects such as flooding, or earthquake can trigger an incident. The industrial market segment comprises, among others, chemical industries, nuclear power plants, hospitals, industrial command and control centres and data storage facilities.

Indian Standard

SECURITY AND RESILIENCE — GUIDELINES FOR HARDENED PROTECTIVE SHELTERS

1 Scope

This document provides guidelines for the design, use and maintenance of hardened protective shelters (hereafter referred to as “shelters”). It specifies guidance on the layout, structures, equipment and actions related to a shelter.

This document is intended for organizations or individuals responsible for or involved in decision-making, planning, implementation, administration, use or upkeep of shelters, such as local, regional and national governments, civil protection agencies, first responders and businesses such as designers, constructers and equipment suppliers.

This document does not cover the minimum requirements or exact specifications for the properties of or actions related to a shelter; nor does it cover rapidly erected temporary shelters, such as lightweight canvas weather shelters, other tarp tent shelters, or metal and container shelters. Military shelters are subject to additional requirements which are outside the scope of this document.

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22300 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
blast resistant
withstanding the effects of a blast with a predefined force

3.2
gastight
preventing gas from entering or escaping

3.3
hardened protective shelter
blast resistant (3.1) and *gastight* (3.2) facility with a capability to maintain internal overpressure with air purified from toxic agents

3.4
normal time
period during which there is no such crisis that would cause the shelter to be activated as during crisis time use

4 Design of a shelter

4.1 Design process

The design of a shelter should be based on operational requirements, depending on the purpose of the shelter and the applicable threat scenario(s). The design process of a shelter is practically similar to that of any capital project. The entire design process from the first conceptual idea to the beginning of construction is presented as a flowchart in Figure 1.

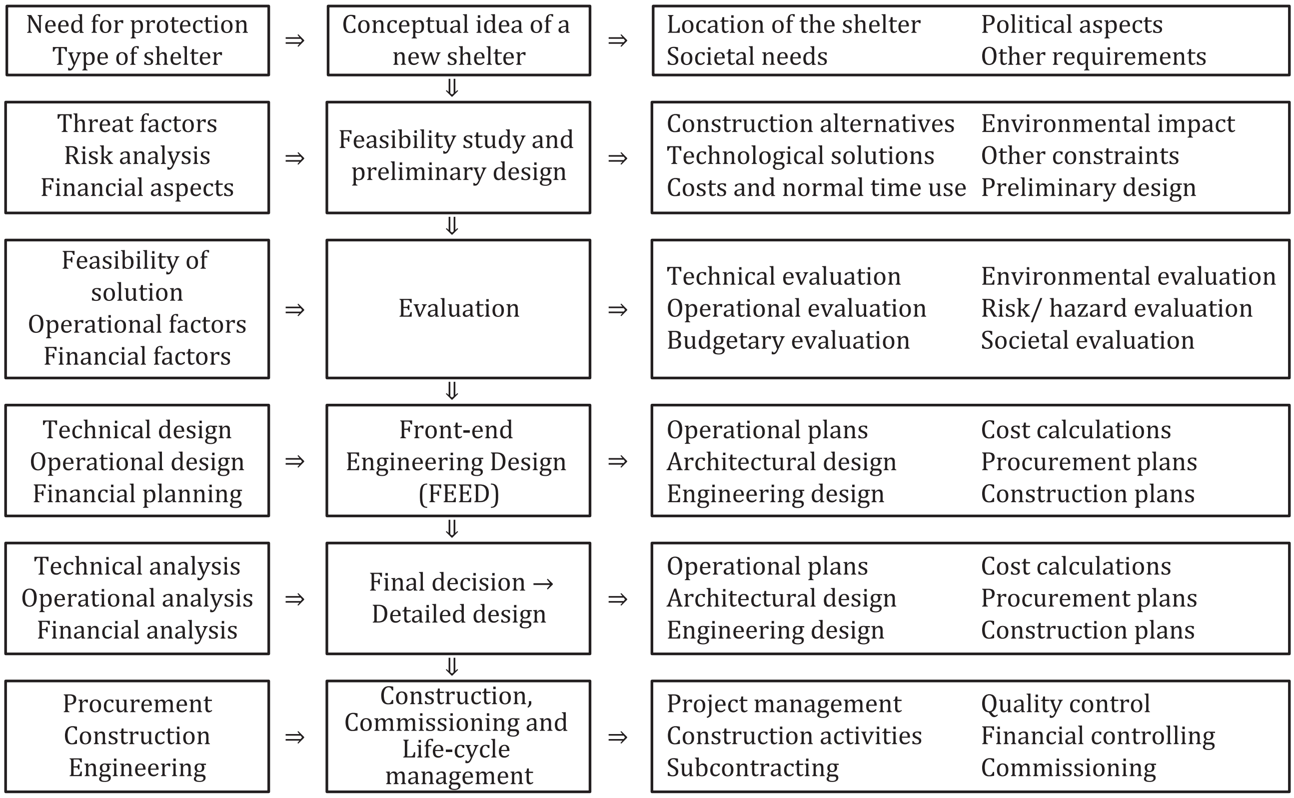


Figure 1 — Design process of a shelter

The operational, architectural and engineering design is described in detail in Figure 2.

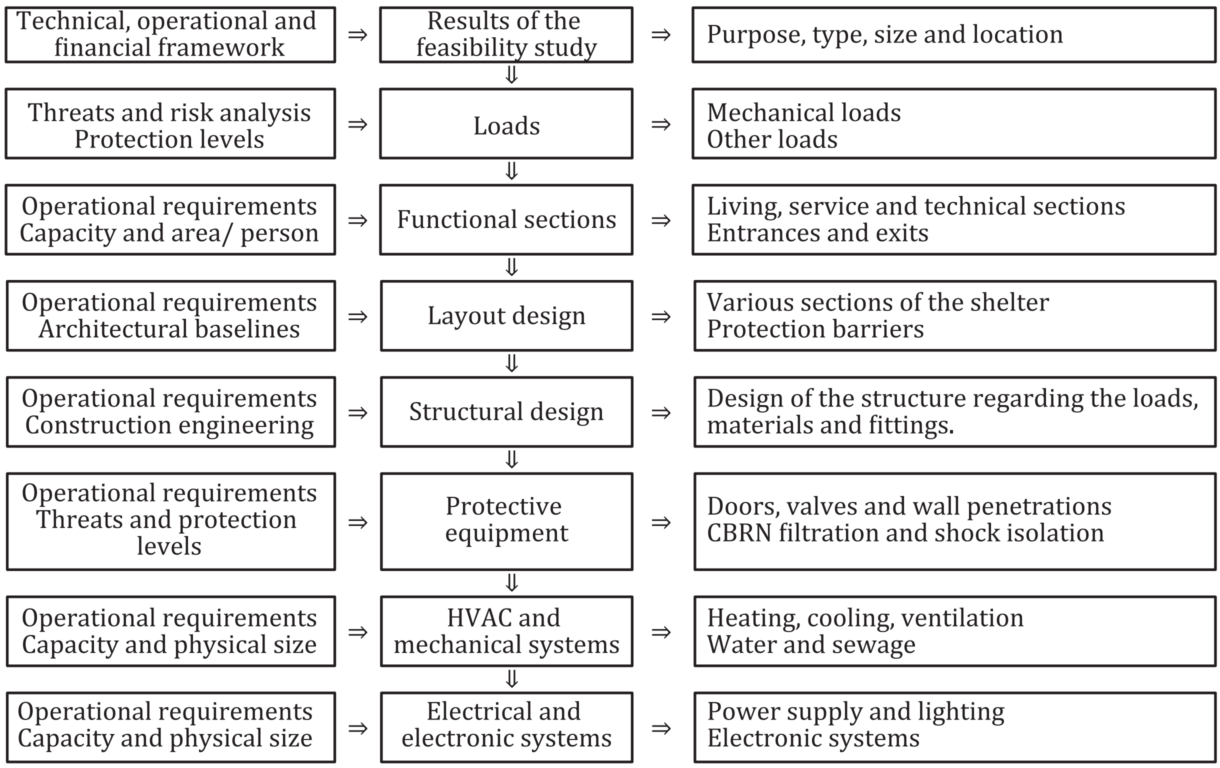


Figure 2 — Detailed design process of a shelter

4.2 Design criteria

4.2.1 Hazards

A shelter gives protection against various effects of external hazards. Table 1 gives examples of hazards, against which the shelter can offer effective protection.

