Recommendation 29

Technical terms and conditions etc. for prefabricated 10-20 kV/0,4 kV secondary distribution substations

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Contents

1. SCOPE

This recommendation applies to type approved prefabricated 10-20 kV/0,4 kV secondary distribution substations realised and tested in accordance with DS/EN 62271-202. The type approval must apply to a fully equipped prefabricated secondary distribution substation including distribution automation (DA) equipment if installed.

The documentation specified in this recommendation and any additional relevant requirements to the documentation specified in the tender documents are an integral part of the delivery.

The substation will be used in underground high voltage and low voltage networks and installed in the public sphere.

Unless otherwise specified in this recommendation or in the purchaser's tender documents, the distribution substation must be suitable for use under the general service conditions set out in DS/EN 62271-202.

If transformers are part of the delivery, transformers must comply with DEFU recommendation 6A. If transformers are not part of the delivery, the substation must be prepared and type-approved for the installation of transformers which comply with DEFU Recommendation 6A. Additional requirements concerning transformers or deviations from DEFU Recommendation 6A may be set out in the tender documents.

This recommendation is available in a Danish and an English version. If there are any discrepancies between the two versions, the Danish version is valid.

2. GENERAL REQUIREMENTS

The substation must comply with Danish legislation.

The requirements and test specifications in force at the time of the invitation to tender and contained in relevant Danish/CENELEC standards must be met. This includes, but is not limited to, these standards:

DS/EN 62271-202	High-voltage switchgear and controlgear – Part 202: High voltage/low voltage prefabricated substations
DS/EN 62271-200	High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
DS/EN 62271-201	High-voltage switchgear and controlgear – Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
DS/EN 61439-1	Low-voltage switchgear and controlgear assemblies – Part 1: General rules
DS/EN 61439-2	Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies
DS/EN 50588-1	Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV – Part 1: General requirements
DS/HD 60364-4-44	Low voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock

It is the responsibility of the user of this recommendation to ensure that the current version and any applicable amendments to regulations (executive orders) and standards are used when preparing invitations to tender. Information about the current version of executive orders and any amendments can be found at www.retsinformation.dk**.** Information about the current version of a standard and any addendums is available from Danish Standards.

The terminology used in this recommendation is in accordance with the definitions in the above mentioned standards.

3. PRINCIPAL DATA

3.1 Ambient temperature -25°C … +40°C

3.2 Rated frequency 50 Hz

3.3 Nominal network voltage and rated voltage

Transformer	Nominal network voltage, [kV]	Rated voltage, [kV]
Low voltage winding	0,4	0,42
High voltage winding	10 15 20	10,5 15,75 21

Other equipment	Nominal network voltage [kV]	Rated voltage [kV]
Low voltage	0,4	1
High voltage	10 15 20	12 17,5 24

3.4 System earthing

Nominal network voltage	System earthing
0,4 kV	Directly earthed (TN-S or TN-C)
10 kV 15 kV 20 kV	Arc-suppression-coil-earthed or isolated neutral point

3.5 Insulation level

Nominal System voltage [kV]	Rated voltage [kV]	Short duration power-frequency withstand voltage [kV]	Lightning impulse withstand voltage (1,2 µs/50 µs) [kV]
0,4	1	2,2	6
10	12	28	75
15	17,5	38	95
20	24	50	125

3.6 Rated power

The rated power of the substation is determined (see DS/EN 62271-202) from the rated power of the transformer for which the substation is type-tested, the total losses in the transformer (the sum of no-load and load losses) at the rated load, and the temperature rise of the top oil and winding at the rated load.

For substations with more than one transformer, the above information must be stated for each individual transformer.

Typical rated powers for 10-15-20/0,4 kV oil-immersed transformers in Denmark are as follows (see DEFU Recommendation 6A):

100 – 200 – 250 – 400 – 500 – 630 – 800 – 1000 – 1250 – 1600 – 2000 – 2500 kVA.

The total losses in a transformer must comply with the load and no-load loss requirement in phase 2 of Commission Regulation (EU) No 548/2014 of 21 May 2014 and No 2019/1783 of 1 October 2019.

The temperature rise of the oil and windings at the rated load of the transformer is 60/65 K O/W (oil-immersed transformers, see DS/EN 60076-1).

3.7 Class of enclosure

Unless otherwise specified in the tender documents, the substation must have class 20. See annex B4 for details of the class of enclosure.

