

DISTRIBUTION SOLUTIONS

# Technical Application Papers No. 28

## Guide for installation of Indoor apparatus in Outdoor units





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# 1. Introduction

Scope of this document is to provide manufacturers and installers using indoor apparatus into outdoor enclosures a guide, which specifies how to implement adequate solutions to ensure environmental conditions equal to those suitable for apparatus itself, in compliance to the indoor standard requirements.



## 2. Standard reference for indoor apparatus and switchboards

From IEC 62271-1 Ed. 2 (2017)

### 4.1.2 Indoor switchgear and controlgear

The normal service conditions for indoor switchgear and controlgear are:

- a) the ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h does not exceed 35 °C. The ambient air temperature does not drop below -5 °C;
- b) there is no influence from solar radiation;
- c) the altitude does not exceed 1 000 m;
- d) the ambient air is not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapours or salt and would be considered as having site pollution severity class (SPS) "very light" according to IEC TS 60815-1:2008;
- e) the conditions of humidity are as follows:
  - the average value of the relative humidity, measured over a period of 24 h, does not exceed 95 %;
  - the average value of the water vapour pressure, over a period of 24 h, does not exceed 2,2 kPa;
  - the average value of the relative humidity, over a period of one month, does not exceed 90 %;
  - the average value of the water vapour pressure, over a period of one month, does not exceed 1,8 kPa.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 High humidity can also be due to ground level rainwater or for underground applications, from incoming cable raceways connected to switchgear.

**ABB Note: the normal service condition according to standard 62271-304 it is Design Class 0. This means COPL.**

**"CO: Condensation does not normally occur (not more than twice a year)"**

From IEC 62271-304 Ed. 1 (2008)

(see also the red notes regarding the next Edition of IEC 62271-304)

### 1 Scope and object

This part of IEC 62271 applies to indoor enclosed switchgear and controlgear complying with IEC 62271-200 and IEC 62271-201, intended to be used in service conditions more severe with respect to condensation and pollution than the normal service conditions specified in IEC 62271-1. This technical specification covers equipment where any of the insulation is exposed to indoor climatic conditions.

The test detailed in this technical specification has been designed primarily to investigate the behaviour of electrical insulation and not corrosion on equipments. Nevertheless, the performance of mechanical components, such as mechanisms, interlocks and enclosures may also be recorded.

NOTE 1 - on the next Edition of 62271-304 this last point will change as follow: The test detailed in this technical specification has been designed primarily to classify the electrical insulation performance of equipment having high-voltage electrical insulation exposed to indoor service conditions, mainly in presence of condensation. The assessment of mechanical components, such as mechanisms, interlocks and enclosure is also considered.

NOTE 2 - And the next phrase will disappear. This technical specification proposes definitions for two degrees of severe service conditions with respect to condensation and pollution. It also proposes test procedures for assessing the performance of enclosed switchgear and controlgear under specified conditions so that conclusions may be drawn concerning their suitability for service under those severe service conditions.

## 2. Standard reference for indoor apparatus and switchboards

**ABB note: for the normal service condition (water condensation max 2 times a year and low pollution level) it is no need to do any special test. For more severe conditions the substation needs to be classified and tested according to IEC 62271-304.**

### **2 Degrees of severity of service conditions under condensation and pollution**

Indoor equipment installed inside a building or room and thus normally protected against the outdoor climatic conditions may be subjected to condensation due to rapid temperature changes and to pollution due to the environment inside the building.

NOTE 3 – This point 2 will change in:

### **3 Definition of indoor service conditions under condensation and pollution**

Indoor equipment is designed to be installed in an operating room inside a building or other housing and thus has a certain level of protection from the outdoor environmental conditions. In addition of the protection given by the building

or other housing construction, precautions (see Annex C) to minimize the amount of deposits inside the switchgear and controlgear can be taken by the choice of an appropriate degree of protection of the enclosed switchgear and controlgear.

Condensation can occur due to rapid temperature changes inside the operating room. Pollution inside the operating room can be present depending on location and surrounding activity. In addition, the occurrence of condensation and the site pollution severity inside the operating room depend on the layout and the protection given by the building or other housing construction.