Table 1 — Hazards and examples of their origins

Hazard	Examples of origin of the hazard
Human-caused hazards (intentional malevolent actions)	War Terrorist act Civil disturbance Sabotage
Technological hazards (accidents or failures of systems and structures)	Industrial accident Transport accident Storage accident Nuclear power plant accident
Natural hazards (acts of nature)	Volcanic eruptions Extreme storms Asteroids, meteorites Solar flares

The effects of hazards can be either mechanical loads caused by various physical forces exerted on the shelter (see 4.4.1) or other effects caused by various toxic agents, radiation or thermal energy (see 4.7.6).

4.2.2 General parameters

The following general parameters for shelter design should be considered:

a) Purpose of the shelter

b) Local environmental conditions

c) Capacity, volume and nominal floor space per person

d) Potential overcrowding

e) Estimated activity level of the occupants

f) Protective functions (expected threats, protection level, sheltering time and pertinent sheltering modes)

g) Habitability criteria for the occupants [air change rate, carbon dioxide (CO_2) and oxygen (O_2) concentration ranges, temperature and humidity]

h) Life cycle management

i) Cost-effect analysis

4.2.3 Type and purpose of a shelter

The recommendations in this document can apply principally to all types and sizes of shelters. They are not intended to be seen purely as technical specifications but rather as descriptions of various functions of a shelter. The technical implementation of these functions varies according to the type and size of the shelter, local climatic conditions and the threat scenarios. The presented technical solutions form a basis for the shelter design. In case some function or recommendation does not apply to a certain shelter size, a pertinent note is provided. The typical sizes of shelters for civil protection are listed in Table 2. Annex B gives examples of typical shelters.

Table 2 — Typical shelter sizes for civil protection

Type of shelter	Purpose and the number of occupants in the shelter
Small shelter	The shelter is designed for protection of inhabitants of one or a few residential buildings. A small shelter is typically designed for a limited number of occupants up to 150 persons and is usually constructed of reinforced concrete.
Medium-sized shelter	The shelter is designed for protection of inhabitants, operatives or visitors of a large estate such as a sizeable residential building, an office block, a shopping mall or a hotel. A medium-sized shelter is typically designed for occupants up to 1 000 persons to accommodate the residents and visitors at the estate and is usually constructed of reinforced concrete.
Large shelter	The shelter is designed for protection of inhabitants, operatives, visitors and people in transit in a town district. A large shelter is typically designed for a large number of occupants up to 10 000 persons and is usually constructed of reinforced concrete or excavated in the bedrock.
Shelter for the protection of civilian assets and functions	The shelter is designed for the protection of industrial or other assets and the functions supporting critical infrastructure such as command and control centres and data centres. The primary design criterion for a shelter for assets and functions is not the number of occupants but the design is dictated by the required functions of the shelter.
Shelter for protection of military assets and functions	The shelter is designed for protection of military assets such as weapons, vehicles or other equipment, as well as critical functions and infrastructure. These shelters are outside the scope of this document, as they could not be seen as shelters for civil protection as defined in the Geneva Convention.[1]

4.2.4 Location

4.2.4.1 Surroundings

A shelter should be located in a suitable place to provide appropriate protection and easy access.

The design should maximize the opportunities to integrate the shelter into the surrounding development.

4.2.4.2 Distance to reach a shelter

A shelter primarily designed for protection of citizens should be easily accessible by foot with a limited distance from the place of residence or workplace of the shelter users.

4.2.4.3 Distance between shelters

In a group of shelters, the distance between individual shelters should be based on the applied threat scenario and risk analysis.

4.2.4.4 Markings and accessibility of a shelter

In the design of markings and accessibility of a shelter, the following should be considered:

a) capacity of the routes and ways equal to the maximum number of users, taking into account their probable direction of arrival;

b) the accessibility of the shelter by persons with disabilities;

c) clear markings (large and visible text with the international symbol for civil protection, a blue triangle on orange background) of entrance routes and entrance ways.

The international symbol for civil protection as defined in item 4, Article 66 of the Protocol Additional to the Geneva Conventions of 12 August 1949, [1] can be used. See Figure 3. The CMYK codes of the colours are C88 M63 Y11 K25 (blue) and M50 Y96 (orange).

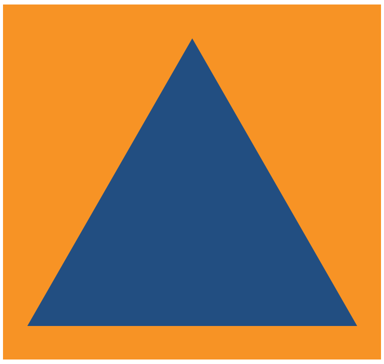


Figure 3 — International symbol for civil protection

4.3 Shelter sections and layout design

4.3.1 General

In the layout design of a shelter, the following should be considered.

a) It is recommended that the architecture of the layout is based on the room space programme, expected traffic, communication and interaction between spaces, and noise control.

b) A shelter is normally divided in several sections, which should all be incorporated in the layout design. The shelter may include:

- — entrance and exit passages: the area for entering and exiting the shelter;
- — living section: the area where people dwell, sit, sleep and work;
- — service section: the area with service facilities, storage and toilets;
- — technical section: the area containing the technical facilities and machinery.

c) In a small shelter, a room may contain more than one section. Similarly, several functions can be contained in one room.

d) In a medium-sized or large shelter, it can be necessary to divide the sections into separate rooms either permanently or when needed.

e) Certain parts of the shelter, such as the technical area, entrances, emergency exit and storage areas, may be restricted from unauthorized persons, clearly marked and locked.

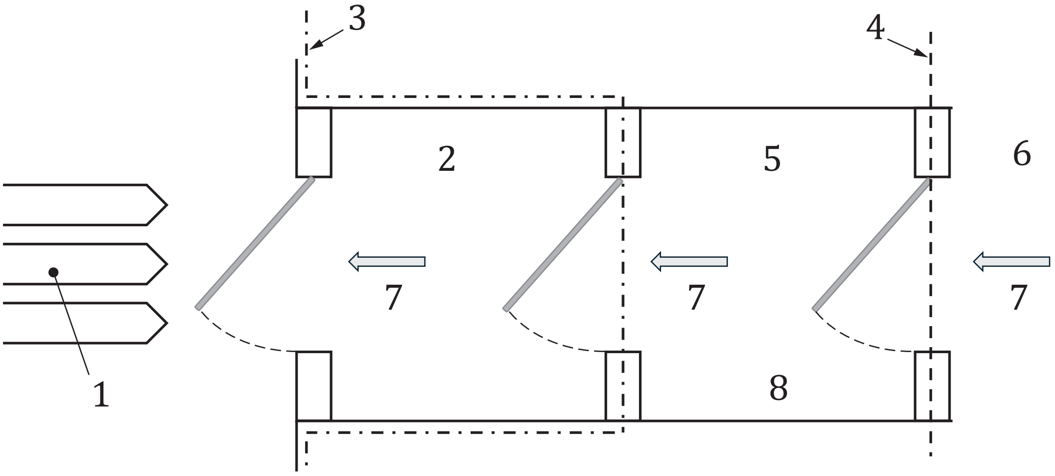
f) Medical, cultural, and other human factors related to the use the shelter.