3.8 Load capacity

Transformers, low voltage and high voltage switchgear, internal connections, etc. must be dimensioned for a continuous load as prescribed by the class of enclosure of the substation, without the temperature limits for the individual components being exceeded, see the relevant Danish/CENELEC standards.

3.9 Overload capacity

Within the limits set by the class of the enclosure, transformers (see DEFU Recommendation 6A) must be dimensioned for overload in accordance with the values set out in IEC 60076-7 for normal transformers (ONAN).

High voltage switchgear, low voltage switchgear and internal connections in the substation must not limit the overload capacity of transformers, see above, when they are installed in a substation.

3.10 Loading of neutral point and neutral connection

Unless otherwise specified in the tender documents, the neutral conductor and busbar on the low voltage side must be dimensioned for a continuous load with the rated current for the low voltage winding of the transformer, see DEFU Recommendation 6A.

Note: If the distribution substation is to be installed in an environment with a high harmonic content in the current and/or asymmetry in the load, it may be necessary to take this into account when the neutral conductors are dimensioned.

3.11 Ability to withstand short circuit

3.11.1 General

Medium voltage and low voltage switchgear, transformers, earthing systems and all internal connections, etc. must be able to withstand the thermal and dynamic influences in the event of external short circuits and earth faults.

3.11.2 High voltage side

As a minimum, unless otherwise specified in the tender documents, a dimensioning symmetrical short circuit current of 20 kA with a duration of 1 second must be used.

The dimensioning earth fault current must be 87% ($\sqrt{3}/2$) of the dimensioning symmetrical short circuit current with a duration of 1 second.

Unless otherwise specified in the tender documents, the peak value of the transient short circuit current is 2,5 times the symmetrical short circuit current.

3.11.3 Low voltage side

As a minimum, unless otherwise specified in the tender documents, a dimensioning symmetrical short circuit current on the low voltage side must be used as indicated below:

Rated power of the transformer [kVA]	Dimensioning symmetrical short circuit current, I_{3SC} [kA], t [s]
≤ 630 kVA	20 kA, 1 s
≥800 kVA and ≤1000 kVA	25 kA, 1 s
>1000 kVA	50 kA, 1 s

The dimensioning earth fault current must be equal to the magnitude and duration of the dimensioning 3-phase symmetrical short circuit current.

For distribution substations which contain or are prepared for the installation of one or more transformers connected in parallel, the dimensioning short circuit current must be adjusted accordingly.

Unless otherwise specified in the tender documents, the peak value of the transient short circuit current is 2,5 times the symmetrical short circuit current.

3.12 Internal arc classification

Unless otherwise specified in the tender documents, the distribution substation must have the following IAC classification:

IAC-AB, 20 kA, 1s.

This provides a tested degree of protection for personnel while operating medium voltage switchgear and for the public.

The IAC classification applies to the arc-tested distribution substation configuration.

The result of an arc test is transferable to distribution substation configurations other than the one tested to the extent permitted by DS/EN 62271-202 and -312, provided the manufacturer can document this in accordance with the above standards. See section 10.

Note: If medium voltage switchgear is replaced at a later date, the arc classification of the distribution substation will not necessarily be preserved as it will be difficult to transfer test results to a new substation configuration, see DS/EN 62271-312.

3.13 Sound level

In principle, the sound level of the transformers must be in accordance with the requirements of DEFU Recommendation 6A. Any additional sound level requirements for a substation must be specified in the tender documents. This includes whether a sound level test in accordance with DS/EN 62271-202 is required, see section 9.

4. CONSTRUCTION

The construction of the substation must be in accordance with DS/EN 62271-202. In addition, the following must apply. Additional requirements or deviations from the following provisions may be specified in the tender documents.

4.1 Enclosure

4.1.1 General

The tender documents must specify whether a substation must be operated from the outside or inside (walk-in substation), and whether it is to be installed at ground level or partly buried (in the case of externally operated substation).

Sides, roof, doors (when closed), ventilation grilles, etc., which form part of the enclosure must have a minimum protection class of IP23D.

When the distribution substation is constructed and fitted out, steps must be taken to minimize the effects of drifting snow and sand, vegetation and pests (mice, rats, etc.).

The enclosure must have no sharp edges.

4.1.2 Materials of the enclosure

Any specific preferences concerning the materials used for the enclosure must be indicated in the tender documents.