The presence of condensation and pollution has the potential to impact the voltage withstand capability of clearances and creepage distances, and possibly the insulating material itself. The concern is that there may be creation of full or partial conductive path between live parts or between live parts and conductive parts not intended to be live (enclosure, etc.).

## 3. Installation maintenance and instruction for apparatus (from VD4 - INSTALLATION AND SERVICE INSTRUCTIONS)

### Installation

#### 3.1. General



**Correct installation is of primary importance. The manufacturer's instructions must be carefully studied and followed. It is good practice to use gloves for handling the pieces during installation.**

#### 3.2. Installation and operating conditions

The following Standards must be taken into particular consideration during installation and service:

IEC 62271-1/DIN VDE 0101

VDE 0105: Electrical installation service

DIN VDE 0141: Earthing systems for installations with rated voltage above 1 kV

All the accident prevention regulations in force in the relative countries.

##### 3.2.1. Normal conditions

Follow the recommendations in the IEC 62271-1 and 62271-100 Standards. In more detail:

##### Ambient temperature

Maximum	+ 40 °C
Average maximum over 24 hours	+ 35 °C
Minimum (according to class – 5), apparatus for indoor installation	– 5°

##### Humidity

The average value of the relative humidity, measured for a period longer than 24 hours, must not exceed the 95%.

The average value of the pressure of the water vapour, measured for a period longer than 24 hours, must not exceed 2.2 kPa.

The average value of the relative humidity, measured for a period longer than 1 month, must not exceed the 90%.

The average value of the pressure of the water vapour, measured for a period longer than 1 month, must not exceed 1.8 kPa.

##### Altitude

≤ 1000 m above sea level.

#### 3.2.2. Special conditions

##### Installations over 1000 m a.s.l.

Possible within the limits permitted by reduction of the dielectric resistance of the air.

##### Increase in the ambient temperature

Reduction in the rated current.

Encourage heat dissipation with appropriate additional ventilation.

##### Climate

To avoid the risk of corrosion or other damage in areas:

- with a high level of humidity, and/or with rapid and big temperature variations, take appropriate steps (for example, by using suitable electric heaters) to prevent condensation phenomena.

## 3. Installation maintenance and instruction for apparatus (from VD4 - INSTALLATION AND SERVICE INSTRUCTIONS)

### 3.3. Power circuit connections of fixed circuit breakers

#### 3.3.1. General recommendations

Select the cross-section of the conductors according to the service current and the short-circuit current of the installation.

Prepare special pole insulators, near the terminals of the fixed circuit breaker or of the enclosure, sized according to the electrodynamic forces deriving from the short-circuit current of the installation.

#### 3.3.2. Assembly of the connections

Check that the contact surfaces of the connections are flat, and are free of any burrs, traces of oxidation or deformation caused by drilling or impacts received.

According to the conductor material and the surface treatment used, carry out the operations indicated in table T1 on the contact surface of the conductor.

#### Assembly procedure

Put the connections in contact with the circuit breaker terminals, taking care to avoid mechanical stresses (traction / compression) on, for example, the conducting busbars on the terminals.

Interpose a spring washer and a flat washer between the head of the bolt and the connection. It is advisable to use bolts according to DIN class 8.8 Standards, also referring to what is indicated in table T2.

In the case of cable connections, strictly follow the manufacturer's instructions to make the terminals.

### T1

#### Bare copper

- Clean with a fine file or emery cloth.
- Tighten fully and cover the contact surfaces with 5RX Moly type grease

#### Copper or silver-plated aluminium

- Clean with a rough dry cloth.
- Only in the case of obstinate traces of oxidation, clean with a very fine grain emery cloth taking care not to remove the surface layer.
- If necessary, restore the surface treatment.

#### Bare aluminium

- Clean with a metal brush or emery cloth.
- Cover the contact surfaces again immediately with neutral grease
- Insert the copper-aluminium bimetal with surfaces shined (copper side in contact with the terminal; aluminium side in contact with the connection) between the aluminium connection and the copper terminal.



## Maintenance

The maintenance operations are aimed at keeping the apparatus in good working condition for as long as possible.

In accordance with what is specified in the IEC 61208 / DIN 31 051 Standards, the following operations must be carried out.

