

Cultural property shelters: construction of new refuges and repurposing of decommissioned protected facilities

Coordination:

Protection of Cultural Property Group, Federal Office for Civil Protection

Co-authors:

Dr. Thomas Wenk

Andrea Giovannini

Shelters Group, Federal Office for Civil Protection

Table of contents

1	Foreword	3
2	Subject overview and objectives	3
2.1	Natural hazards: protection goals	4
3	PCP shelters: New builds	5
3.1	General	5
3.1.1	Terms of service	5
3.1.2	Room organisation	5
3.1.3	Internal fixtures and fittings.....	5
3.1.4	Commissioning.....	7
3.1.5	Climate control.....	7
3.2	Thermal protection	8
3.2.1	Conditions and requirements	8
3.3	Moisture protection	8
3.3.1	Conditions and requirements	8
3.3.2	Structural and organisational measures.....	8
3.4	Climate control	8
3.4.1	General climate control specifications.....	8
3.4.2	Setpoints	9
3.4.3	Airtightness of the PCP shelter structure and storage rooms.....	10
3.5	Pollutants and indoor air quality	11
3.6	Light	11
3.6.1	Natural light.....	11
3.6.2	Artificial light.....	11
3.7	Armed conflicts	12
3.8	Fire.....	12
3.9	Water.....	12
3.10	Earthquakes.....	13
3.10.1	Load-bearing structure	13
3.10.2	Installations and equipment	14
3.11	Other natural hazards	14
3.11.1	Conditions and requirements	14
3.11.2	Structural and organisational measures.....	14
3.12	Power shortages.....	14
3.13	Vandalism, terrorism and sabotage	15
3.13.1	Building security	15
3.14	Risks from the surrounding environment.....	15
4	Conversion of decommissioned protected facilities into PCP shelters.....	16
4.1	Preliminary remark	16
4.2	Conversion process	16
4.3	Preliminary investigations	16
4.4	Thermal insulation, moisture protection, pollutants and lighting	17
4.5	Indoor climate	17
4.5.1	Conditions and requirements	17
4.5.2	Structural and organisational measures.....	17
4.6	Hazards.....	17
4.6.1	Armed conflicts	17
4.6.2	Fire	18
4.6.3	Flooding.....	18
4.6.4	Earthquakes	18
4.6.5	Other natural hazards.....	18
4.6.6	Power shortages.....	19
4.6.7	Vandalism, terrorism and sabotage	19
5	Legal bases & references	20

1 Foreword

The Federal Act on the Protection of Cultural Property during Armed Conflicts, Disasters and Emergencies (CPPA), which Switzerland enacted in January 2015, extends the scope of the country's legal bases to include natural hazards. The effects of climate change observed around the world seem to indicate that Switzerland, like other countries, will experience more extreme weather. It is therefore vital that the country has a sufficient supply of shelters to protect its cultural assets. Although Switzerland currently has more than 300 of these refuges ('PCP shelters'), not all institutions with important cultural artefacts have adequate facilities to protect them. It is therefore essential that plans are developed to rectify the situation and to build more PCP shelters over the coming years.

Cultural artefacts are highly susceptible to damage and must therefore be handled and stored with care. The aim of the present report is to outline the requirements that PCP shelters must meet – location, construction, ambient conditions, lighting etc. – so that they are able to offer their contents with the best-possible protection from armed conflicts, power shortages, vandalism, fires, water damage, earthquakes and other natural hazards. Protection of cultural property efforts in Switzerland tend to focus on disaster and emergency scenarios. Yet, events happening around the world serve as a reminder that armed conflicts still pose a risk.

Under the coordination of the Protection of Cultural Property Group of the Federal Office for Civil Protection (FOCP), Earthquake engineer Thomas Wenk and conservator-restorer Andrea Giovannini provided their expert input during the development of the principles set out below. In addition, the Shelters Group of the FOCP, as the agency in charge of reviewing applications to convert/decommission protected facilities, overseeing construction work and ensuring the operational readiness of cantonal shelters, contributed its extensive knowledge and expertise to the process.

2 Subject overview and objectives

In the 1970s, against the backdrop of the Cold War and with memories of the Second World War still fresh, Switzerland began building refuges to protect not only the population but also its cultural heritage. It would pursue this policy until the early 1970s and 1990s. Today, these shelters are still used to store important cultural artefacts. Although originally designed to withstand the impact of armed conflict, these facilities should also offer effective protection against natural disasters. The technical specifications for PCP shelters¹ are still based on an armed conflict scenario and on the assumption that, where necessary, cultural assets will be stored in these facilities. The legal provisions governing PCP shelters are set out in the *Bundesgesetz über den Schutz der Kulturgüter bei bewaffneten Konflikten (KGSG)*², the *Bundesgesetz über den Bevölkerungsschutz und den Zivilschutz (BZG)*³ and in the *Verordnung über den Zivilschutz (ZSV)*⁴.

Given the expense involved in building a PCP shelter from scratch, a more cost-effective solution would be to repurpose decommissioned protected facilities.⁵ Since the FOCP issued its in-

¹ FOCP instructions of 4 April 1995 on the construction of cultural property shelters.

² [SR 520.3 - Bundesgesetz vom 20. Juni 2014 über den Schutz der Kulturgüter bei bewaffneten Konflikten, bei Katastrophen und in Notlagen \(KGSG\) \(admin.ch\)](#)

³ [SR 520.1 - Bundesgesetz vom 20. Dezember 2019 über den Bevölkerungsschutz und den Zivilschutz \(Bevölkerungs- und Zivilschutzgesetz, BZG\) \(admin.ch\)](#)

⁴ [SR 520.11 - Verordnung vom 11. November 2020 über den Zivilschutz \(Zivilschutzverordnung, ZSV\) \(admin.ch\)](#)

⁵ Cost considerations are not the only reason for converting protected facilities that have become surplus to requirements. If left unused, these decommissioned sites, or parts of them (e.g. the ventilation system, heavy current or protective envelope), can present a risk over time.

structions on the use of these structures in 2012, their numbers have fallen. However, not all protected facilities make suitable PCP shelters. They must first satisfy two fundamental criteria: location and accessibility. In some cases, they are sited too close to groundwater or water pipes; in others they do not have the right technical installations or offer the right ambient conditions. This is why experts increasingly demand that before the project begins in earnest the suitability of the proposed site is evaluated based on the latest hazard maps.