The materials used, whether or not they are specified in the tender documents, shall at least meet the relevant requirements in DS/EN 62271-202.

If metals (e.g., stainless steel or similar) are used, the enclosure shall be protected against corrosion, see section 4.1.11.

4.1.3 Internal layout of the distribution substation, barriers, markings, etc.

The substation must have separate low voltage, transformer and high voltage compartments. Preferences concerning the location of compartments must be indicated in the tender documents.

Barriers between compartments must have a protection class of at least IP2X and must be marked and realised as prescribed in DS/EN 61936-1. The low voltage switchgear and controlgear assembly and the enclosure of the medium voltage switchgear may be included as part of the barrier.

All live conducting parts of the main circuit, including parts contained in the low voltage switchgear and controlgear assembly, must have an enclosure with a protection class of at least IP2X. The transformer horns are exempt from this requirement. A bar must be fitted inside the door to the transformer compartment to ensure that live parts of the bushings on the high voltage side and low voltage side are out of reach. The bar must be marked and installed as prescribed in DS/EN 61936-1.

The medium voltage switchgear, low voltage switchgear and controlgear assembly, transformer, earthing system and internal cable connections must be easy to inspect and maintain. The transformer must be easy to inspect while it is energized.

Easy access must be provided to install cables in the low voltage switchgear and controlgear assembly and medium voltage switchgear.

4.1.4 Compartment for electronic equipment, etc.

If a separate compartment for electronic equipment (DA equipment, RTUs, fibre, meters, etc.) is to be provided, this must be specified in the tender documents.

If a non-authorised person is to have access to the compartment (e.g. for operation and maintenance of electronic equipment), the compartment must be accessed from the outside of the substation through a separate door to the compartment, and barriers to the other substation compartments must have a minimum protection class of IP2XC (access for unskilled persons). If only authorised persons have access, a minimum of IP2X is sufficient.

The compartment for electronic equipment, etc. must be located in the substation so that the air temperature in the compartment does not exceed the requirements for installation of electronic equipment.

4.1.5 Doors

Unless otherwise specified in the tender documents, an externally operated substation must have separate doors for low voltage, transformer and high voltage compartments. If the distribution substation has a separate compartment for electronic equipment, there must also be a separate door to this compartment (see section 4.1.4) if access by a non-authorised person is to be possible.

The doors must open outwards to an angle of at least 135° and must be fitted with a mechanism to hold them open in this position. The holding mechanism must be able to withstand a wind speed of at least 28 m/s.

It must not be possible for doors to strike against metal parts of the substation enclosure.

The door opening to the medium voltage switchgear and low voltage switchgear and control assembly must be large enough to allow access to the full width of the equipment. For substations installed at ground level, access to the full height of the equipment must be possible. For a partly buried substation, there must be plenty of space to access the full height of the equipment, for example to install cables in the cable compartments in the medium voltage switchgear and low voltage switchgear and controlgear assembly.

Doors must have a 3-point closing mechanism which closes at the top, the middle and the bottom.

The doors must be prepared for locking with a padlock. The dimensions of the padlock to be used for locking doors must be specified in the tender documents.

4.1.6 Connection of emergency power generator
There must be an opening to connect the cable of an emergency power generator to the low voltage switchgear and controlgear assembly, located at the low voltage compartment. The opening must not be located in the door to the low voltage compartment (it must be possible to open and close the door while the emergency generator is connected).

The opening must be equipped with a hatch that can be fastened from the inside when an emergency power generator is not connected.

The protection class of the substation enclosure with an emergency power generator connected must be at least IP23D.

4.1.7 Roof
The inside of the roof must be designed so that condensation water cannot drip onto equipment.

It must be possible to detach the roof with ordinary tools and lift it off the enclosure. Detachable lifting brackets must be fitted.

Operation and maintenance of equipment in a substation must be possible without the need to remove the roof.

The roof must not be used to attach fittings etc. for supporting cables and similar items.

4.1.8 Ventilation
The substation must be equipped with the necessary ventilation corresponding to its rated power, see section 3.6 and class of enclosure, see section 3.7. The ventilation must be natural air ventilation.

4.1.9 External dimensions
If there are requirements concerning external dimensions (ground surface area and height above ground level), they must be indicated in the tender documents.

4.1.10 Internal dimensions
Requirements concerning internal dimensions must be specified in the tender documents, for example in the form of dimensions for the transformer, medium voltage switchgear and low voltage switchgear and controlgear assembly.