Inspection:	Finding out the actual conditions
Overhauling:	Measures to be taken to maintain the specific conditions
Repairs:	Measures to be taken to restore the specific conditions.

### 3.4. General

The vacuum circuit breakers are characterised by simple, sturdy construction and a long life.

The operating mechanism requires maintenance and functional inspections to reach the expected operating-life (see par. 9.3.2.).

The vacuum interrupters are maintenance-free for their whole operating life.

Vacuum interruption does not produce any harmful effects even when there are frequent interruptions at the rated and short-circuit current.

The interventions during service and their aim are determined by the ambient conditions, by the sequence of operations and by the short-circuit interruptions.

The maintenance operations must only be carried out by trained personnel and who follow all the safety regulations.

Furthermore, it is advisable to call on ABB personnel, at least in cases for checking the performances in service and for repairs.

Cut the power supply off and put the apparatus under safe conditions during the maintenance operations.



**Before carrying out any operations, check that the circuit breaker is open, with the spring discharged and that it is not supplied (medium voltage circuit and auxiliary circuits).**

## 3. Installation maintenance and instruction for apparatus (from VD4 - INSTALLATION AND SERVICE INSTRUCTIONS)

### 3.5. Operating life expectancy

The operating life expectancy for the VD4 circuit breakers is as follows:

vacuum interrupters: up to 30.000 operations, according to their type (see par. 7.2.3. Trip curves);

switching device, actuator and transmission system: up to 30.000 operations, under normal operating conditions, according to the type of circuit breaker and with regular with operations correctly executed it is possible to carry out up to 1000 racking-out/in operations (as prescribed in the IEC 60271-200 Standards);

the data regarding the operating life are basically applicable to all the components which cannot be directly affected by operator activity. The manually operated components (moving parts of isolatable parts, etc.) can vary their behaviour.

### 3.6. Inspections and functionality tests

#### 3.6.1. Interruption devices in general

Check the conditions of the interruption devices with regular inspections.

Inspection at fixed intervals can be avoided when the apparatus is permanently under the control of qualified personnel.

The checks must, first of all, include visual inspection to check for any contamination, traces of corrosion or electrical discharge phenomena.

Carry out more frequent inspections when there are unusual operating conditions (including severe climatic conditions) and in the case of environmental pollution (e.g. high level of contamination or an atmosphere with aggressive agents).

Visual inspection of the isolating contacts. It is recommended to turn the contact system alternately in order to keep the internal surface of the contact areas clean. The contact areas must be cleaned when there are signs of overheating (discoloured surface) (also see Repairs).

#### 3.6.2. Stored energy operating mechanism

Carry out the functional test of the operating mechanism after 5.000 operations or during ordinary maintenance operations as specified in par. 9.2.1. and service the release devices at least every 5 years (see par. 9.3.2.).

Before doing the test, open the circuit breaker and carry out the following operations: in the case of withdrawable circuit breakers, take the circuit breaker to the isolated for test position in the case of fixed circuit breakers: cut off the power supply to the medium voltage circuit.

#### Note

Insulate the work area and make it safe, following the safety regulations specified in the IEC/DIN VDE Standards.

### Functional test

- With the circuit breaker not connected to the load, carry out a few opening and closing operations.
- If foreseen, cut the power supply to the spring charging motor off. Discharge the spring by closing and opening the circuit breaker by means of the closing and opening pushbuttons.
- Visually inspect the lubrication conditions of the tulip isolating contacts, of the sliding surfaces, etc.
- Check correct electrical and mechanical operation of the various devices, with particular attention to the interlocks.
- The screws and nuts are tightened in the factory and correct tightening is marked with a collared sign. No further tightening operations are foreseen during the operating life of the circuit breaker. However, following any maintenance interventions, should it be necessary to re-tighten the screws or nuts, it is recommended to always replace the screws and nuts and to keep to the values indicated in fig. 12.

### 3.6.3. Circuit breaker pole

No other check except what has already been specified in par. 9.2.1. is necessary.

### 3.6.4. Withdrawable assembly (truck and circuit breaker)

Visually inspect the components, especially those which may be damaged by incorrect operations (also see table in chap. 8).