The aim of the present report is to formulate specifications to ensure that PCP shelters, whether new or repurposed, guarantee optimal protection against armed conflicts, acts of vandalism, fires, floods, earthquakes and other natural hazards. The specifications also cover hazards that are intrinsic to the structure itself. Elements like an unsuitable indoor climate, excessive or incompatible lighting and the presence of harmful materials can affect and even damage the objects in storage. The construction of new PCP shelters and the repurposing of decommissioned facilities are subject to a raft of specifications and requirements, which include the implementation of rigorous structural and organisational measures. The protection goals are basically the same for both types of protective structure.

The present report should serve as a point of reference for the drafting of an ordinance on PCP shelters. The 1995 instructions on the construction of cultural property shelters have been repealed. The planned ordinance is to be harmonised with the usual legal provisions and adapted to the current risk situation.

2.1 Natural hazards: protection goals

Art. 64 BZG and Art. 84 ZVS set out the general minimum legal requirements for PCP shelter construction projects.

PCP shelters should be built to withstand natural hazards damage-free for a return period of up to 300 years. For rarer events, the provisions set the return period at 1,000 years and permit an 'acceptable' level of damage.

Opting for a suitable location that is outside higher risk zones and the introduction of the requisite structural measures should make it possible to achieve this first protection goal. The second protection goal requires the development of an emergency preparedness plan based on the time available to respond to an incident (e.g. flooding). For certain events (e.g. earthquakes) where the response time is extremely short, supplementary structural measures must be introduced beforehand.

The purpose of an emergency preparedness plan is to ensure that the incident response is as fast and effective as possible. Potential risks vary depending on the location and nature of the shelter and the prevailing situation. The plan should include:

1. A hazard analysis
2. Preventive measures and periodic checks
3. List of incident response measures
 - a. alert plan and lists
 - b. immediate and concrete damage-control measures
 - c. organisational measures to manage the emergency
 - d. institutionalisation of processes and post-response efforts
 - e. identification of priority evacuations and development of an evacuation plan
 - f. contact lists (experts, suppliers)

3 PCP shelters: New builds

3.1 General

3.1.1 Terms of service

The conditions of use are set out in an agreement drawn up according to SIA Standard 260:2013 and based on the following specifications.

The operational life of a PCP shelter must be 100 years.

The payload is determined on a case-by-case basis pursuant to Category E (storage areas) of SIA Standard 261:2014. The reference values for the minimum payload will be $q_k \geq 20 \text{ kN/m}^2$ and $Q_k \geq 20 \text{ kN}$ unless the values indicated in the technical instructions on the design and construction of protective structures (TWK 2017) are higher.

The building envelope must be watertight for the duration of its operational life (100 years). To meet this requirement, the following measures must be taken:

- The building will be constructed from watertight concrete, thereby satisfying the criteria of waterproof class 1 as defined in SIA Standard 272:2009.
- A waterproofing system will be installed throughout the building.
- To prevent the reinforced concrete from cracking, the building will meet the criteria for the highest waterproof class as defined in SIA Standards 272:2009 and 262:2013.
- When determining the minimum reinforcement required, account will be taken of changes in the resistivity of concrete over 100 years, i.e. during the operational life of the shelter.

3.1.2 Room organisation

The division of the space depends on its intended use and must comply with fire compartment specifications. The ceiling must be a minimum of 2.60 m high; a space of at least 0.20 m must be left between the ceiling and the vent ducts, the lights and shelving. Cultural artefacts must never be stored, even temporarily, on the floor but at least 20 cm above it (equivalent to EUR-pallets stacked two high).

Evacuation routes must always be wide enough to accommodate the cultural artefacts stored in the shelter. There will be a minimum of two evacuation routes; these must be at least 1.50 m wide. The normal access route must not be fitted with steps. However, if there are steps, technical equipment should be installed which make it possible to easily move a trolley and pallets in and out.

Permanent work stations must not be set up inside the PCP shelter but sited outside the perimeter of the protected area.

If the PCP shelter has more than one floor, the most valuable artefacts, wherever possible, should not be stored on the lowest floor.

There should be passageway that runs the length of the outside walls. It must be at least 40 cm wide and kept permanently clear. Storage racks may be installed along the inside walls. However, they should be mounted at least 5 cm away from the wall itself. When setting up the shelving units, it is important to avoid creating tight corners as these will make it difficult, if not impossible, to clean the space.

3.1.3 Internal fixtures and fittings

As a general rule, the installation of internal fixtures and fittings in the PCP shelters will comply with the technical instructions on the shock resistance of civil protection shelter fixtures (TW Schock 2021). To protect inventory in the event of an armed conflict, the necessary fastening measures must be prepared and implemented for all interior fittings and fixtures (fixed shelves, mobile shelving and plan chests). These must be incorporated into the planning and tendering phase and approved by the authorities (cantonal and federal). In the interests of earthquake safety, all fixtures and fittings must be firmly secured in place.

3.1.3.1 Fixed shelf racks

- The side panels and shelves of the rack must be made from metal. At a minimum, they should be powder-coated, but ideally should be galvanised and powder-coated, or in stainless steel.
- Load-bearing capacity: this will depend on the objects that the shelves will hold. The racks must also be able to support the material when wet, as well as withstand the force of an earthquake. For documents, the minimum load-bearing capacity should be 80 kg/m; for documents such as bound newspaper collections, binders etc., it should be 150 kg/m.
- The top of the storage rack must be closed with a shelf.
- The shelves must be adjustable: height 20 – 25 mm.
- The objects on the lowest shelf should be at least 20 cm above the floor (precautionary measure in case of flooding). There must be enough clearance between the floor and the lowest shelf for a vacuum cleaner to access the space (approx. 15 cm).
- The racks must not have a back panel but should be stabilised using cross-braces (same applies to double racks).
- The side panels must be adapted to the needs of the objects stored on the racks and offer them adequate protection, e.g. to prevent smaller objects slipping or falling.
- The use of self-supporting, easy-to-move bookends is recommended.
- Label holder strips must be riveted or screwed into place; no self-adhesive label holders will be used.
- In the interests of earthquake safety, fixed racks must be firmly secured in place as per Section **Fehler! Verweisquelle konnte nicht gefunden werden..**