If a substation is to be prepared for the installation of DA equipment, this must be taken into account when the dimensions are specified.

4.1.11 Protection against corrosion
Unless otherwise specified in the tender documents, the protection against corrosion must be suitable for atmospheric corrosion category C4. For parts of a distribution substation buried in soil, corrosion category IM3 must be used.

4.1.12 Exterior cladding and visual appearance
Special requests concerning colour and other visual appearance must be specified in the tender documents.

4.2 Foundation

A substation must have a solid foundation made of concrete. The foundation must be dimensioned for the weight of the transformer, low voltage switchgear and controlgear assembly and medium voltage switchgear, etc.

Penetration of moisture, vegetation and animals from below must be prevented/inhibited.

In compartments for the low voltage switchgear and medium voltage switchgear, there must be recesses where cables can enter the distribution substation. The recesses must be located in one of the sides facing the terrain and must be placed according to the position of the high voltage and low voltage switchgear, so that cables can be easily routed directly up to the connection points in the switchgears.

There must be a protective bonding conductor for ensuring equipotential bonding that directly connects the reinforcement in the foundation to the main earthing busbar of the distribution substation, see also section 4.4.

Requirements concerning the substrate on which the substation is to be installed on must be set out in the tender submitted.

4.3 Oil retention tank

The distribution substation must be realised with one oil retention tank per transformer. Each tank must have sufficient capacity for all the oil in the transformer.

Joints in oil retention tanks must be made of heat-resistant and oil-resistant material and must be durable throughout the service life of the substation.

Additional requirements concerning oil retention tanks may be specified in the tender documents.

4.4 Earthing system

4.4.1 General

A main earthing busbar must be provided in order to connect earthing conductors and protective bonding conductors for ensuring equipotential bonding as well as an external earth electrode.

The following definitions are used, see DS/EN 50522:

Earthing conductor:	Conductor that provides a conductive connection between a point in the distribution substation and the main earthing busbar of the distribution substation.
Protective bonding conductor:	Protective conductor for ensuring equipotential bonding.

The earthing system must be able to withstand the thermal and dynamic influences in the event of external and internal short circuits and earth faults affecting the distribution substation, see section 3.11.

Earthing systems must be realised in accordance with the principle stated in figure B1.1, B1.2 or B1.3 in annex B1. The preferred principle must be indicated in the tender documents.

4.4.2 Main earthing busbar

The main earthing busbar must be made of copper and have a cross section in accordance with the requirements of DS/EN 62271-202. The requirement is considered to be met if the current density does not exceed 200 A/mm^2 for a duration of 1 second.

4.4.3 Earthing conductors

Earthing conductors shall be realised as stranded bare copper conductors or copper busbars. They must be clearly marked with what they are protecting at the point where they are connected to the main earthing busbar.

Earthing conductors shall be directly connected between the main earthing busbar and the following points in the substation:

	Dimensioning current	Dimensioning current density
PEN or PE busbar of the low voltage switchgear and controlgear assembly	The dimensioning earth fault current and duration of the low voltage side, see section 3.11.3.	Unless otherwise specified in the tender documents, the value used is 190 A/mm^2 for a duration of 1 second, see annex D in DS/EN 50522 for a bare copper conductor in air and a final temperature of 300^{o}C.
Earthing busbar of the medium voltage switchgear	The dimensioning earth fault current and duration of the high voltage side, see 3.11.2.	
Earthing terminal of the transformer tank	The greater of the dimensioning earth fault currents of the high voltage and low voltage sides, see 3.11	

4.4.4 Protective bonding conductor

Protective bonding conductors for ensuring equipotential bonding must be connected directly between all conductive parts of the distribution substation that are not intended to carry a fault current, and the main earthing busbar. This includes, but is not limited to:

- The enclosure and frame of the medium voltage switchgear
- The frame of the low voltage switchgear and controlgear assembly
- The reinforcement in the foundation – protective bonding conductors must be connected to the iron reinforcement bars in the foundation
- Oil retention tanks
- The enclosure of the substation including doors (the hinges are not acceptable as an equipotential bonding connection).

Protective bonding conductors must be made of copper and must carry green and yellow markings throughout their length. They must have a conductor cross section of at least 35 mm^2.

