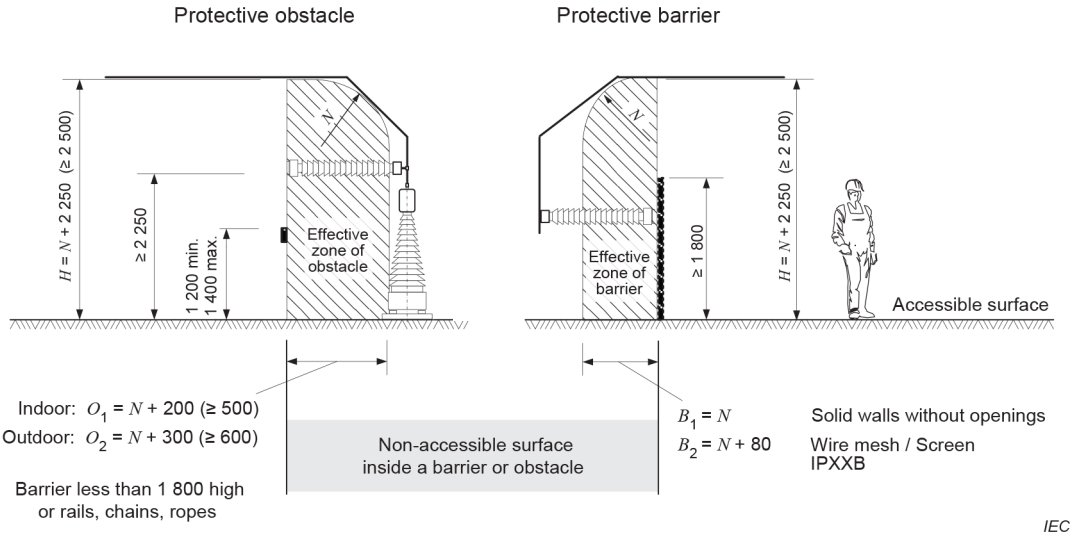
Dimensions in millimetres




**Key**

$H$ minimum clearance of live parts above accessible surface at the external fence

$B_1$ barrier clearance to solid walls without openings

$B_2$ barrier clearance to wire mesh/screen IPXXB

$N$ minimum clearance of danger zone

$O_1$ obstacle clearance, indoor

$O_2$ obstacle clearance, outdoor

**Figure 2 – Protection against direct contact by protective barriers or protective obstacles within closed electrical operating areas**