3.1.3.2 Mobile shelving

- Specifications for mobile shelving tracks:
 - They must be made from galvanised metal.
 - They must be embedded in the floor, where possible.
 - If the tracks are mounted on the floor, all interspaces must be covered with mobile metal plates to ensure that base of the unit is flush with the floor. The metal plates must be easy to remove for cleaning purposes or in an emergency. Chipboard panels will not be used.
- Specifications for mobile shelving unit wheels:
 - They must be made from metal, have a minimum diameter of 10 cm and are fitted with maintenance-free ball bearings.
 - The drive system must be manual and fitted with a metal rotary handle. The load capacity is determined based on the weight of the shelves when full.
- Specifications for side panels:
 - They must be open. However, if this is not appropriate for the objects in storage, the panels must be made from perforated sheet metal (approx. 40% open area) or wire mesh. No element must not have cutting or sharp edges.
 - In the interests of better air circulation, no gaskets should be mounted between the elements.
 - A system must be installed that makes it possible to lock in place a whole bank of units (multiple shelving units that move simultaneously) to prevent them from moving even when subjected to vibrations (e.g. from an earthquake). The mobile shelving units must be locked in place outside business hours.
- Fastening measures for mobile shelving in an armed conflict:
 - Mobile shelving must be fixed together as a block with brackets and/or clamping sets to prevent it from moving along the slide rail.

3.1.3.3 Flat file cabinets

- Specifications for flat file cabinets:

- The load capacity of each drawer must be adapted to the documents they hold (when wet); for A0 format documents, minimum load capacity must be 60 kg.
- When the drawers are open, at least 70% of their surface must be easy to reach.
- The drawers must be fitted with a locking system to ensure that only a single drawer can be open at any one time. The cabinet unit must also be lockable.
- Alternatives to flat file cabinets:
 - Given that good quality flat file cabinets tend to be expensive, larger shelving units fitted with deeper shelves may be used instead. The objects may be stored on the shelves in large-format archival storage boxes and/or file folders. This ensures the optimal use of the available space and makes it easier to evacuate the objects stored there. However, this solution makes direct access to the contents more difficult.

3.1.4 Commissioning

- Particular attention will be paid to the moisture content in the concrete and the structural drying-out process.
- All new builds and complex conversion project need to take into account that building materials are also a source of moisture, which can substantially affect the quality of the indoor climate. The drying out process begins once the site is protected from the rain, the inside of the structure is dry and the indoor relative humidity is < 60%.⁶ Drying times differ widely depending on the materials used, thickness and the type of wall construction – from as a little as a few months (highly porous and relatively thin materials) to as much as 10 years (concrete) (see also Section 3.4.1).
- Once construction work is completed, the PCP shelter will undergo a final cleaning. Given that the purpose of the facility is to store cultural artefacts, this process will also involve removing any residual (or fine) dust and meticulously cleaning all surfaces, as well as all stationary and mobile installations (fixtures and fittings). At the end of the cleaning process, it is advisable to measure the level of particulates in the air.
- Checks must be carried out every three months during the first 24 months that the ventilation and air-conditioning systems have been in service. Adjustments will be made where necessary.
- To keep risks to a minimum, maintenance checks should be performed from the outset on the storage rooms, structure and immediate surroundings of the PCP shelter. Maintenance work should also be regularly carried out, especially on the water drainage system, seals (including door seals), technical installations and equipment.⁷

3.1.5 Climate control

All PCP shelters must be fitted with a meter (data logger) to monitor the temperature and relative humidity in the facility.⁸

- The accuracy of the relative humidity measurements must be in the range of +/- 0.5 °C and +/- 2%.
- The meter must be set to record the temperature and relative humidity at 20-minute intervals, and have sufficient capacity to store a minimum of 12 months of temperature and relative humidity data (i.e. two sets of 26,000 data points).
- The meter must be equipped with a screen that directly displays the current temperature and relative humidity in the given space.
- The readings must be checked on site at least twice a month.
- A full evaluation should be carried out once a year.

⁶ The relative humidity in the first months of operation should be less than 70%.

⁷ See also the FOCP instructions on periodic shelter checks (PSK 2013) and supporting directives.

⁸ If a group of smaller shelters share the same ventilation system, a data logger does not have to be set up in each room. One monitor per 200 m² will suffice.

- The climate data must be kept for at least three years so that they can be analysed should a problem arise at a later date.

3.2 Thermal protection

3.2.1 Conditions and requirements

- In underground facilities, the soil serves as an extremely stable heat and cold accumulator. Depending on the depth of the structure and the composition of the soil, the temperature of the soil fluctuates little over the year. These properties can have both positive and negative effects on the ambient conditions of the PCP shelter.
- The aim of thermal insulation is to optimise the circulation of heat between the PCP shelter and its environment (both internal and external). Consequently, the thermal insulation of the envelope (external walls, floors and ceilings) should be determined according to the indoor climate setpoints and the planned ventilation and climate control systems. As a general rule, the maximum permissible temperature differences between the coldest and warmest parts of the space should be 2 °C.
- Where possible, an external thermal insulation system should be used as it offers good heat storage mass which in turn keeps the indoor temperatures stable. If internal thermal insulation is the only viable solution, insulation may be added to the inside walls and floors/ceilings.
- Thermal insulation may only be installed on permanently dry walls.
- See also Section 3.4.

3.3 Moisture protection

3.3.1 Conditions and requirements

To prevent the ingress of moisture and water, the terms of use set out stringent requirements regarding the waterproofing of the building envelope. The water-resistant performance of the structure must be completely guaranteed for a period of 100 years and for all possible events – from a rise in the groundwater level right through to a 300-year flooding event (see Section 3.1.1).