4.3.2 Entrance and exit passages

4.3.2.1 General

The principle for design of entrance and exit passages is described in Figure 4.

NOTE In a small shelter, it is possible that separate pressure and air locks are not feasible, as the pressure and gastight protection barrier can be combined into a single barrier (see 4.3.5.2).



Key

1	entrance and exit lane(s)	2	pressure lock
3	blast protection barrier (blast-proof doors and valves)	4	gastight barrier (gastight doors and valves)
5	air lock	6	gastight and blast protected area
7	flushing the locks with air	8	decontamination facilities

NOTE This figure is not to scale.

Figure 4 — Pressure and air locks

In the design of the entrance and exit passages, the following should be considered:

a) the logistics related to managing and supplying the shelter;

b) the number of persons sheltered and the directions and rate of entering and exiting;

c) the width and number of passage lanes;

d) the size and number of entrance doors;

e) accessibility for persons with disabilities;

f) different scenarios, also considering the possibility of blocked entry or exit passages;

g) blast wave mitigation measures (pressure lock and angular passages);

h) contamination prevention and decontamination measures (air lock).

4.3.2.2 Pressure lock

A pressure lock is a space between the outer and the inner blast resistant door; it protects the shelter entrance from blast effects. In the design of the pressure lock, the following should be considered:

a) preventing a simultaneous opening of the blast resistant doors on both sides of the pressure lock;

b) flushing of the pressure lock with exhaust air from the shelter to remove any contaminated air.

4.3.2.3 Air lock

An air lock is a space between the inner blast resistant door and the gastight door at the gastight barrier; it protects the shelter entrance from contamination and enables decontamination of persons entering the shelter. In the design of the air lock, the following should be considered:

a) flushing of the air lock with exhaust air from the shelter to remove of any contaminated air;

b) facilities for decontamination such as shower, water tap, sink and floor drain as well as waste management of contaminated garments.

4.3.2.4 Emergency exits

A shelter should have at least one emergency exit. In the design of the emergency exit(s), the following should be considered:

a) opening to a different direction from the entrance(s);

b) reaching outside the estimated collapse area of the structures above or adjacent to the shelter;

c) designing the emergency exit ways or tunnels as short as possible to prevent suffocation of people exiting the shelter in an emergency;

d) emergency lights for the pathway leading towards emergency exit.

4.3.3 Living section

In the design of the living section and the allocation of space for the occupants and various necessary functions, the following should be considered:

a) space allocation to the occupants for sleeping, sitting and standing as well as for the necessary furniture;

b) access to the various facilities of the service section;

c) human management (including hygiene control and social aspects such as safety and security);

d) potential overcrowding.

NOTE The above aspects are normally regulated by operational requirements.

4.3.4 Service section

4.3.4.1 General

In the design of the service section, the following should be considered:

a) toilets;

b) first aid and medical care;

c) waste disposal;

d) water and food storage;

e) equipment storage;

f) other service functions.

4.3.4.2 Toilets

In the design of toilets, the following should be considered:

a) the number and capacity of toilets;

b) type of toilets (e.g. flushing toilets, dry toilets);

c) management and logistics of human waste;

d) prevention of odours;

e) accessibility for disabled people;

f) hand cleaning facilities.

4.3.4.3 First aid and medical care

In the design of first aid and medical care, the following should be considered:

a) the capacity, level and quality of medical services, equipment and supplies;

b) plan for handling of deceased people.

4.3.4.4 Waste disposal

In the design of waste disposal, the following should be considered:

a) an area close to the toilets for disposal of human waste;

b) an area close to the entrance airlock for disposal of contaminated garments and materials after decontamination procedures;

c) facilities for disinfection of the toilets after emptying.

4.3.4.5 Water and food storage

In the design of the water and food storage, the following should be considered:

a) storage with a capacity for a full occupancy (including potential overcrowding) over a maximum sheltering period;

b) thermal conditions in the shelter;

c) safe and secure storage with a space for distribution of water and food;

d) filling and replenishing of the storage.

4.3.4.6 Equipment storage(s)

In the design of the equipment storage, the location and capacity should be considered.

Examples of equipment include medical care, firefighting, rescue, clothes, dry toilets, tools, spare CBRN filters and any equipment needed to convert the shelter into crisis time operation.

4.3.4.7 Other service areas

Other service areas such as kitchen and baby changing room should be considered.

4.3.5 Technical section

4.3.5.1 General

In the design of the technical section, the following should be considered:

a) dirty and clean technical areas;

b) placement of technical equipment;

c) placement of power generation (see 4.6.1);

d) ground water and flooding control;

e) command and control.

4.3.5.2 Dirty and clean technical areas

The dirty and clean technical areas are parts of the technical section separated by a gastight protection barrier, which consists of gastight wall(s) with gastight equipment in all openings and penetrations, as shown in Figure 5.

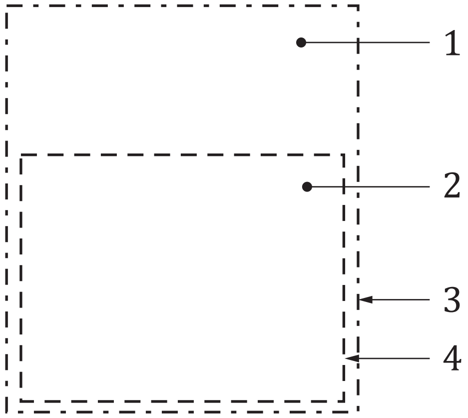
The dirty technical area is the area outside the gastight protection barrier but inside the blast protection barrier. In the design of the dirty technical area, the following should be considered:

a) locating cooling system components such as condensing units and cooling radiators in the dirty technical area to enable the use of outside air for cooling;

b) minimizing the size of the dirty technical area and the amount of equipment housed within it.

The clean technical area is the area inside the blast protection barrier and the gastight protection barrier. Any mechanical and electrical equipment potentially requiring service during sheltering should be located in the clean technical area.

NOTE In a small shelter, it is possible that it is not feasible to install separate barriers for blast and gastight protection; in this case, there is no dirty technical area, but the functions a) and b) above are located in the clean technical area.



1 Dirty technical area outside the gastight protection barrier but inside the blast protection barrier (all equipment requiring large volumes of air)

2 Clean technical area inside the gastight protection barrier and the blast protection barrier (all equipment that requires service during sheltering)

3 Blast protection barrier

4 Gastight protection barrier

NOTE This figure is not to scale.

Figure 5 — Clean and dirty technical areas

4.3.5.3 Placement of technical equipment

In the design of the placement of technical equipment, the following should be considered:

a) convenience to the shelter occupants;

b) easy access for the shelter operators and accessibility to all equipment and systems;

c) reduction of noise transfer;

d) reduction of risk of contamination when handling the pre-filters and the CBRN filters.

4.3.5.4 Ground water and flooding control

In the design of the ground water and flooding control, the following should be considered:

a) passive water level control (self-draining system);

b) active water level control (ducting, sumping, pumping and monitoring);

c) prevention and control of water leaks and seepage;

d) measures against buoyancy (e.g. anchoring).

4.3.5.5 Monitoring, control and management

In medium-sized and large shelters, a specific control area can be needed for monitoring, control and management of all sheltering functions.