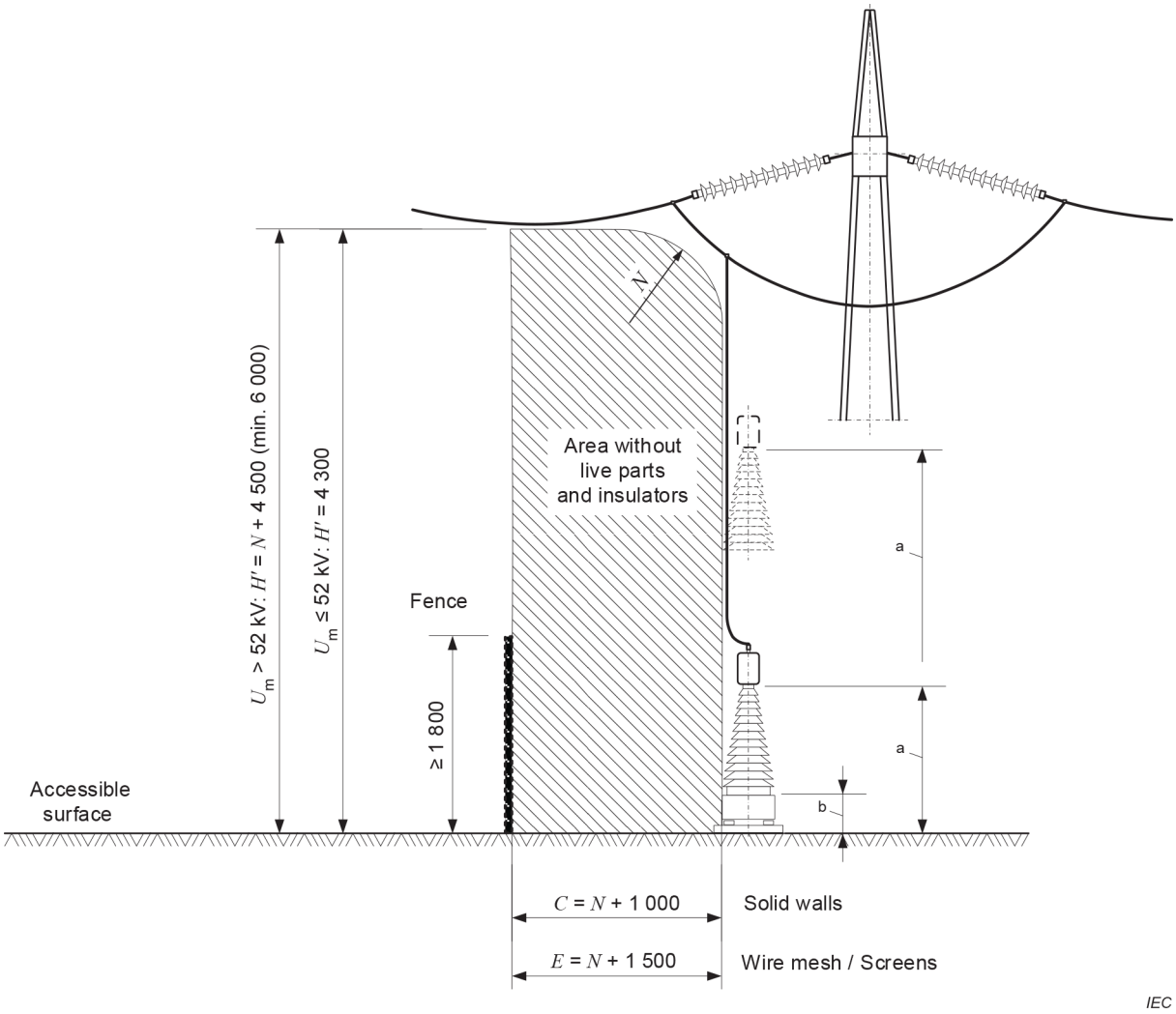
### 7.2.4 Boundary clearances

The external fence of outdoor electrical power installations of open design shall have the following minimum boundary clearances in accordance with Figure 3:

– solid walls (for height, see 7.2.7): $C = N$ + 1 000 mm;

– wire mesh/screens (for height, see 7.2.7): $E = N$ + 1 500 mm.

Dimensions in millimetres




**Key**

$C$ minimum distance from boundary to solid wall

$E$ minimum distance from boundary to wire mesh or screens

$H'$ minimum clearance of live parts above accessible surface at the external fence

$N$ minimum clearance of danger zone

[a] If this distance to live parts is less than $H$ (see 7.2.5), protection by barriers or obstacles shall be provided.

[b] If this distance is smaller than 2 250 mm, protection by barriers or obstacles shall be provided.

**Figure 3 – Boundary distances and minimum height at the external fence/wall**

### 7.2.5 Minimum height over access area

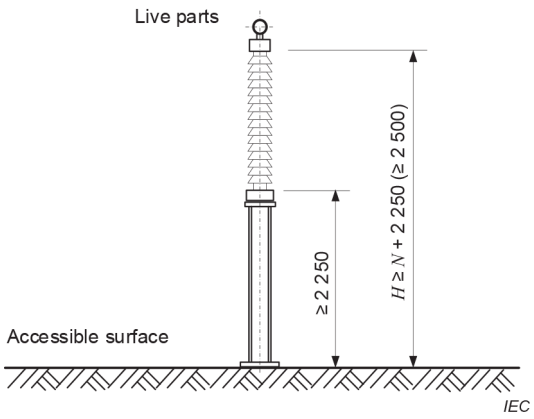
The minimum height of live parts above surfaces or platforms where only pedestrian access is permitted shall be as follows.

– For live parts without protective facilities, a minimum height $H$ = $N$ + 2 250 mm (minimum 2 500 mm) shall be maintained (see Figure 2, Figure 3 and Figure 4). The height $H$ refers to the maximum conductor sag (see Clause 4).

– The lowest part of any insulation, for example the upper edge of metallic insulator bases, shall be not less than 2 250 mm above accessible surfaces unless other suitable measures to prevent access are provided.

Where the reduction of safety distances due to the effect of snow on accessible surfaces needs to be considered, the values given above shall be increased.