3.3.2 Structural and organisational measures

Waterproofing measures include the use of waterproof concrete that satisfies the criteria for waterproof class 1 and the installation of an all-over flexible waterproofing system. The minimum reinforcement to prevent cracking must meet the strictest requirements in order to guarantee the waterproof performance of the reinforced concrete walls, floor and ceilings. The doors to the PCP shelters must offer sufficient protection against water ingress. Other openings must be authorised beforehand by the authorities and be gas-, pressure- and water-tight. Openings in the remaining parts of the building must be higher than the water level of a 300-year flood (See Section 3.9).

The inside of the PCP shelter must not contain any water or wastewater pipes (exception: heating pipes; see also Section 3.9).

3.4 Climate control

3.4.1 General climate control specifications

- Where possible, the indoor climate of PCP shelters should be controlled by passive measures, e.g. through the use of appropriate building materials.
- As a general rule, the structure of separating walls should consist of drainage, waterproofing, thermal insulation, a concrete wall and vapour-permeable paint.
- A specialist in building engineering physics must be involved in the modelling of the 'spontaneous' climate in the facility. Given that it can take several years for concrete walls to dry out, plans will be made for the installation of the simplest possible ventilation system.

- The building may only be used once it is sufficiently dry, i.e. when, without the use of technical equipment, the relative humidity in closed spaces remains below 60% for at least 72 hours.
- In principle, the properties of the building envelope and that of the room, with or without the use of basic climate control technology, should make it possible to achieve the indoor climate setpoints for PCP shelters.⁹
- It would be advisable to carry out a thermal and hygrometric simulation of the building before deciding on the technical installations for the building envelope and ventilation system.
- First, a review must be undertaken to ascertain whether the ambient conditions in the shelter and its location merit the installation of an artificial ventilation system. Underground facilities usually need to be ventilated artificially due to the limited spontaneous exchange of indoor and outdoor air.
- Controlled natural ventilation is another effective way to maintain a stable indoor climate as air is only drawn from the outside (depending on the time of year) when it has the required properties. An analysis therefore should be carried out to ascertain whether the local climate and building envelope properties are conducive to the use of outside air to ventilate and control the climate of the PCP shelter. One alternative is the installation of a conventional monobloc unit that heats, cools, humidifies and dehumidifies. In this instance, the installation must be designed in such a way that it does not cause any short-term climate fluctuations. The short-term climate fluctuation should be < 3% RH/hr.
- A combination of the two is also possible, e.g. natural ventilation coupled with the installation of a dehumidifier.
- Having separate heating and ventilation systems may be advisable, particularly if the PCP shelter uses controlled natural ventilation.
- The climate control plan for the PCP shelter must factor in the direct and indirect effects of light, in particular the heat released by artificial light and air-conditioning units.
- The surface of the ventilation ducts (where present) must be smooth and made from metal. Self-adhesive components must not be used to mount or insulate the ducts.
- All climate control devices and ventilation systems must be installed outside the PCP shelter to avoid the cultural artefacts suffering damage should this equipment fails. The presence of machines inside the storage areas are not only a potential source of damage but can also have undesirable side-effects due to the heat they release.
- The distribution of air (air infiltration and exfiltration in the case of ventilation systems) should make it possible to maintain a stable indoor climate throughout the room. Maximum permissible fluctuations, vertically and horizontally, are 2 °C and/or 5% RH.

3.4.2 Setpoints

- There are many, sometimes contradictory, norms stipulating indoor climate setpoints for cultural property storage facilities. The values recommended in the present document are empirical. Where necessary, conservation and restoration professionals will help to identify climate specifications for specific cultural artefacts.
- As a general rule, the setpoints proposed here should guarantee a stable indoor climate and prevent short-term fluctuations. It should be noted that slow seasonal fluctuations generally do not pose a risk for most cultural artefacts.
- The following setpoints are recommended for paper documents, posters, textiles, pictures, wood, ethnological objects etc.:

⁹ The nine principles of building engineering physics for the indoor climate quality in PCP shelters: 1. High level of building airtightness; 2. Well-insulated external walls; 3. High level of building inertia; 4. Complete drying of building materials; 5. Simple heating system; 6. Open-pore materials (can be compensated for by the properties of the objects in storage); 7. Access via airlocks; 8. Efficient lighting; 9. No permanent work stations. (Christoffersen, L.D.: ZEPHIR Passive Climate Controlled Repositories, Lund University, 1995)

- In winter: 12–18 °C, 40–50% RH¹⁰,
Fluctuations < 1 °C/day, < 3% RH/hr and < 5% RH/day.
- In summer: 18–24°C, 50–60% RH,
Fluctuations < 1 °C/day, < 3% RH/hr and < 5% RH/day.
- Climate fluctuations between winter and summer should not be more than 2 °C and 5% RH/week. In the event that an installation has to be manually programmed/reset periodically, there should be at least two intermediate settings between the summer and winter climate settings.
- The following setpoints are recommended for metals and other materials:
 - In winter: 12–18 °C; 30–40% RH; fluctuations < 1 °C/day, < 3% RH/hr and < 5% RH/day.
 - In summer: 18–24 °C; 30–40% RH; fluctuations < 1 °C/day, < 3% RH/hr and < 5% RH/day.
 - It is important to remember that these moisture setpoints can only be achieved through constant dehumidification (with the technical and power outlay this process entails).
- The following setpoints are recommended for photographs, multimedia and other highly temperature-sensitive materials:
 - Year-round: 12–14 °C; 30–40% RH; fluctuations < 1 °C/day, < 3% RH/hr and < 5% RH/day.
 - Setpoints should be determined based on the object and its material composition.
 - It is important to remember that these moisture setpoints can only be achieved through constant dehumidification (with the technical and power outlay this process entails).
- Share of fresh air in the supply air:
 - For objects which do not release any volatile substances (VOC¹¹ etc.) and/or other chemically active substances, the fresh air supply should generally be 1 volume/day¹² (approx. 0.05 vol/hr). However, it is generally not a problem if the room is not ventilated for several days.
 - For objects which release substantial amounts of pollutants, the quantity of filtered fresh air must be adjusted to the type and concentration of the harmful substance it releases. Another alternative could be the installation of the appropriate air filters in the air recirculation system to remove these pollutants.
 - To avoid uncontrolled ventilation, it is important that the ventilation system is sealed off from the outdoor climate. This requirement equally applies when the ventilation system is not in service.
- Air circulation:
 - The volume of recirculated air depends on the properties of the building, the storage room, the fixtures and fittings and the objects stored there.
- Air filtration:
 - External air and recirculated air must, at a minimum¹³, be treated by a F9 air filter.¹⁴
 - In certain cases, activated carbon and gas adsorption filters could be used to eliminate air pollution caused by gas releases. The final decision will be based on the results of an evaluation of external air quality, the pollutants emitted by the contents of the storage area and the requirements that must be met in relation to these objects.