4.4 Structural design

4.4.1 General

A shelter gives protection against pressure waves, ground shocks, fragment impacts and collapse loads in addition to the ordinary basic mechanical loads, as explained in Table 3.

Table 3 — Mechanical loads exerted on a shelter

Load	Causes
Basic mechanical load	Overlying structure, payload, wind load, snow load, load by earth pressure and earthquakes
Pressure load	Pressure wave (positive and negative phases) propagating in the air
Ground shock	Shock wave propagating in the soil
Collapse load	Debris from collapsing overhead or adjacent building(s)
Fragment load	Impact of a high kinetic energy flying fragment or projectile

In the structural design of a shelter, the following should be considered:

a) reinforcing the shelter so that it can withstand all the mechanical loads described in Table 3, according to the applied threat scenarios;

b) selecting materials with properties and quality fulfilling the requirements of the intended protective capability of the shelter;

c) refraining from using frangible or spalling and delaminating materials (such as mortar or masonry);

d) designing the structure for a slow and highly deforming behaviour in case of failure;

e) mounting all equipment and installations so that their fittings tolerate movements of the shelter structure due to shock loads without breaking the fittings loose;

f) minimizing noise for the living and service sections.

NOTE During normal time, easily removable internal walls and partitions that do not cause damage to the shelter structures or equipment can be used.

4.4.2 Calculation of the loads

When calculating the loads, it should be taken into account that:

a) the loads for the structures of the shelter can be either normative (based on regulative values) or calculated (based on dynamic or static analysis);

b) depending on the loads considered, two types of analysis methods for the structural design are available:

— in case of quasi static loads with long duration, static replacement loads should be applied in structural design, according to generally accepted static analysis methods;

— in case of impulsive loads with short duration, generally accepted dynamic analysis methods should be used;

c) a proper safety factor should be applied in the analysis.

4.4.3 Bedrock and concrete shelters

The shelter may be either a monolithic reinforced concrete structure or excavated in the bedrock.

a) For a bedrock shelter:

— particular attention should be given to the soil survey at the site of the shelter;

— the rock cavern should be reinforced by injection and bolting.

b) For a shelter made of reinforced concrete:

— a homogenous and non-porous concrete cast is a premise for blast resistant and airtight reinforced concrete structure. Working with exceptionally thick blast and shock resistant reinforced concrete structures can require special arrangements in placing the rebar system and in the process of pouring, curing and aftercare of the concrete cast;

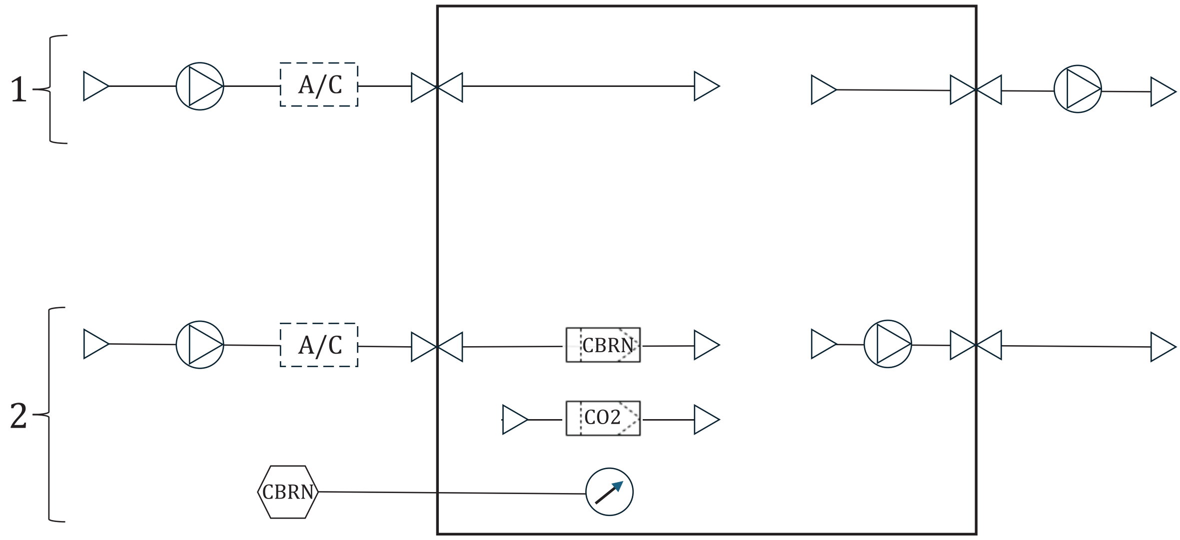
— if the calculated thickness and stiffness of a reinforced concrete structure differs from the requirements related to other effects (direct radiation, fallout or fragments), the more stringent requirements should be applied;

— when using precast concrete elements for erecting the shelter frame, it should be ensured that there is a blast and shock resistant connection of the concrete elements and the airtightness of the element seaming.

4.5 Heating, ventilation, air conditioning (HVAC) and other mechanical systems

4.5.1 Ventilation and air conditioning

The ventilation of a shelter is usually provided by two parallel and separate systems; one for the normal time use and the other for crisis time use. The crisis time ventilation system is connected to a CBRN filtration system (see 4.7.6.3) as depicted in Figure 6.



Key

1 normal time ventilation system

2 crisis time ventilation system

Figure 6 — Normal and crisis time ventilation systems with CBRN detection

In the design of the ventilation, the following should be considered:

a) capacity of both systems to provide a sufficient air change rate and an even distribution of the air flow inside the shelter space;

b) additional capacity of the crisis time ventilation system to provide sufficient overpressure;

c) ensuring a proper blast protection and gas tightness for the supply and exhaust air channels of both normal time and crisis time ventilation system;

d) designing the aboveground structures of the air intake shaft of the crisis time ventilation system so that they can withstand a collapse of the surrounding structures and soil without becoming obstructed or blocked.

NOTE 1 In medium-sized and large shelters, a system for indoor air circulation in shut-off mode can be necessary.

NOTE 2 Depending on the circumstances, active or passive cooling system with humidity control can be required.

4.5.2 Water supply and sewage

In the design of the water supply and sewage system, the following should be considered:

a) sufficient amount of drinking water and water for decontamination, washing, sanitation and firefighting;

b) water storage tank(s) designed for complete draining, leak protection and sampling;

c) sufficient sewage capacity.

4.6 Electrical and electronic systems

4.6.1 Power generation

In the design of the power generation, the following should be considered:

a) external electricity distribution network with a sufficient safety margin;

b) an emergency power source (with sufficient redundancy) to ensure the supply of power to the crisis time ventilation system, emergency lighting, as well as the control and communication system during a cut of the external electricity;

NOTE In a small shelter, the auxiliary power can be produced manually, while in a medium-sized or large shelter, a combination of generators and batteries can be used.

c) generator fuel storage tank(s) designed for complete draining, leak protection, sampling and manual cutting off the fuel flow in case of emergency.

4.6.2 External communication

In the design of the external communication system, the following should be considered:

a) ensuring connection to the outside world through a combination of various channels, such as radio transceivers, landlines, data communication, mobile phone networks and satellite connections;

b) maintaining a list of the relevant external contacts.

4.6.3 Internal communication

A large shelter should include a suitable internal communication system for command-and-control purposes as well as for informing the occupants. Examples of such systems are internal telephone and closed-circuit television networks, as well as public address systems.

4.6.4 Situational awareness

A situational awareness system giving the shelter operators sufficient understanding on the outside conditions should be considered. This can be achieved through sensors or human observation.