Dimensions in millimetres




**Key**

$H$ minimum clearance of live parts above accessible surface

$N$ minimum clearance of danger zone

**Figure 4 – Minimum heights within closed electrical operating areas**

### 7.2.6 Clearances to buildings

Where bare conductors cross buildings which are located within closed electrical operating areas, the following clearances to the roof shall be maintained at maximum sag (see Figure 5):

– the clearances specified in 7.2.5 for live parts above accessible surfaces, where the roof is accessible when the conductors are live;

– $N$ + 500 mm where the roof cannot be accessed when the conductors are live;

– $O_2$ in lateral direction from the end of the roof if the roof is accessible when the conductors are live.

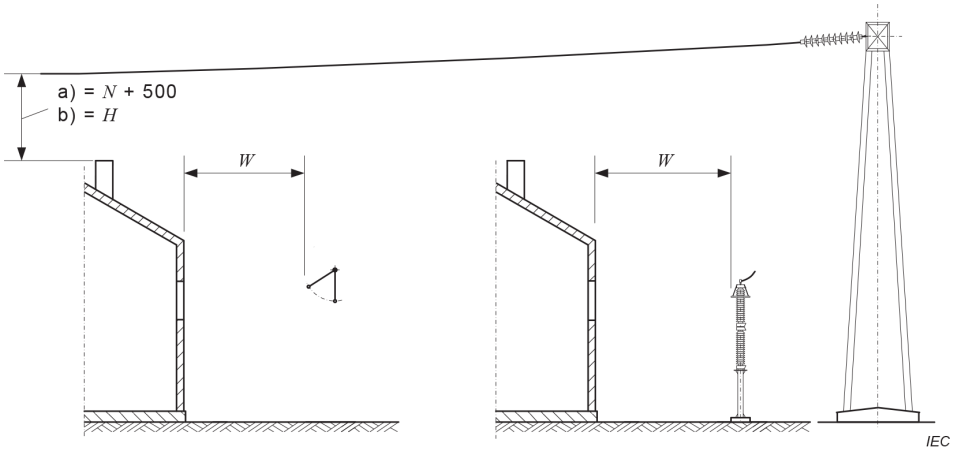
Where bare conductors approach buildings which are located within closed electrical operating areas, the following clearances shall be maintained, allowing for the maximum sag/swing in the case of stranded conductors:

– outer wall with unscreened windows: minimum clearance given by $W$;

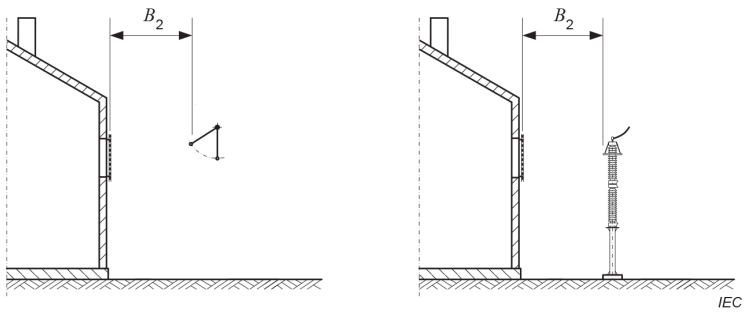
– outer wall with screened windows (screened in accordance with 7.2.2): protective barrier clearances $B_2$ in accordance with 7.2.2;

– outer wall without windows: $N$.

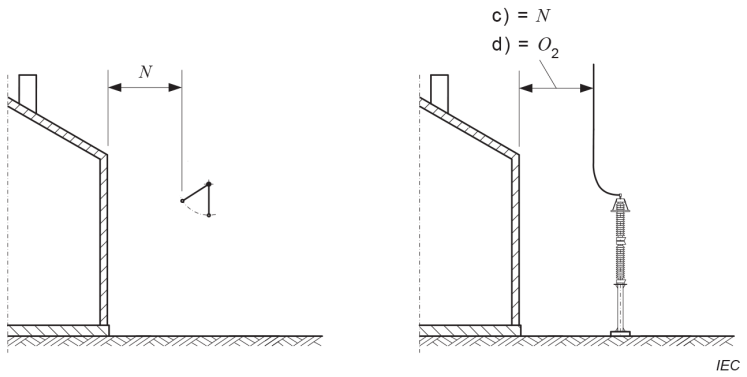
Dimensions in millimetres




**a) Outer wall with unscreened windows**




**b) Outer wall with screened windows**




**c) Outer wall without windows**

**Key**

a) The roof cannot be accessed when the conductors are live.

b) The roof can be accessed when the conductors are live.

c) $N$ if the roof is non accessible when the conductors are live.

d) $O_2 \geq N$ + 300 mm (minimum 600 mm) if the roof is accessible when the conductors are live.