3.4.3 Airtightness of the PCP shelter structure and storage rooms

- The ventilation flaps must be airtight, especially the fresh air inlet flaps.

¹⁰ RH: relative humidity.

¹¹ Volatile organic compounds.

¹² For a space with a room volume of 500 m³, up to 500 m³ of fresh air (external air) may be supplied over a 24-hour period.

¹³ As per DIN EN 779.

¹⁴ In terms of prefilters, an G4 or G5 class air filter will be installed as standard.

- It is advisable to check and document the airtightness of the building envelope and the ventilation system (e.g. by means of the blower door test).
- For areas which are visited on a regular basis (more than twice a week), the installation of an entry airlock is advisable so as to keep the intake of external air to a minimum. The airlock may take the form of a lightweight structure.

3.5 Pollutants and indoor air quality

The surroundings, the building, building components and the cultural artefacts stored there can all be a source of air pollution. Every effort should be made to minimise these sources through an informed choice of location, building materials and ventilation system.

- The aim here is to prevent the release of pollutants by structural elements (e.g. walls, thermal insulation, plaster, paint, floor coverings, appliances, equipment, interior fittings, etc.). Therefore, this point must be factored in when selecting building materials and the fixtures and fittings for the shelter.
- Attention should also be paid to the release of pollutants from the cultural objects themselves. Materials such as PVC and other plastics, cellulose acetates and nitrates, wood and wood panels may release volatile organic compounds.
- Some cultural artefacts (e.g. in ethnological and natural history collections) can be hazardous for humans because they have been treated with chemicals. There is also a risk that these chemicals could be released into the ambient air.
- There are also another set of cultural objects (e.g. metals, photographs etc.) which, under certain circumstances, can trigger chemical reactions. It is important not to overlook this eventuality.
- Every effort should be made to minimise dust emissions from walls, ceilings and floors.
- When treating walls and ceilings, only vapour permeable mineral paints should be used.
- The floor should be treated with a paint or resin that provides an even, durable and easy-to-clean waterproof layer.

3.6 Light

Every effort should be made to minimise the direct and indirect effects of light on the cultural artefacts in storage.

3.6.1 Natural light

PCP shelters do not have any natural light.

3.6.2 Artificial light

In principle, only lighting approved by the Spiez Laboratory (FOCP) should be used in PCP shelters.¹⁵ Authorised lighting components feature on the corresponding lists. The use of artificial light should be kept to a minimum. Here, a distinction must be made between the direct and indirect effects that light can have on an object:

- Direct effects include chemical damage and an irreversible change in the colour of delicate artefacts. The UV rays emitted by certain light sources are particularly active and aggressive.
- Indirect effects include the conversion of light beam radiation into heat as soon as it is absorbed by a surface.

It is recommended that lighting in the facilities is kept to a bare minimum and used only when strictly necessary. PCP shelters should remain in darkness when not in use. It may make sense to fit the lighting system with an automated switch-off feature (i.e. the light turns off when someone exits the room).

¹⁵ See also: [ZKDP Homepage \(admin.ch\)](#)

- As a general rule, the lighting should deliver 150-200 lux. However, this setpoint should be adjusted on a case by case basis.
- To keep heat emission levels as low as possible, the artificial light sources should offer the best possible lumens-per-watt performance. An output of at least 100 lm/W is recommended.
- The artificial light sources should emit practically zero or very little UV radiation. The UV component of the radiation should be $< 75 \mu\text{W}/\text{lm}$.
- It is advisable to choose the colour rendering¹⁶ according to the intended use of the given space (e.g. CRI $R_a > 90$).

3.7 Armed conflicts

The protection of a PCP shelter from armed conflict is ensured by compliance with *TWK 2017*, *TW Schock 2021* and the *Administrative Weisungen für den Neubau und die Erneuerung von Schutzanlagen und Kulturgüterschutzräumen (AW 2004)*.

In addition to the technical instructions mentioned earlier, the building project must meet the conditions and requirements stipulated by the FOCP before it can be approved.

3.8 Fire

No permanent workplaces may be set up inside the PCP shelter.

The fire protection strategy for a PCP shelter must comply with the fire protection regulations of the Association of Cantonal Fire Insurance Companies (VKF/AEAI).

In addition to VKF/AEAI fire protection regulations, the following requirements apply:

- As a general rule, rooms must be separated by fire compartments with a surface area of 200 – 300 m². The constituent parts of these compartments must satisfy the REI 90 fire resistance specifications.
- All protective components in the fire compartments must comply with FOCP building regulations.
- Non-essential equipment may not be kept in rooms where cultural artefacts are stored. This applies particularly to electrical, ventilation and air-conditioning equipment.
- Only the cultural property stored in the PCP shelter may contribute to its fire load. Consequently, all equipment and furniture must be made of non-flammable material.
- Combustible building materials must not be used.
- Rooms where cultural artefacts are stored must be equipped with a fire alarm system in order to keep the space under constant surveillance.
- The shelter must be equipped with extinguishers, containing the appropriate extinguishing agent and have sufficient extinguishing capacity. Only fire extinguishers and extinguishing agents approved by the FOCP may be used. These can be found in the corresponding list.¹⁷
- The extinguishing agent will depend on the type of cultural artefact stored in the room where the extinguisher is fitted.
- In principle, sprinkler systems should not be used.

3.9 Water

To protect against flooding, and the ingress of groundwater or water from existing pipes, the following requirements apply:

¹⁶ The spectrum of the light sources varies widely. Some have only limited colour rendition; with others the rendition is fuller. The colour rendering index is decisive here: perfect colour rendering is 100, but anything above 90 is more than adequate.