Visually inspect the isolating contacts and that all the contact elements are clean, especially in cases where signs of overheating are found (also see par. 9.4.).

Visually inspect and carry out the functional tests of the locks, checking their correct operation and activation without abnormal force – maximum 25 N (also see table in chap. 8).

## 3.7. Overhauling

### 3.7.1. Interruption devices in general

Should it have been necessary to clean the devices during the inspections, according to what is specified in par. 9.2.1., use the following procedure:

- insulate the work area and make it safe, following the safety regulations specified in the IEC/DIN VDE Standards;
- general cleaning of the surfaces:
  - dry and eliminate light deposits of dirt with a soft dry cloth;
  - more resistant deposits of dirt can be removed using slightly alkaline domestic type detergent or Rivolta BWR 210 type detergent;
- cleaning insulating surfaces and conductive parts.

After cleaning, rinse thoroughly with clean water and dry carefully.

#### Note

Only use detergents without halogens and never 1.1.1-trichloroethane, trichloroethylene or carbon tetrachloride!

## 4. Apparatus for indoor installation

### Some samples

High flexibility - Modular AIS design

#### AIS design offers high flexibility

- Choose from various switching devices
- Vacuum or SF6 as per customer preference
- Fixed, removable or withdrawable devices

#### Highly flexible also on other components

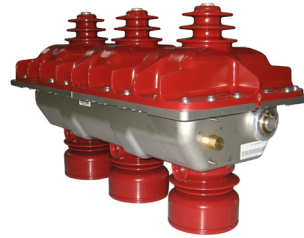
- Conventional instrument transformers
  - current transformers (CTs) type DIN, Ring
  - voltage transformers (VTs) type DIN
- Digital offering
  - Current and Voltage sensors
  - Protection relays



Vacuum Circuit Breakers



SF6 Circuit Breakers



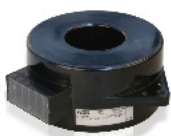
SF6 insulated switch-disconnector



Hybrid Vacuum CB and LBS



Conventional Instr. transformers



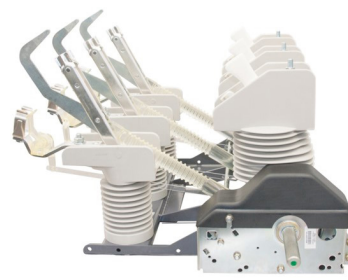
Non-conventional Current and Voltage sensors



Protection relays



Air insulated switch-disconnector, type NAL



Air insulated switch-disconnector, type NAL-H

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## 5. Maintenance and instruction for switchboard UniSec

**NOTE**

Under abnormal operating conditions (including adverse climatic conditions) and/or particular environmental conditions (among which, heavy pollution and aggressive atmosphere), inspection at shorter intervals may be necessary

**CAUTION**

Follow the maintenance instructions in the manuals for the relative components

**NOTE**

Should partial discharges occur as a result of condensation, application of a thin silicone film over the surface concerned is often effective as a temporary remedy. It is advisable to ask the ABB after-sales service department for advice regarding permanent solutions to this uncommon type of problem

## 6. Switchboards units for indoor installation

### UniSec switchboard sample

Secondary Distribution AIS

#### Products

UniSec Circuit breaker panels WBC (LSC2B) and SBC-W (LSC2A) mixed in same switchgear line-up

Withdrawable circuit breaker panels



## 7. Effects of the outdoor environment: specific climatic conditions

When the environmental conditions are particularly aggressive during service, manufacturers of circuit breakers for indoor use should be consulted about every special service condition, e.g. in the presence of dust, smoke, corrosive gas, vapours or salt, etc. However, IEC 62271-1 gives specific indications about switchgear and controlgear. Chapter 4.2 "Special service conditions" and in particular in section 4.2.3 "Exposure to pollutions" the user is asked to define the site pollution severity (SPS) class according to IEC TS 60815-1. Furthermore, appendix K includes descriptions of the classes "Very light", "Light" and "Medium" and suggestions for the minimum nominal specific creepage distance by pollution level to be adopted in these cases. For indoor applications up to 52 kV the IEC Standard IEC 62271-304 "High voltage switchgear and controlgear - Part 304: Design classes for indoor enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 52 kV to be used in severe climatic conditions" can also be used.