4.6.5 Intentional electromagnetic interference IEMI (EMP and HPM) protection

Depending on the threat scenario, it is possible to consider the protection of electronic, electrical and technical equipment against Intentional Electromagnetic Interference (IEMI), including Electromagnetic Pulse (EMP) and High Power Microwaves (HPM).

4.6.6 Monitoring and control

In the design of the monitoring and control system in large shelters, a connection to a building automation system (when available) for service and maintenance purposes should be considered.

4.7 Shelter protective equipment

4.7.1 General

The shelter protective equipment is a group of special devices particularly designed to shield the enclosed shelter space, the ventilation and air conditioning systems, as well as other installations against the effects of hazards to the shelter.

To prevent incorrect use of the equipment, simple user interfaces should be applied. This includes:

a) marking the function, position and rotational direction of each switch and knob;

b) prevention of inadvertent opening of sealed equipment;

c) limiting the movement of the equipment.

4.7.2 Blast protection

4.7.2.1 Blast resistant doors

Blast resistant doors (including blast hatches and shutters) prevent the penetration of blast waves caused by explosions through the passageways into the shelter. In the specification and selection of blast resistant doors, the following should be considered:

a) installing blast doors in every passage penetrating the blast protection barrier;

b) using blast doors with at least same protection level as the surrounding wall;

c) using blast doors designed for the rebound effect and the negative phase of the blast.

NOTE As large blast doors can be heavy and slow to open or close, smaller side doors can be installed next to the main doors to facilitate entry and exit.

4.7.2.2 Blast valves

Blast valves (including valves for air, combustion engine exhaust gases and water, waste and fuel tank vent pipes) prevent the penetration of blast waves through the ventilation channels, ducts and pipes into the shelter. In the specification and selection of the blast valves, the following should be considered:

a) installing blast valves in every air channel penetrating the blast protection barrier;

b) using blast valves with at least the same the protection level as the surrounding wall;

c) using blast-actuated valves, which close by both positive and negative phases of the blast and open automatically once the effect of the outside overpressure (positive or negative) has ceased;

d) assessing the pass-through pressure and impulse escaping the blast valves, and if necessary, attenuating them by means of an expansion chamber located behind the blast valves;

e) installing shut-off valves in the sewage line(s).

4.7.3 Gas tightness

4.7.3.1 Gastight doors

Gastight doors (including gastight hatches and shutters) shield the passageways against the entry of gases and other harmful substances. In the specification and selection of gastight protective doors, the following should be considered:

a) installing gastight doors having a minimum leakage air flow rate to facilitate maintaining overpressure in every passage penetrating the gastight protection barrier;

b) using gastight doors that can withstand the eventual pass-through residual blast pressure and impulse prevailing in the air lock.

NOTE In a small shelter, it can be practical to merge the blast resistance and gas tightness functions into one combined blast resistant and gastight door.

4.7.3.2 Gastight valves

Gastight valves shield the ventilation air channels against the entry of gases and other harmful substances and enable flushing of the air lock, pressure lock and decontamination facilities to remove potential contaminants. In the specification and selection of the gastight valves, the following should be considered:

a) installing gastight valves in every air channel penetrating the gastight protection barrier;

b) gastight valves may also be used to control the overpressure and the air flow rate by controlling the exhaust air flow

c) using gastight valves that withstand the eventual pass-through residual blast pressure and impulse prevailing behind the blast valves;

d) ensuring that the leak rate through a closed valve is sufficiently low to maintain overpressure.

NOTE Besides manual operation, the gastight valves can have provision for electrical or electro-mechanical actuators for automatic and remote-control operation.

4.7.4 Tightness of penetrations

The tightness of all penetrations through blast protection and gastight protection barriers should be ensured with pertinent wall sleeves sustaining the desired blast resistance and/or gas tightness at every location where the utilities (ducts, pipes and cables) penetrate the respective barrier.

4.7.5 Ground shock isolation

Any equipment that is not shock-proof should be isolated with a ground shock isolation system which attenuates the shock forces transmitting from the support base.

4.7.6 CBRN protection

4.7.6.1 CBRN effects

A shelter should give protection against effects of various CBRN hazards as described in Table 4.

Table 4 — CBRN effects

Effect	Causes
Chemical effect	Chemical warfare agents and toxic industrial compounds
Biological effect	Biological warfare agents and other pathogens
Radiological effect	Fallout radiation from dispersed radioactive material
Nuclear effect	Initial radiation from a nuclear detonation

4.7.6.2 CBRN detection

A shelter may include a CBRN detection system that monitors the ambient environment of the shelter as well as the air taken in through the crisis time ventilation system. In the specification and selection of the CBRN detection systems, the following should be considered:

a) real-time monitoring of the typical chemical warfare agents and potential toxic industrial compounds, aerosols and particles containing radionuclide substances;

b) sampling and detection of the threat caused by biological warfare agents and other pathogens.

In addition, the concentration of toxic by-products of fires such as carbon monoxide (CO) should be monitored.

4.7.6.3 CBRN filtration

CBRN filtration system enables shelter occupants to stay in a toxic-free environment for the designed sheltering time by filtering the harmful agents from the incoming air.

For large shelters, where the operators cannot visually monitor the status of all equipment, remote monitoring and control should be considered.

4.7.7 Removal of carbon dioxide and addition of oxygen

In a shelter designed for a long sheltering time, a carbon dioxide (CO_2) removal and oxygen (O_2) addition system, as well as a monitoring system for the levels of the above-mentioned gases may be installed.

4.8 Safety and security

4.8.1 Physical safety and security

In order to guarantee the safety and security of a shelter, the following should be considered:

a) protection of the air intake of the shelter against unauthorized access or sabotage, and locating it in a place where the surrounding air is clean and free of particles;

b) protection of the water intake from communal water supply against unauthorized access or sabotage;

c) protective and alarm systems (mechanical or electronic locking, access control, burglary alarm, perimeter protection and video surveillance) around the shelter and at its entrances and exits;

d) protection of all systems and storage in the shelter against unauthorized access and sabotage;

e) provision of opening blocked or warped perimeter doors from inside in case of emergency;

f) an adequate illumination of all rooms and corridors;

g) floor plan and signs indicating the nearest emergency exit.

4.8.2 Fire safety

In the design of the fire safety, the following should be considered:

a) layout to prevent a fire from spreading;

b) using fire resistant materials;

c) minimum storage of flammable material and fuel;

d) fire alarm;

e) non-contaminating fire extinguisher system and equipment;

f) smoke extraction routes or channels.

5 Commissioning of a shelter

When commissioned, the shelter should be inspected and functionally tested according to operational requirements, taking into account the instructions of equipment and system suppliers. In the commissioning of a shelter, the following should be considered:

a) inspection that the design follows the operational requirements before the commissioning starts;

b) inspection that the work performed at the site of the shelter follows the design (drawings and other documentation);

c) airtightness of the shelter structure and equipment such as ventilation openings, utility penetrations and passageways through the shelter structure, including documentation of air leak rates;

d) the functions of the shelter protective equipment and systems;

e) the functions of the HVAC and electrical systems;

f) the communication systems.