^{17 17} See also: [ZKDP Homepage \(admin.ch\)](http://zkdp.admin.ch)

- As a general rule, the PCP shelter should be sited in zones coloured white in the corresponding hazard map (no or negligible hazard).¹⁸
- PCP shelters must not be built in zones coloured red (significant risk) or blue (medium risk) on the corresponding hazard map.
- In exceptional cases, PCP shelters may be built in zones coloured yellow (low hazard) or yellow-white hatched (residual hazard) in the corresponding hazard map. However, additional protective measures must be taken in such instances. The requirements of SIA Standards 261:2014 and 261/1:2003 will apply.
- The PCP shelter must be entirely above the 300-year flood level.

The structural measures detailed in Section 3.3.2 guarantee that the PCP shelter is watertight.

- All access and opening are to be elevated above the ground so that they are higher than the 300-year flood level. Temporary protection measures such as flood gates and coffer-dam systems are to be used to protect the PCP shelter against a 1,000-year flood.
- The following protective measures must be taken to avoid damage from sources of water inside the building:
 - No water pipes (except for the shelter's heating system pipes¹⁹) may pass through the PCP shelter.
 - No wastewater pipes are permitted in PCP shelters. Discharges into the wastewater system in areas other than the PCP storage rooms will be monitored. Where necessary, backflow protection will be installed.
 - Water collection tanks for fire protection purposes must be sited in the upper parts of the building to prevent the ingress of water in the PCP shelter.
 - The entrance to a PCP shelter should be designed in such a way that water cannot enter should an incident occur, for example by installing a doorstep or slope. Regardless of the form the entrance takes, it should be designed to allow a trolley and pallets to enter and exit.
 - If necessary, water collection tanks will be equipped with suitable drainage paths. Where ditches are sited lower than the wastewater pipes, it would make sense to install a permanent connection for an external water pump. In this instance, the set-up should provide for the installation of duplicate internal water pumps and, if necessary, their connection to an emergency generator.
 - In places where water could seep in or collect, a water sensor should be installed directly on the floor (rooms with technical equipment, cultural property storage rooms, corridors).
 - Cultural artefacts must never be stored, even temporarily, on the floor but at least 20 cm above it (equivalent to EUR-pallets stacked two high).

3.10 Earthquakes

3.10.1 Load-bearing structure

- In terms of seismic design, PCP shelters must be a class III structure, i.e. it meets the highest requirements according to SIA Standard 261:2014. It can therefore be assumed that a shelter designed in accordance with *TWK 2017* meets the earthquake-resistant requirements for the load-bearing structure of class III buildings.
- No structural measures beyond those specified in the *TWK 2017* are required for the load-bearing structure.

¹⁸ See also: <https://www.bafu.admin.ch/bafu/de/home/themen/naturgefahren/fachinformationen/naturgefahrensituation-und-raumnutzung/gefahregrundlagen/ Gefahrenkarten--intensitaetskarten-und-gefahrenhinweiskarten.html>

¹⁹ If this is the case, rooms where cultural artefacts are stored must not share the same heating circuit as other parts of the PCP shelter.

3.10.2 Installations and equipment

It is important that all objects in the PCP shelter (fixtures, fittings and cultural artefacts) are braced horizontally to stop them from moving or falling as a result of earthquake ground motion.

- Conditions and requirements
 - In addition to the load-bearing structure, all non-load-bearing components (or 'secondary components') as well as installations and equipment must meet the earthquake-resistant requirements for class III buildings. It is assumed that components which are subject to testing and meet the requirements of *TW Schock 2021* also satisfy the requirements regarding the earthquake-resistant performance of the load-bearing structure of class III buildings.
 - Equally, the same requirements apply to the cultural objects stored in the shelter. They must be appropriately secured by means of a horizontal bracing system (e.g. addition of padding, shock absorbers or elastic straps placed in front of the shelves). Structural anchoring provides sufficient protection against vertical impacts (uplift).
- Structural and organisational measures
 - All fittings that are not subject to testing must meet the earthquake-resistant requirements for class III buildings defined in SIA Standard 261:2014. They include bracing in both horizontal directions; equation (49) of the above standard is used to calculate the bracing forces. Special attention must be paid to the effect that the horizontal bracing forces may have on the objects in storage. Soft padding should make it possible to avoid localised overload.

3.11 Other natural hazards

3.11.1 Conditions and requirements

In terms of natural hazards such as high winds, hail, landslides, snow, avalanches, debris flows, falling stones, rock and ice, it may be assumed that a shelter designed in accordance with *TWK 2017* provides sufficient protection, provided that it is sited in a zone coloured white²⁰ on the corresponding hazard map.²¹

PCP shelters may not be sited in zones coloured red or blue on the corresponding hazard map.

In exceptional cases, PCP shelters may be built in zones coloured yellow (low hazard) or yellow-white hatched (residual hazard) in the corresponding hazard map. However, additional protective measures must be taken in such instances. The requirements of SIA Standards 261:2014 and 261/1:2003 will apply.

3.11.2 Structural and organisational measures

An emergency preparedness plan must be drawn up that takes account of the response lead time for each hazard and ensures that damage will be kept to a minimum, even during rare events with return periods of up to 1,000 years.

3.12 Power shortages

Emergency concepts should ensure that, in the event of a power shortage, an external power supply is provided via a mobile power generator, battery backup or other solution. This should

²⁰ Recommendation on Spatial Planning and Natural Hazards, Federal Office for Spatial Development, Bern 2005.

²¹ *Bundesgesetz über den Wasserbau* (Art. 6) and *Bundesgesetz über den Wald* (Art. 36).

take account of the requirements of cultural assets which are particularly sensitive to temperature and humidity, such as photographs, microfilms, multimedia assets, metals, etc.²² It is worth bearing in mind that, alongside the heating, ventilation and air-conditioning systems of the PCP shelter, the access control system, electronic water sensors and other components also depend on electricity.