By and large, a correct assessment of the environmental conditions must be based on a set of historical data recorded daily, monthly or on a seasonal basis (as appropriate). Surveys prior to installation dedicated to a specific situation may not be sufficiently comprehensive to determine whether the environment-product are compatible. The switchgear and controlgear manufacturers must be consulted after these analyses have been conducted, especially if the service conditions are more severe than normal.

(Note: abstract from 1VCP000735 - Rev.C -2018-06 Technical Application Papers No. 26)

## 8. Main requirements for the substations

Regarding the location, the substation can be within the volume of the building to be powered or separate from it. It may also be located on the roof of the building to be served, of course, after a careful study of the static and dynamic loads to which the roof will be subjected. In any case, the location of the substations must be such that it allows authorized personnel to access it as necessary, to perform service operations and maintenance on the components of the substation, even of those of greater size and weight, such as transformers. The substation can be non-prefabricated (covered under IEC 61936-1) or prefabricated (IEC 62271-202).

In addition, the substation must meet local standards and country or state specific requirements for substation structure, regarding:

- a) low frequency magnetic fields
- b) access and layout type
- c) structure (e.g. walls, floors, ceilings, ...) and visual appearance
- d) ventilation and protection class
- e) infiltration of water or flooding
- f) expected static and dynamic mechanical loads
- g) lightning

The substations must be fitted with lockable doors or otherwise require the use of tools to open or remove them so as to prevent access by unauthorized persons. In particular, the room hosting the metering systems must be accessible both by the User and by the Distributor.

The location of the structures must be such that the MV lines necessary for connection can be built and maintained in compliance with current regulations regarding electrical installations and safety as well as electromagnetic pollution. Separation, in terms of responsibility for the operation, running and maintenance of the various substations, should be easily distinguished on the planimetric diagrams. Measurement of the energy withdrawn by a User at a sampling point must take place close to the MV connection using voltage and current transformers that are the responsibility of the Distributor. The dimensions of the connection room must necessarily allow the in-out insertion scheme to be adopted, which might be necessary at a later time. As a guideline, the overall surface area occupied by the delivery and metering room should be about 16 m<sup>2</sup>.

The construction details are to be provided in the connection documentation provided by the Distributor; in any case, the design of the room for the network system at the user installation must comply with the regulations issued by the Distributor.





### **Prefabricated substation foundation & location highlights**

Important factors that influence life time of prefabricated substation:

- Placement of substations and proximity to harsh environments.
- Materials of the substation and possibility of condensation.
- Draining of the ground around the substation and preparation of the foundation including backfilling of cable trench.
- Elimination of pollution and humidity
- Placement of kiosks in terrains.
- Elimination of corona effect sources in design and installation: cable terminations, busbars, sharp edges...
- Heating, better utilization of the heating from the transformer and ventilation, according to the design class acc. IEC 62271-304 of installed products. It's recommendable the use of heaters that assure an adequate air circulation, reducing the thermal excursion and avoid condensation.
- Respect of maintenance plan, to be done as per manufacturer instructions. Minimalization of space and placing requirement has already influenced development of kiosks and stations however the proper maintenance is still required.