4.4.5 Preparation for connection to external earth electrodes

The main earthing busbar must be prepared for the connection of external earth electrodes. The number of external earth electrodes must be specified in the tender documents.

4.5 Meter

If specified in the tender documents, the distribution substation must be prepared for the installation of a settlement meter in the low voltage compartment and must be delivered with a meter support in accordance to “Fællesregulativet” (only in Danish) published by Dansk Energi.

4.6 Socket outlet and lighting

The tender documents must specify whether the substation must be equipped with a socket outlet and/or built-in lighting. If so, the realisation of the socket outlet and lighting must be described in more detail. In all cases, they must be realised and verified in accordance with the DS/HD 60364 series.

The lighting must be a Class 2 appliance. Socket outlets must be protected by an RCD (30mA).

Lighting must meet the functional requirements (illuminance, UGR limit, illuminance uniformity, colour rendering indices) in DS/EN 12464-1 for:

- Area; industrial activities and crafts – electrical and electronics industry
- Type; assembly work
- Activity; medium, e.g., switchboards.

4.7 Internal cable connections

4.7.1 General

The cables must be installed as prescribed by the cable manufacturer and fixed so that they can withstand all thermal and dynamic influences during normal operation and in the event of external earth faults and short circuit faults.

The cables must not lay over sharp edges. Fittings, ties, etc. used to fix the cables must not be able to damage the cables.

Any racks, ladders, etc. made of conductive materials that are necessary for the correct installation of cables must have a protective bonding conductor for ensuring equipotential bonding (see section 4.4.4) directly connected to the main earthing busbar.

The cables must have clear phase markings.

4.7.2 Low voltage cables
The connections are realised with single-conductor cable with stranded copper conductor and a rated voltage U_0/U (U_m) of 0,6/1 (1,2) kV. The cables must be dimensioned for a maximum conductor temperature of 90°C.

The cables must be installed in such a way that it is possible to change the phase sequence at the low voltage transformer horns.

The neutral conductor between the neutral terminal of the transformer and the neutral or PEN busbar of the low voltage switchgear and controlgear assembly must be realised with the same cable type and cross section as used for the phase conductors.

Requirements concerning conductor cross sections and combinations of conductor cross sections and the number of parallel cables must be specified in the tender documents.

4.7.3 Medium voltage cables
Connections must be realised with single-conductor PEX cable with stranded copper conductor and copper wire shield with a rated voltage of:

Nominal network voltage [kV]	Rated voltage U_0/U (U_m) [kV]
10	6/10 (12)
15	9/15 (17,5)
20	12/20 (24)

The cable must be realised and tested as prescribed in HD620 10D.

Requirements concerning conductor and shield cross sections must be specified in the tender documents.

The cable shield must be connected to the earthing busbar of the medium voltage switchgear and must be open to the transformer.

4.7.4 Connection to transformer
If the transformer is not included in the delivery, the type of bushings on the transformer's primary and secondary sides must be indicated in the tender documents. See DEFU Recommendation 6A.

4.8 Internally operated (walk-in) distribution substation

Not applicable to externally operated substations.

Unless otherwise specified in the tender documents, Class 2 lighting fixtures and the functional requirements for lighting must be provided, see section 4.6.

4.9 Transport arrangements

The substation must be realised with detachable or invisible lifting brackets.

For substations with a rated power up to and including 630 kVA, the lifting brackets must at least be strong enough to lift a fully assembled substation including transformer. For distribution substations with a rated power above 630 kVA, the lifting brackets must be strong enough to lift a substation without a transformer installed.

4.10 Marking

4.10.1 Rating plate
A weatherproof and oil-resistant rating plate with the minimum information specified in DS/EN 62271-202 shall be attached to the inside of the door to the medium voltage equipment. Unless otherwise specified in the tender documents, the nameplate must be constructed of stainless steel.

The following information shall appear:

- Name of manufacturer
- Type designation
- Serial no.
- Reference to instruction manual
- Reference to DS/EN 62271-202
- Year of manufacture

If the distribution substation has an internal arc classification in accordance with DS/EN 62271-202, the following information shall also appear on the rating plate:

- IAC classification, test current and duration

Rating plates for the individual components of the substation are realised in accordance with the relevant product standards. The rating plate for the low voltage switchgear and controlgear assembly, medium voltage switchgear and transformer must be attached to these components in such a way that they can be easily read while the distribution substation is in operation.