$B_2 \geq N$ + 80 mm

$W = N$ + 1 000 for $U_m \leq$ 123 kV

$W = N$ + 2 000 for $U_m >$ 123 kV

$H$ minimum height

$N$ minimum clearance of danger zone

**Figure 5 – Approaches with buildings within closed electrical operating areas**

### 7.2.7 External fences or walls and access doors

Measures shall be taken to minimize the risk of unauthorized access to outdoor electrical power installations.

Where this is by means of external fences or walls, the height and construction of the fence/wall shall be designed to prevent climbing. Additional precautions may be required in some installations to prevent access by excavation beneath the fence.

Precautions may also be required in some installations to prevent adjoining climbing structures from reducing the protection of external fences or walls.

NOTE 1 Examples of such adjacent climbing structures are trees, external fences, other buildings, etc.

The external fence/wall shall be at least 1 800 mm high. The lower edge of a fence shall not be more than 50 mm from the ground (for clearances, see Figure 3).

Access doors to outdoor electrical power installations shall be equipped with security locks.

External fences/walls and access doors shall be marked with safety signs in accordance with 8.9.

In some cases, for public security reasons, additional measures may be necessary.

The degree of protection of IP1X (see IEC 60529) shall be used.

The use of metal mat fences with a mesh size of 50 mm × 200 mm (width × height) fulfils the requirement of IP1X.

## 7.3 Indoor electrical power installations of open design

The layout of open-type indoor installations shall take into account the minimum phase-to-phase and phase-to-earth clearances specified in Clause 5.

The design of the electrical power installation shall be such as to prevent access to danger zones taking into account the need of access for operational and maintenance purposes. Therefore, safety distances or permanent protective facilities within the installation shall be provided.

For protective clearances, safety distances and minimum height, see 7.2.

For buildings, corridors, escape routes, doors and windows, see 7.5.

For solid walls or screens less than 1 800 mm high, and for rails, chains or ropes, the protective obstacle clearances are at least:

– $O_1 = N$ + 200 mm (minimum 500 mm, see Figure 2).

For chains or ropes, the values shall be increased taking into account the sag. They shall be fitted at a minimum height of 1 200 mm to a maximum of 1 400 mm, where appropriate.

## 7.4 Installation of prefabricated type-tested switchgear

### 7.4.1 General

Subclause 7.4 specifies additional requirements for electrical equipment which apply to external connections, erection and operation at the place of electrical power installation. The installation shall be dimensioned and designed to avoid danger to persons and damage to property, taking into account the type of installation and local conditions.

Factory-built, type-tested high voltage switchgear shall be manufactured and tested in accordance with relevant IEC standards such as IEC 62271-1, IEC 62271-200, IEC 62271-201 and IEC 62271-203.

NOTE In some countries, switchgear complying with IEC 62271-201 is considered to be an open type indoor electrical power installation.

The switchgear shall be well adapted to its purpose, clearly arranged and so designed that essential parts are accessible for erection, operation and maintenance. Arrangements and access shall be provided to permit assembly at site. Future possible extensions should be considered.

Appropriate arrangements shall be made for external connections. Conductors and cables shall be selected and arranged in such a way as to ensure safe insulation level between conductors and between each conductor and surrounding earthed metallic structures.

Safety devices that are intended to reduce the internal switchgear pressure resulting from a fault shall be designed and arranged with consideration for their potential hazard to persons. For arc faults, see also 8.5 and 8.8.3. For $SF_6$ leakage see 8.8.2.

### 7.4.2 Additional requirements for gas-insulated metal-enclosed switchgear

#### 7.4.2.1 Design

If platforms and ladders are necessary for operation and maintenance, they shall be designed and arranged to provide safe access. These elements may be fixed or removable.

Where necessary, arrangements shall be made to protect the switchgear from dangerous vibrations from transformers/reactors with gas-insulated connections. Bellows shall be provided, where necessary, to allow for heat expansion, erection tolerances and settlement of foundations.

For electrical power installations with gas-insulated equipment, having several pressure chambers, clear labels shall be provided indicating the construction of the installation and the position of partitions. Monitoring devices shall be clearly marked and located to permit easy supervision.