# 8. Main requirements for the substations

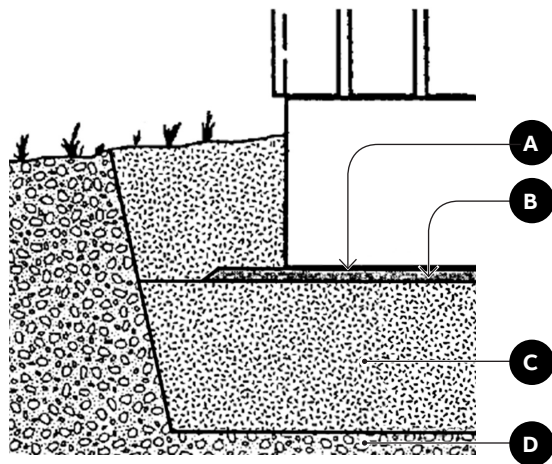
## Foundation highlights – ground work

### Ground work

When placing of substations it is important to evaluate the drain quality of existing filling compound. The filling compound should consist of relatively large sand and a small mix of humus or soil and also be frost proof. Filling compound who has a fine consistency as for example clayey soil or clay, which hold the water, is not to be recommend. The compound must be changed and we recommend to use of one bed with large crushed stone/soil and then filling with smaller crushed stone/soil up to the base plate level. The filling compound must compresses gradually during the process to avoid setting in the ground. The filling compound around the building should be large, good draining crushed stone or soil. It is important that the construction pit has outlet so the water do not stay in the pit.

(Note: abstract from NAL application inside prefabricated substation, by Tomasz Komalski)

### Preparation of ground for substation



- A Adjusting level sand/concrete
- B Prospective felted fabric
- C Frostproof compound
- D Frostproof dept

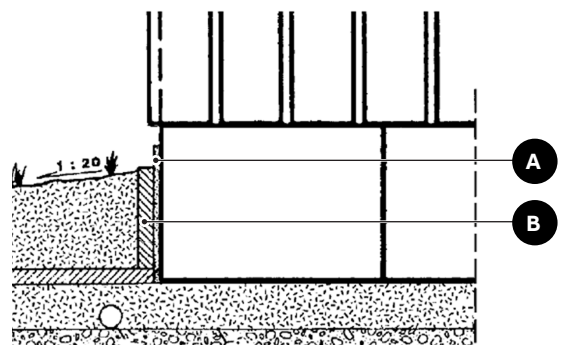
### Galvanic currents

All metals has different inner galvanic voltage range. When one connect different metals with each other electrical at the same time who one have a leading fluid/compound between them, a galvanic current will flow. This process is equivalent by corrosion of metals. This is a phenomenon which can arise in connection with earthing of metal base plate.

**Therefor it is important to select filling compound which have is of good drain and insulation qualities for foundation.**

It is also to recommend to use continuous bus line for earthing and insulated earth wire towards the building. If earth rod/plate is used it should be placed in good distance from the base plate of the building for example under the cable channel and insulate incoming earth wire.

The **foundation plastic** outside of the base plate can be use to make a good insulation and prevent current linkage to earth to avoid galvanic current. Please also refer to the latest version of "Medium Voltage Assembly Compact Secondary Substation (CSS) Installation and Maintenance Manual".



- A Humidity rafter / Foundation plastic
- B Ground plate

Prefabricated substation foundation & location highlights – ground preparation



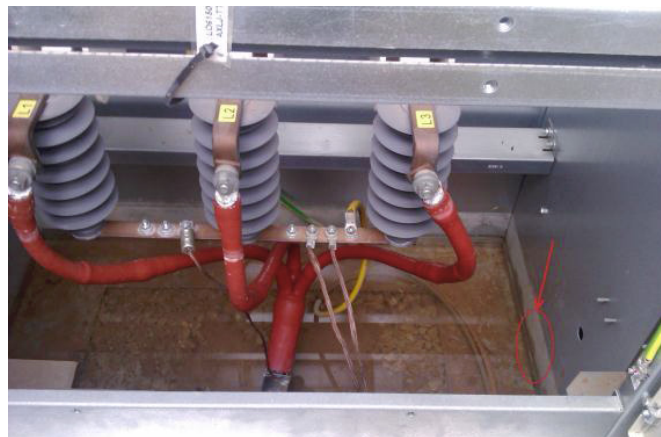
Prefabricated substation on the small hill with proper ground preparation ...