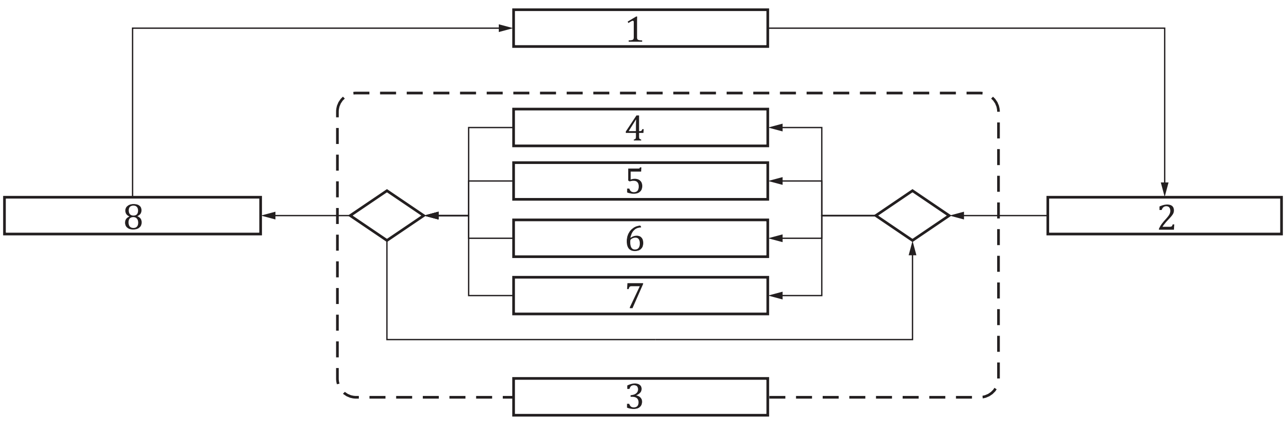
NOTE It can be necessary to carry out some inspections during the construction of the shelter.

6 Use and maintenance of a shelter

6.1 Sheltering cycle

The sheltering cycle consists primarily of the normal time use and the crisis time use, with two transition periods (activation and deactivation) between them. During the crisis time, the shelter can be used in four modes. Figure 7 depicts the sheltering cycle.

NOTE It is possible that not all four sheltering modes are able to be included in the cycle.



Key

1 normal time

2 activation period

3 crisis time

4 shut-off mode

5 filtration mode

6 by-pass mode

7 readiness mode

8 deactivation period

Figure 7 — The sheltering cycle

6.2 Normal time use

Under normal time, the following should be considered:

a) the normal time use should not compromise the operational requirements of the shelter as a crisis time protective facility;

b) in order to sustain the readiness of the shelter, a maintenance programme should be established, with regular:

- testing of airtightness and overpressure of the shelter structure and related equipment (doors, valves and penetrations);
- functional testing and service of all systems and equipment, including ventilation flow rate and leak rates;
- monitoring of the indoor air and maintaining predefined temperature and humidity conditions to avoid mildew build up and corrosion;
- monitoring of the shelter for water leaks, seepage and drainage;
- cleaning of the shelter to avoid dirt and dust build up, and if necessary, replacement of worn-out consumables;
- documenting the above-mentioned activities;
- in large shelters: spooling and disinfection of drinking water storage tanks;
- in large shelters: testing of the fuel in the storage tanks and cleaning of the tanks.

6.3 Activation period – preparing the shelter for crisis time use

The shelter space should be convertible into a functional shelter within a predetermined activation period. The activation period will be initiated by the responsible authorities. When preparing the shelter for crisis time use, the following should be considered:

a) clearing entrances and emergency exit routes of obstructions;

b) removing combustible materials near the air intake channels;

c) removing goods, materials and structures kept in the shelter or in front of its entrances during the normal time use;

d) dismantling and removal of any temporary constructions;

e) preparing the ventilation system—especially the air intake pipeline—for crisis time use;

f) filling and replenishing storage;

g) cleaning of the shelter;

h) arranging the management of the shelter with defined responsibilities in:

- shelter occupying logistics,
- introduction and upkeep of daily routines,
- assignment of technical tasks in operating the shelter protective equipment and systems,
- upkeep of situational awareness,
- human management including mental care of the shelter occupants,
- first aid and medical care of the shelter occupants;

i) for a small shelter, the residents may appoint and train an adequate number of citizens for managing the shelter;

j) installing guiding signs at the perimeter of the shelter.

6.4 Crisis time – use of the shelter in various sheltering modes

During the crisis time, the shelter is in one of the four available modes described in Table 5.

Table 5 — Sheltering modes

#	Mode	Blast barrier	Ventilation	Outside services	CBRN filtering
1	Shut-off mode	Closed	Closed	Disconnected	Off
2	Filtration mode	Closed	Crisis time	Disconnected	On
3	By-pass mode	Closed	Crisis time	Disconnected	Off
4	Readiness mode	Open	Normal time	Connected	Off

The four modes (including the instructions on bringing the shelter into a mode) are presented in detail in Annex A. These modes should be applied during the crisis time use.

6.5 Deactivation period – preparing the shelter for normal time use

After the crisis has ended, the shelter should be serviced and prepared for normal time use.

When preparing the shelter for normal time use, the following should be considered:

a) cooling and cleaning of the shelter;

b) removing packed waste and emptying waste and drainage tanks;

c) inspecting the condition and refilling of water tanks for drinking and cooling water;

d) replacing filters and other consumables including restocking of fuel for power generators (when available), taking into account the maximum storage life for diesel fuel;

e) providing maintenance for all equipment and systems following the instructions of the system suppliers;

f) documenting all procedures performed during the deactivation period;

g) compiling a summary of the events and experiences during the sheltering modes to be used in future training of the shelter operating personnel for continuous improvement.

6.6 Modifications and alterations during the service life of a shelter

Any modifications to the previously approved design of a shelter should be approved and inspected in advance before they are implemented.

Annex A

(informative)

Sheltering modes

A.1 Shut-off mode

The sheltering phase often begins with the shut-off mode, during which the shelter is closed, made gastight and all outside services except for network power are disconnected.

Depending on the duration of the shut-off mode, it can be necessary to remove the accumulated CO_2 from the indoor air. The O_2 concentration should also be kept on an acceptable level.

To bring the shelter to the shut-off mode, the following should be done:

a) switching off the normal time ventilation including the gastight closing of the normal time air intake and exhaust channels;

b) closing all blast resistant and gastight doors and hatches after removing vehicle ramps and gangways at the doors if necessary;

c) closing of all water supply, sewer and central heating valves;

d) switching off the automatic fire extinguishing system (if available).

During the shut-off mode, the following should be considered:

e) ascertaining that the respective doors and hatches at entrances and exits are not opened;

f) following the information received from the authorities or the situational awareness system regarding the required duration of the shut-off mode;

g) keeping the shelter occupants calm and informed about the situation;

h) monitoring and controlling the indoor air CO_2 and O_2 content and operating the CO_2 removal and O_2 addition systems (if available);

i) monitoring and controlling the indoor temperature and humidity and operating the cooling system (if available);

j) preparing the shelter for the filtration mode when:

   — the toxic concentration of the ambient air has decreased to a level established safe for the CBRN filters, or

   — the pre-set maximum concentration of CO_2 or the minimum concentration of O_2 have been reached.

NOTE In case the shelter does not have sensors for the detection of the toxic concentration of the ambient air, the decision can be based on information received from the relevant authorities.

A.2 Filtration mode

During the filtration mode, a minimum amount of air to guarantee the survival of the occupants and to maintain an overpressure inside the shelter is taken in through the CBRN filtration system.

To bring the shelter to the filtration mode, the following should be done:

a) if the normal time ventilation is active, it should be switched off, including the gastight closing of the normal time air intake and exhaust channels;

b) deploying the crisis time ventilation system and taking the CBRN filtration system online;

c) adjusting the internal overpressure to the designed level by regulating the exhaust air flow.

During the filtration mode, the following should be considered:

d) ascertaining that only the entrances and exits provided with airlocks are used and that persons entering the shelter are directed to a decontamination process;

e) flushing the pressure lock, air lock and decontamination facilities with air to remove potential contaminants;

f) following the information received from the authorities or the situational awareness system regarding the required duration of the filtration mode;

g) keeping the shelter occupants calm and informed about the situation;

h) preparing the shelter for the by-pass mode once the ambient air is found to be toxic free.