Gas pipelines and fittings in areas where mechanical damage is expected shall be protected.

$SF_6$ gas pipelines shall be marked where there is a possibility of confusion with other pipelines.

#### 7.4.2.2 Erection on site

Erection of GIS shall be carried out in a clean environment.

For outdoor electrical power installations, it may be necessary to provide a suitable temporary housing over the work area to protect the equipment from the environmental conditions whilst installation and/or maintenance is taking place.

For $SF_6$ gas handling, see 9.3.3.

For $SF_6$ leakage, see 8.8.2 and 8.8.3.

#### 7.4.2.3 Protection against overvoltages

Protection of the GIS against overvoltages should normally be provided by the surge arresters installed on the feeders. In some cases, the protection given by this equipment may be inadequate. This situation arises mainly in the following configurations:

– large distance between the GIS and transformers;
– transformers connected to the GIS by means of cables;
– long busbars open at their ends;
– connection to overhead lines by means of insulated cables;
– locations with high probability of lightning strokes.

For these configurations, the installation of additional surge arresters may be required. Their location should be based on experience with similar situations or on calculations.

#### 7.4.2.4 Earthing

The enclosure of a GIS shall be connected to the earthing system at least at the following points:

a) inside the bays:
   – close to the circuit-breaker;
   – close to the cable sealing end;
   – close to the $SF_6$/air bushing;
   – close to the instrument transformer;
b) on the busbars:
   – at both ends and at intermediate points, depending on the length of the busbars.

The three enclosures of a single-phase type GIS shall be bonded together with short connections and earthed at least at the end of the enclosure of the outgoing and incoming feeders. The bonding conductor shall either be rated to carry the nominal current of the switchgear 'bay' or 'cubicle' and busbars, or if a lower rated bonding conductor is used, then it shall be proved by tests that such a conductor is sufficient for safe operation.

Additional bonding straps are not required at flange joints if it can be ensured that the contact pressure of the flange provides adequate contact connection for high frequencies.

Earthing conductors of surge arresters for the protection of gas-insulated electrical power installations shall be connected to the enclosure with a connection which is as short as possible.

Metallic sheaths (for example metal enclosures, armoured coverings, screens) of cables with nominal voltages above 1 kV should be connected directly to the GIS enclosure.

In some special cases, e.g. cathodic protection of cables, it may be necessary to separate the earth connection of the cables from the GIS enclosure. In this case, the installation of a voltage surge protection device is recommended between the sealing end and enclosure.

## 7.5 Requirements for buildings

### 7.5.1 General

Buildings comply with national building codes and fire regulations. Where such national standards do not exist, the following may be used as a guide.

Subclause 7.5 indicates the requirements that have to be satisfied in areas or locations where electrical equipment for high-voltage installations is installed. For the purpose of this document, prefabricated substations covered by IEC 62271-202 are not considered as buildings.

### 7.5.2 Structural provisions

#### 7.5.2.1 General

Load-carrying structural members, partition walls, claddings, enclosures, etc. shall be selected to withstand the expected combustible load.

Electrical operating areas shall be designed to prevent ingress of water and to minimize condensation.

Materials used for walls, ceilings and floors on the ground shall, where possible, not be damaged by water penetration or leakage. If this requirement cannot be met, precautions shall be taken to prevent the consequences of a leak or of condensation affecting the operating safety.

The building design shall take into account the expected mechanical loading and also internal pressure caused by an arc fault.

Other equipment such as pipelines, if allowed in substations, shall be designed so that the electrical power installation is not affected, even in the event of damage.

#### 7.5.2.2 Specifications for walls

The external walls of the building shall have sufficient mechanical strength for the environmental conditions.

The mechanical strength of the buildings shall be sufficient to withstand all static and dynamic loads due to normal operation of the electrical power installation.

The passage of pipes or wiring systems shall not affect the structural integrity of the walls.

Metal parts that pass through walls shall meet the requirements of Clause 10.

Panels of the exterior surface of buildings that are accessible to the general public shall not be removable from the outside. The constituent materials of the external enclosures shall be capable of withstanding the attacks of atmospheric elements (rain, sun, aggressive wind, etc.).