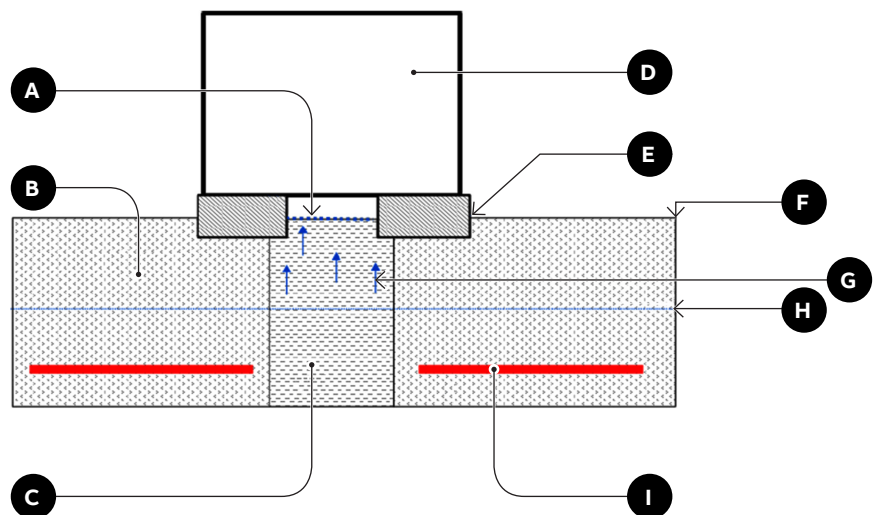
... however located very close to the water

Prefabricated substation foundation & location highlights – cable trench backfilling

Backfilling of cable trench is needed



The cable trench needs backfilling in order to raise ground level and stop capillarity of water.



- A High humidity and possible water
- B Ordinary soil
- C Ordinary soil back fill or not enough gravel
- D CSS enclosure
- E CSS baseframe
- F Ground level
- G Capillar effect
- H Ground water level
- I Loop cables

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## 9. Some solution for particular condition

### **Subject: Hydrogen sulphide and sulphur dioxide corrosion of silver components**

The most dangerous chemical products for electrical equipment are SO<sub>2</sub> (sulphur dioxide) and H<sub>2</sub>S (hydrogen sulphide).

H<sub>2</sub>S in harmful concentration is found inside chemical factories, geothermic power stations, water treatment plant, etc.

The major source of SO<sub>2</sub> emissions are the combustion of fuel for electricity generation and heating, processes in non-ferrous smelting and refining industry, oil and gas industry.

### **Consequences**

H<sub>2</sub>S and SO<sub>2</sub> on silver alloys cause the formation of Ag<sub>2</sub>S (silver sulphide) which is a bad current conductor; the contact resistance is dramatically increased, leading to overheating. This could jeopardize correct operation of the equipment and then causes destructive damage.

Hopefully, when the contacts are breaking current, the arcing destroys locally silver sulphide. Though, contacts that are in open position (or closed position with no load) during a long time will experience increased contact resistance depending on the H<sub>2</sub>S concentration. This will a negative effect on the performance especially at low loads (low current).

## 10. Conclusions

### A) Mandatory environmental condition

Ambient temperature  $-5\div+40$  °C (35° Aver. Max in 24h) aerated  
Humidity 95% max in 24h  
Altitude  $\leq 1000$ m  
Absence of pollution (pouder, chemical substances, salt, flammables, etcetera..)

To avoid high level of humidity, provide proper aereation.

To avoid pollution, installation of filters on the aeration opening.

To avoid condensation, provide the presence of heaters sufficient to create proper condition inside substation.

In case the condition inside substation cannot be improved all apparatus and insulating components installed inside need to withstand the tests described in the standard IEC 62271-304

### B) Maintenance planning

Cleaning, greasing/lubrification of operation mechanism, according to the Instruction Manuals of each apparatus.

Cleaning and protection of exposed electrical parts with appropriate grease for electrical use.  
Note: attention on the coupling of metals on the contacts points, to avoid electrochemical reaction (IEC/TR 60943).

### C) Particular execution

In case of particular condition of temperature/humidity/pollution, have to be find solutions to reduce the impact of that on the apparatus (example: ambient air conditioned, air filtered, IP upgrading of the container....)

In case of possible pollution by H<sub>2</sub>S and/or SO<sub>2</sub> , tinning of the conductive parts and the contact surfaces of the main circuit parts would be necessary (instead of silvering). The low voltage contact points are need to be gold plated.



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For further details please contact:



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More product information:

[abb.com/mediumvoltage](http://abb.com/mediumvoltage)

Your contact center:

[abb.com/contactcenters](http://abb.com/contactcenters)

More service information:

[abb.com/service](http://abb.com/service)

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