A.3 By-pass mode

The shut-off or filtration modes are usually followed by the by-pass mode, during which the shelter doors remain closed, and the air intake will bypass the CBRN filtration system.

To bring the shelter to the by-pass mode, the following should be done:

a) disconnecting the CBRN filtration system from the crisis time ventilation system;

b) readjusting the overpressure valves or adjustable exhaust valves to correspond to the larger by-pass air quantity.

During the by-pass mode, the following should be considered:

c) following the information received from the authorities or the situational awareness system regarding the required duration of the by-pass mode;

d) keeping the shelter occupants calm and informed about the situation;

e) preparing to terminate the by-pass mode once it is established to be safe to exit the shelter;

f) preparing to maintain the shelter in the elevated readiness mode until the threat is confirmed to have passed.

A.4 Elevated readiness mode

Following the by-pass mode, the shelter should remain at the elevated readiness mode until the threat is confirmed to have passed. In this mode, the readiness to rapidly initiate shut-off mode is kept at high level.

To maintain the shelter in the elevated readiness mode, the following should be done:

a) switching off the crisis time ventilation system and switching on the normal time ventilation system to enable the flushing of the shelter with fresh air;

b) opening all water supply and sewer closing valves to facilitate cleaning of the shelter, provided the communal water is established safe for use;

c) cleaning of the shelter and removing the toilet waste;

d) replacing pre-filters and CBRN filters if necessary;

e) filling the water, food, sanitation, medical supply and fuel storage;

f) replacing the personal protective equipment supplies.

Annex B

(informative)

Examples of shelters

B.1 Small shelter for apartment house

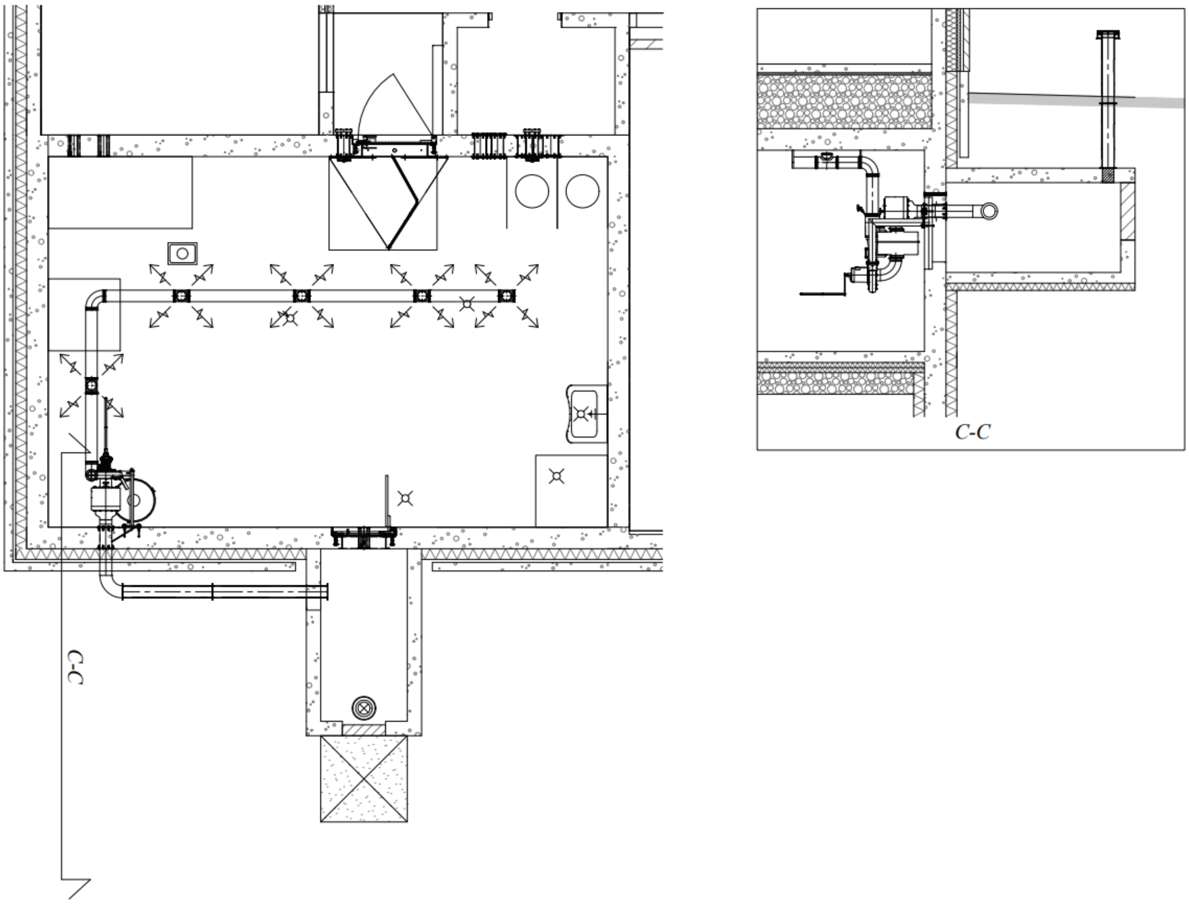


Figure B.1 — Small shelter

Figure B.1 shows an example of a small shelter located in the basement of an apartment building. The shelter is intended for protection of the residents of the building. The net area of the shelter is approximately 45 m^2. The shelter is designed for structural blast protection of 100 kPa and is provided with an electromotor and manual hand crank operated CBRN filtration system. The shelter has an entrance on the top side of the figure provided with a blast door and a lock tent acting as an air lock. On the opposite side there is a blast protected emergency exit leading into a combined air intake and emergency exit tunnel. The tunnel length is designed to lead outside the potential collapse area of the building above.