#### 7.5.2.3 Windows

Windows shall be designed so that entry is difficult. This requirement is considered fulfilled if one or more of the following measures are applied:

– the window is made of unbreakable material;
– the window is screened;
– the lower edge of the window is at least 1 800 mm above the access level;
– the building is surrounded by an external fence at least 1 800 mm high.

#### 7.5.2.4 Roofs

The roof of the building shall have sufficient mechanical strength to withstand the environmental conditions.

If the ceiling of the switchgear room is also the roof of the building for pressure relief, the anchoring of the roof to the walls shall be adequate.

#### 7.5.2.5 Floors

The floors shall be flat and stable and shall be able to support the static and dynamic loads.

### 7.5.3 Rooms for switchgear

The dimensions of the room for switchgear and of the required pressure-relief openings depend on the type of switchgear and the short-circuit current.

If pressure-relief openings are necessary, they shall be arranged and situated in such a way that when they operate (blow out due to an arc fault) the danger to persons and damage to property is minimized.

### 7.5.4 Maintenance and operating areas

Maintenance and operating areas comprise aisles, access areas, handling passages and escape routes.

Aisles and access areas shall be adequately dimensioned for carrying out work, operating switchgear and transporting equipment.

Aisles shall be at least 800 mm wide.

The width of the aisles shall not be reduced even where equipment projects into the aisles, for example permanently installed operating mechanisms or switchgear trucks in isolated positions.

Space for evacuation shall always be at least 500 mm, even when removable parts or open doors, which are blocked in the direction of escape, intrude into the escape routes. If relevant, the doors of switchgear 'bay' or 'cubicle' should close in the direction of escape.

For erection or service access ways behind closed installations (solid walls), a minimum width of 500 mm is required.

Clear and safe access for operating persons shall be provided at all times.

Below ceilings, covers or enclosures, except cable accesses, a minimum height of 2 000 mm is required.

Exits shall be arranged so that the length of the escape route within the room does not exceed 40 m for installation of rated voltages $U_m$ greater than 52 kV, and 20 m for installation of rated voltages up to $U_m$ = 52 kV. This does not apply to accessible bus ducts or cable ducts. If the above distances of the escape route cannot be met, an agreement shall be made with the user.

Permanently installed ladders or similar are permissible as emergency exits in escape routes.

### 7.5.5 Doors

Access doors shall be equipped with security locks to prevent unauthorized entry.

Access doors shall open outwards and be provided with safety signs in accordance with 8.9.

Doors which lead to the outside shall be of low flammability material, except where the building is surrounded by an external fence at least 1 800 mm high.

Doors between various rooms within a closed electrical operating area are not required to have locks.

It shall be possible to open emergency doors from the inside without a key by using a latch or other simple means, even when they are locked from the outside. This requirement need not be complied with for small installations where the door has to be kept open during operating or servicing.

The minimum height of an emergency door shall be 2 000 mm and the minimum clear opening 750 mm.

### 7.5.6 Draining of insulating liquids

Protective measures shall be taken when insulating liquids are used (see also 8.8).

### 7.5.7 Heating, ventilation and air conditioning (HVAC)

#### 7.5.7.1 General

Suitable indoor conditions shall be provided to ensure correct operation of the electrical equipment (e.g. by adequate cooling, heating, dehumidifying, ventilation or by attention to the design of the building).

NOTE For precautions reducing pollution, condensation, temperature variation and humidity occurring in high-voltage substations, see Annex C of IEC TS 62271-304:2019.

Adequate ventilation shall be provided to dissipate heat generated by the electrical equipment.

Where natural ventilation is inadequate, additional measures shall be implemented. Mechanical ventilation systems (permanent or temporary) shall be designed to take smoke management into consideration. They shall be so arranged that inspection and maintenance can be carried out even when the electrical equipment is energized with consideration to location of equipment pressure-relief vents.

Monitoring of the operation of a permanent fan is recommended.

Ventilation openings shall be designed so as to prevent any dangerous proximity to live parts and any dangerous ingress of foreign bodies.

Coolants and heat transfer media shall not contain mechanical impurities or chemically aggressive substances in quantities or qualities which may be hazardous to the correct function of the electrical equipment in the electrical power installation.

Filters or heat exchangers shall be provided, if necessary.

Rooms containing high-voltage transformers and switchgear, located within public or residential buildings shall be provided with dedicated inlet and outlet ventilation ducts terminating outside the building.

Wherever possible, air intakes should be positioned remote from any potential source of atmospheric contamination.