3.13 Vandalism, terrorism and sabotage

3.13.1 Building security

To protect against burglary, all PCP shelter openings must be equipped with locks that satisfy RC 6 specifications – the highest lock class as defined in SIA Standard 343.201:2011 (Doors, windows, curtain walls, grills and closures – Anti-burglary protection – Requirements and classification).

Organisational measures are to be taken to restrict access to the PCP shelter to the smallest possible group. In addition, access is only permitted when specialist staff are present and an access control system is installed that records all entries and exits.

3.14 Risks from the surrounding environment

- Industrial areas, fuel depots, etc. pose an increased risk of disaster.
- The site of the PCP shelter should be at least 300 m away from major traffic routes (rail, road, shipping).
- Access and escape routes will be determined according to the cultural artefacts which will be kept in the PCP shelter.

²² Cultural objects made of paper, leather, parchment, fabric and similar materials can easily be stored for several days in low-tech repositories with no power supply or other measures.

4 Conversion of decommissioned protected facilities into PCP shelters

4.1 Preliminary remark

This section exclusively addresses issues that relate specifically to conversion projects. It is therefore a supplement to the section on the construction of new PCP shelters. However, the protection goals are fundamentally the same for both types.

4.2 Conversion process

Since the Federal Office for Civil Protection instructions on the use of existing protected facilities came into effect on 1 October 2012, several protected facilities have been decommissioned by their owners, after prior consultation with the FOCP.²³ In such instances, the FOCP always recommends evaluating whether these facilities lend themselves to a change of use. In the case of command posts, facilities for rescue units, protected infirmaries and first-aid posts that have become surplus to requirements, these evaluations should focus primarily on whether they could be repurposed as PCP shelters. Obsolete technical systems can be dismantled.

The decommissioning of protected facilities are subject to the applicable legal provisions. The conversion process is as follows: after the owner has submitted the appropriate application to the FOCP, an overall plan is drawn up, including the dismantling and conversion measures, and submitted within five years to the canton and the FOCP for review and approval. The owner is responsible for the dismantling of the facility. Conversion work and project coordination fall to the cantons. A conversion project must meet the following criteria:

- In accordance with Art. 91 para. 3 BZG, the federal government does not bear the dismantling costs.
- Responsibility for the safety inspection of electrical installations lies with the owner.
- Once the facility has been dismantled, responsibility for monitoring and checking the safety of the installations passes from the Federal Inspectorate for Heavy Current Installations (ESTI) to the regional energy supplier.
- The relevant cantonal civil protection office will coordinate a site visit, which will be attended by all parties involved. Together, they will identify the possibilities of repurposing the facility as a PCP shelter. Where necessary, the FOCP can provide support.

4.3 Preliminary investigations

Before proceeding with clarifications on the possible change of use, preliminary investigations must be conducted with a view to determining whether the existing site satisfies the following criteria and does not present the following risks:

- Location
 - Site exposed to water hazards (groundwater, rivers, storms, 300-year flood, etc.). See also Section 3.9.
 - Site at increased risk from natural hazards. See Section 3.1.1.
 - Site with increased exposure to the risk of disaster due to the presence of industrial estates, fuel depots, etc. See Section 3.1.4.
 - Site that is too close to major transport routes (rail, road, shipping). It should be located at least 300 m away from these routes.
- Humidity

²³ According to Art. 71 para. 1 BZG, protected facilities may in principle only be decommissioned with the approval of the FOCP.

- Masonry moisture: concrete walls, floor and ceilings that have a particularly high moisture content can lead to damp seeping into the building which can lead to permanent changes in the ambient conditions.
- The maximum release of moisture in concrete walls is 0.005 g/h/m².
- The moisture content of the concrete should first be measured with a capacitive hygrometer at a depth of at least 25 mm. To double check the results, the values should be confirmed with a resistive hygrometer or other suitable instrument at a minimum depth of 100 mm.
- Readings should be taken at least 2 m from all walls, at a height of 20, 100 and 200 cm respectively, and on the floors and ceilings.
- In addition, a climate test should be conducted to measure the moisture released by the room envelope. The relative humidity in the room should be below 60% RH at the start of the test. The test requires the room to be sealed for 96 hours; all ventilation systems and other equipment also must be turned off. The values are deemed to be in order if the rise in RH is less than 5%.

4.4 Thermal insulation, moisture protection, pollutants and lighting

Conversions are subject to the same provisions as new builds.

4.5 Indoor climate

4.5.1 Conditions and requirements

Conversions are subject to the same provisions as new builds.

4.5.2 Structural and organisational measures

- As a general rule, the instructions in Sections 3.4.2 and 3.4.3 apply also to conversions and should be adapted where required.
- A test of the spontaneous indoor climate may be conducted and its findings used to determine the choice of ventilation system for the PCP shelter.²⁴
- The climate test results should also be analysed by a HLS engineer and a conservation expert. The aim here is to make the best use of the properties of the existing building envelope, improve them if necessary and, where required, plan for the use of technical installations.
- Older emergency ventilation systems used in civil protection shelters should be dismantled. Older, unused supply air ducts should be water- and airtight. In principle, the pressure relief valves must be sealed.

4.6 Hazards

4.6.1 Armed conflicts

Conversions are subject to the same provisions as new builds.

²⁴ In principle, the properties of the existing building envelope should make it possible to maintain humidity values of < 60% RH without recourse to technical installations. It would be advisable to record the ambient conditions (temperature and relative humidity) in closed rooms with little or no heating, at least twice a year – once in summer (July–August), once in winter (January–February) – over several weeks, where possible over a 12-month period; all equipment in the room should be deactivated and no-one permitted to enter while the tests are under way. For these measurements suitable data loggers should be used that offer an accuracy range of at least +/- 0.5 °C and +/- 2% RH. Readings should be continuously taken, at a minimum time interval of 20 minutes.

4.6.2 Fire

Conversions are subject to the same provisions as new builds.