B.2 Medium-sized shelter for sizeable buildings

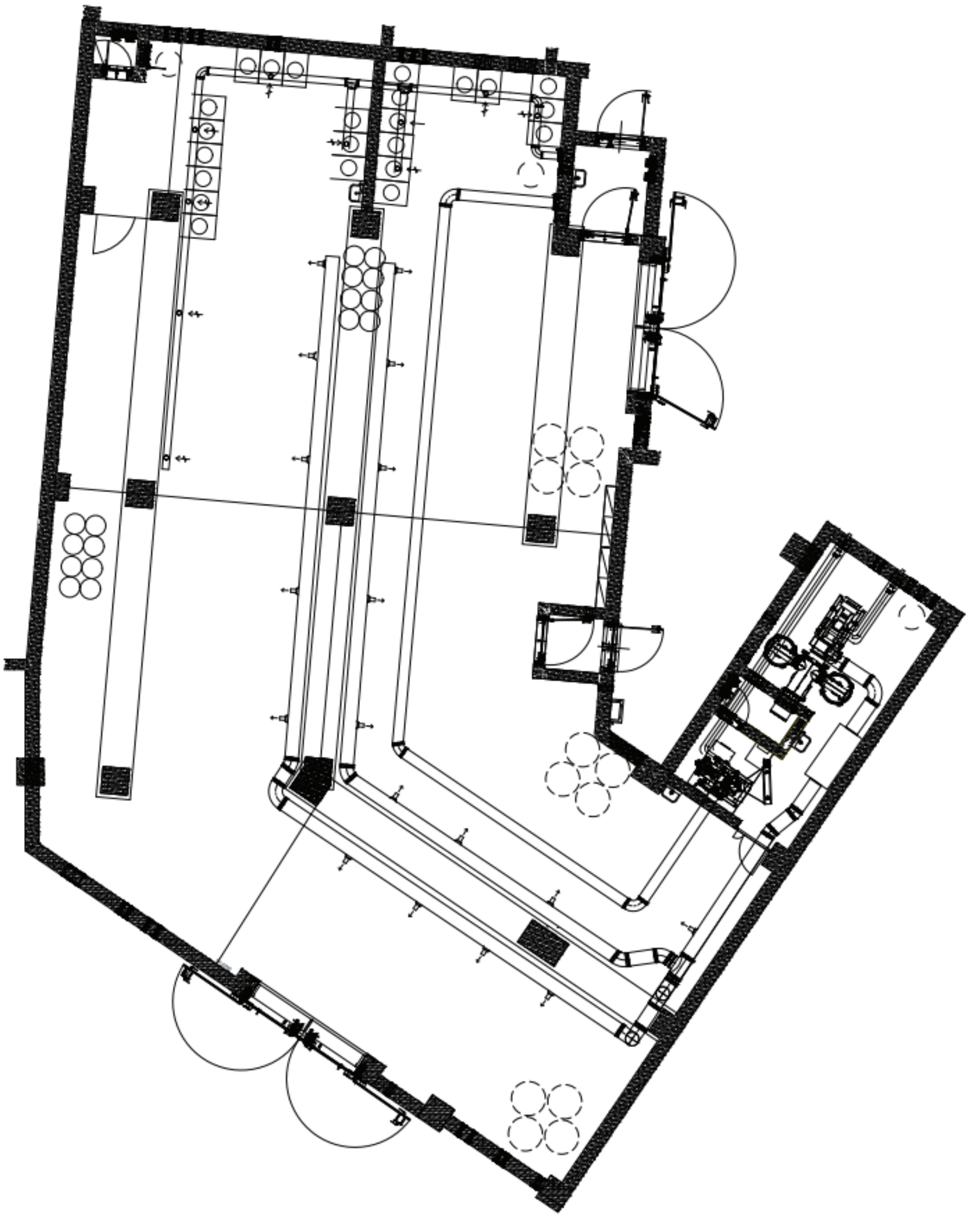


Figure B.2 — Medium-sized shelter

Figure B.2 shows an example of a medium-sized shelter located in the basement of an office building. The shelter is intended for protection of the tenants and people working in the building. The net area of the shelter is 460 m^2. The shelter is designed for structural blast protection of 200 kPa and is provided with an electromotor driven CBRN filtration system with a small diesel engine for power back-up. The shelter has two large entrances/exits with double leaf blast resistant doors for vehicle access as the shelter is used as a logistics warehouse during normal time. These access points will be closed and sealed when the shelter is prepared for crisis time use and the access is then provided through the combined pressure and air locks located in the upper right corner and approximately in the middle of right-hand side wall. A blast protected emergency exit shaft is depicted on the upper left corner of the plan view.

B.3 Large shelter for a city district

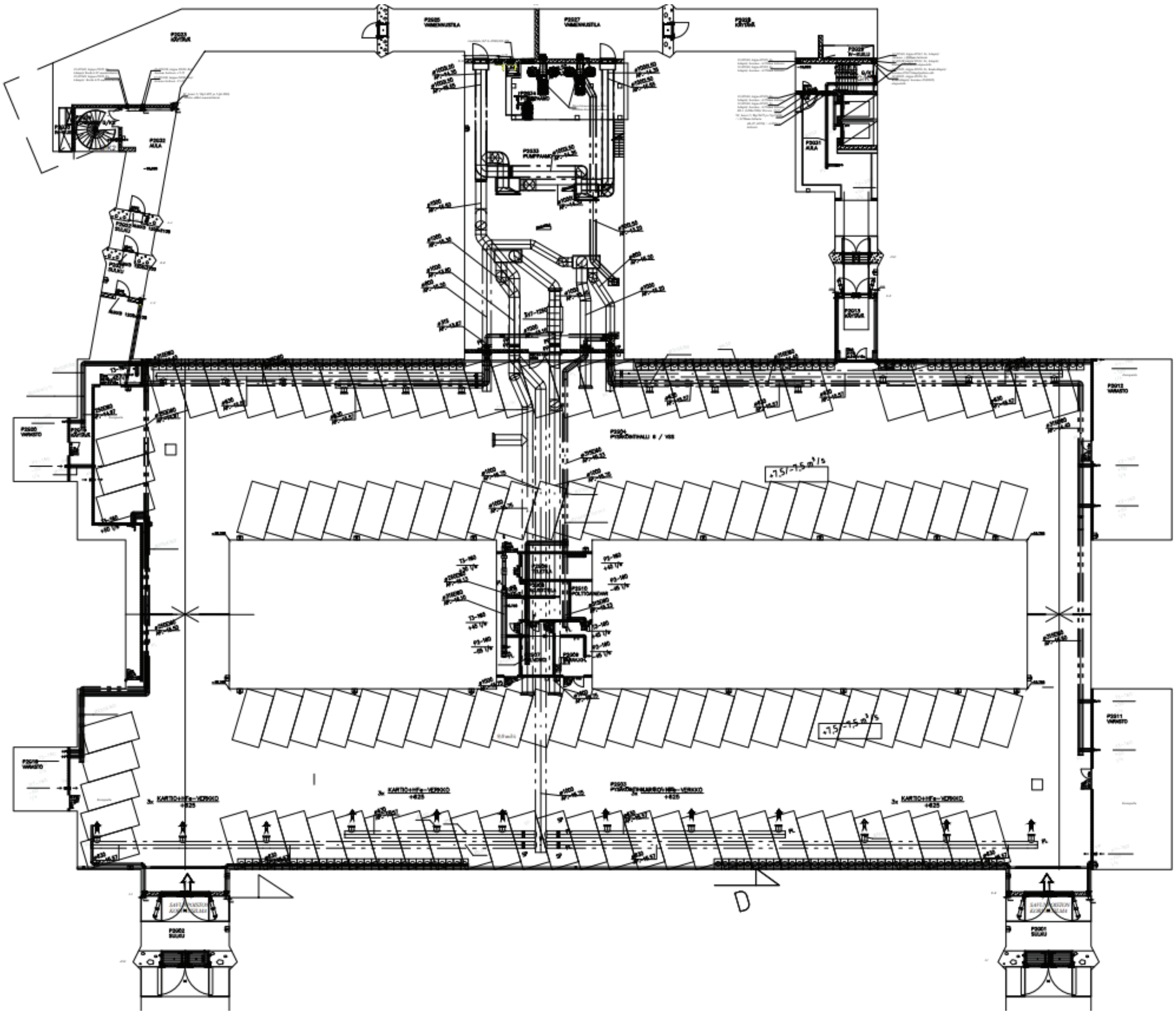


Figure B.3 — Large shelter

Figure B.3 shows an example of a large shelter excavated in the bedrock below a large shopping mall. The shelter is primarily intended for protection of the people living in the local area and not having a shelter in their own apartment building. The net area of the shelter is approximately 3 800 m^2. The shelter is designed for structural blast protection of 300 kPa and is provided with a CBRN filtration system and a ground water sumping and pumping station, both driven by electromotor and diesel engine. As both the crisis time ventilation system and ground water pumping are separately backed up by diesel power, a general back up power generation is not regarded as necessary in this case. The normal time use of the shelter is a parking garage serving the clients of the shopping mall.

Bibliography

[1] International Committee of the Red Cross. (1949). Geneva Convention relative to the protection of civilian persons in time of war. https://ihl-databases.icrc.org/en/ihl-treaties/gciv-1949

[2] United Nations. (1948). Universal Declaration of Human Rights. https://www.un.org/en/about-us/universal-declaration-of-human-rights