4.6.3 Flooding

- Conditions and requirements
 - Conversions are subject to the same provisions as new builds.
- Structural and organisational measures
 - As a general rule, no water pipes should pass through PCP shelters.
 - If water pipes cannot be removed, they must remain visible. A water detector should be installed to ensure that any problems can be identified in time. If the water pipe runs above the storage racks, it would be advisable to install a metal tray underneath the pipe; it should be fitted with a water detector and, where possible, a water outlet.
 - Water pipes that could not be removed must be inspected thoroughly and replaced if necessary.
 - Water pipes that could not be removed must be clad with effective thermal insulation to prevent heat loss and the condensation of water vapour.
 - Surplus and/or unused water outlets should be permanently closed with a pressure-resistant seal.
 - Existing water outlets should be fitted with backflow protection.
 - Manhole covers should be fitted with the appropriate seals and fastenings to render them water pressure-tight.
 - Thorough checks should be carried out on windows to ensure that they are air- and watertight. The water outlet in the air shafts should be kept free and cleaned regularly.
 - Thorough checks should be carried out on the existing escape routes to ensure that they are air- and watertight. Unnecessary openings in the building envelope should be blocked up and rendered air- and watertight.

4.6.4 Earthquakes

In principle, conversions are subject to the same provisions as new builds. Earthquake resistance checks should be carried out on existing shelters that do not meet the requirements of TWK 2017. If the requirements for new class III buildings are not fully met, earthquake-proofing measures must be implemented to rectify the situation.

4.6.5 Other natural hazards

With regard to protection against natural hazards such as wind, hail, landslides, snow, avalanches, debris flows, rock, block and ice falls, it may be assumed that a protected facility offers sufficient protection provided that it is located in a zone coloured white²⁵ on the corresponding hazard map.²⁶

Facilities in zones coloured red or blue on the corresponding hazard map may not be converted into PCP shelters.

Facilities in zones coloured yellow or yellow-white hatched on the corresponding hazard map may be converted into PCP shelters. However, additional protective measures must be taken. The requirements of SIA Standard 261:2014 and SIA Standard 261/1:2003 will apply.

²⁵ Recommendation on Spatial Planning and Natural Hazards, Federal Office for Spatial Development, Bern 2005.

²⁶ Bundesgesetz über den Wasserbau (Art. 6) and Bundesgesetz über den Wald (Art. 36).

4.6.6 Power shortages

The same provisions apply as for new buildings.

4.6.7 Vandalism, terrorism and sabotage

Conversions are subject to the same provisions as new builds.

5 Legal bases & references

Legal bases:

- Bundesgesetz über den Schutz der Kulturgüter bei bewaffneten Konflikten, bei Katastrophen und in Notlagen **KGSG** 2015
- Verordnung über den Schutz der Kulturgüter bei bewaffneten Konflikten, bei Katastrophen und in Notlagen **KGSV** 2015
- Bundesgesetz über den Bevölkerungsschutz und den Zivilschutz **BZG** 2019
- Verordnung über den Zivilschutz **ZSV** 2020
- Technische Weisungen für den Pflicht- Schutzraumbau **TWP 1984**
- Technische Weisungen für die Konstruktion und Bemessung von Schutzbauten **TWK 2017**
- Technische Weisungen für die Schocksicherheit von Einbauteilen in Zivilschutzbauten **TW Schock 2021**
- Technisches Pflichtenheft für die Herstellung, Lieferung und Montage von Schutzbauabschlüssen und Drucktüren für Schutzbauten des Zivilschutzes **TPH-19**
- Technische Weisungen für den Unterhalt von vollwertigen Schutzbauten **TWU 2000**
- Technische Weisungen für die Erneuerung von Anlagen und speziellen Schutzräumen **TWE 1997 Anlagen**
- Weisung des Bundesamtes für Bevölkerungsschutz (BABS) zur kantonalen Bedarfsplanung für Schutzanlagen der Führungsorgane und Zivilschutzorganisationen vom 1. Januar 2024
- Administrative Weisungen für den Neubau und die Erneuerung von Schutzanlagen und Kulturgüterschutzräumen **AW 2004**
- FOCP database of civil protection components (<https://www.zkdb.vbs.admin.ch/>)

Background documentation:

- Bericht des Bundesrates an die Bundesversammlung über die Konzeption 1971 des Zivilschutzes vom 11. August 1971 (BBl 1971 II 516)
- Bericht des Bundesrates an die Bundesversammlung über Einsatz und Organisation des Zivilschutzes Zivilschutz-Leitbild vom 26. Februar 1992 (BBl 1992 II 922)
- Leitbild Bevölkerungsschutz. Bericht des Bundesrates an die Bundesversammlung über die Konzeption des Bevölkerungsschutzes vom 17. Oktober 2001 (BBl 2002 1745)
- Strategie Bevölkerungsschutz und Zivilschutz 2015+. Bericht des Bundesrates vom 9. Mai 2012 (BBl 2012 5503)
- Umsetzung Strategie Bevölkerungsschutz und Zivilschutz 2015+. Bericht an den Bundesrat vom 6. Juli 2016 (VBS und RK MZF)
- Standortbestimmung zu den Schutzanlagen und Schutzräumen des Bevölkerungsschutzes. Bericht des Bundesrates in Erfüllung der Motion 05.047 der Finanzkommission NR vom 18. November 2005. Bern, August 2007.
- Werterhaltungskonzept Schutzbauten 2010; Phase I, Situationsanalyse. Bericht vom Dezember 2008 (BABS)
- Werterhaltungskonzept Schutzbauten 2010; Phase II, Schutzanlagen. Bericht vom Dezember 2009 (BABS)

Bibliography (abridged):

- Giovannini, Andrea: De Tutela Librorum. Die Erhaltung von Büchern und Archivalien. Baden 2010.
- Bonvin, Michel; Giovannini, Andrea: Passive Management of the Climate of an Archive Storage Facility. In: ABI Technik 2022; 42(3): 180–192.

- Giovannini, Andrea: Architektur und Konservierung: Der Bau von Archivmagazinen /Architecture et conservation: la construction des dépôts d'archives. In: A. Gössi. Archivbauten in der Schweiz und Fürstentum Liechtenstein. Baden, Hier und Jetzt, 2007.
- Christoffersen, L.D.: Zephir. Passive Climate Controlled Repositories. Lund 1995.
- Hilbert, Günter: Sammlungsgut in Sicherheit. Belin, Gebr. Mann Verlag, 2002.