4.10.2 Warning of electrical voltage
An electrical voltage warning sign of type ISO 7010 W012 (lightning triangle) must be attached to the outside of each of the four sides of the substation.

4.10.3 Substation number and name
On the outside of the distribution substation, there must be space and the possibility to attach signs with the distribution substation number, grid company and substation name.

5. LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLY

Low voltage switchgear and controlgear assembly shall be realised and tested as prescribed in DS/EN 61439-1 and 61439-2. Integrated components built into the low voltage switchgear and controlgear assembly must be realised and tested as prescribed in relevant Danish/CENELEC standards.

If a low voltage switchgear and controlgear assembly owned by a third party is installed in a substation, the requirements in this recommendation must also be met, and the third party owned switchgear and controlgear assembly must be covered by the type approval of the substation.

In addition, the following must apply. Additional requirements or deviations from the following provisions may be specified in the tender documents.

5.1 Principal electrical data

5.1.1 Rated frequency
See section 3.2.

5.1.2 Rated voltage
See section 3.3.

5.1.3 System earthing
System earthing must be indicated in the tender documents, TN-S or TN-C.

5.1.4 Insulation level
See section 3.5.

5.1.5 Rated current
The low voltage switchgear and controlgear assembly must be dimensioned for a rated current corresponding to the rated power of the substation (see section 3.6), taking account of the rated current of the transformer protection.

5.1.6 Ability to withstand short circuit
The low voltage switchgear and controlgear assembly must be able to withstand the thermal and dynamic influences in the event of external short circuit and earth faults. For the dimensioning short circuit level of the low voltage switchgear and controlgear assembly, see section 3.11.3.

Phase conductors, neutral conductors and earthing conductors must be dimensioned for the full 3-phase short circuit current.

5.2 Constructional details

5.2.1 General
The low voltage switchgear and controlgear assembly must be touch-safe on all sides with a minimum protection class IP2X when fully installed in the substation. This also includes the rear of the low voltage switchgear and controlgear assembly facing the transformer compartment in the distribution substation.

Requirements to form of internal separation (see DS/EN 61439-2) in the low voltage switchgear and controlgear assembly must be indicated in the tender documents.

The switchgear and controlgear assembly must be protected against short circuits caused by pests.

The low voltage switchgear and controlgear assembly must be DIN standardised.

5.2.2 Busbar
Phase, neutral, PE and PEN busbars must be able to carry the rated current of the low voltage switchgear and controlgear assembly over the full length of the busbar. Neutral, PE and PEN busbars must be of the same type and dimensions as phase busbars.

The tender documents must specify whether the switchgear and controlgear assembly is to be constructed with a PEN busbar (see figure B1.1) or with separate neutral and PE busbars connected by an earthing conductor able to carry the full short circuit current (see figure B1.2) or with separate neutral and PE busbars (see figure B1.3).

5.2.3 Incoming connection
Unless otherwise specified in the tender documents, the incoming connection to the switchgear and controlgear assembly must be equipped with a switch-disconnector which must be realised and tested in accordance with DS/EN 60947-3.

If the switchgear and controlgear assembly is to be delivered with a circuit breaker, this must be realised and tested in accordance with DS/EN 60947-2. The circuit breaker must meet the requirements for circuit breakers suitable for electrical isolation in DS/EN 60947-2.

5.2.4 Outgoing connection
Requirements concerning the number of outgoing connections in the low voltage switchgear and controlgear assembly must be indicated in the tender documents. Unless otherwise specified in the tender documents, the switchgear and controlgear assembly must be prepared for expansion with at least 3 additional outgoing connections.

Note: In the case of an expansion of outgoing connections with circuit breakers instead of fuse terminal blocks, it should not be assumed that there is space for at least 3 additional outlets in the low voltage switchgear and controlgear assembly.

The outgoing connections must be prepared for the connection of low voltage distribution cables with up to 5 conductors, with aluminium or copper as the conductor material. The number of cables (parallel) per outgoing connection and the relevant conductor cross sections must be indicated in the tender documents. The outgoing connections must be equipped with mechanical strain relief devices which must be able to handle the specified number of cables and cross sections.

Unless otherwise specified in the tender documents, outgoing connections must be equipped with fuse terminal blocks suitable for installation in a standard DIN rail system. The fuse terminal block type must be indicated in the tender documents.

If an outgoing connection is to be realised with a circuit breaker, this must meet the requirements in DS/EN 60947-2 for circuit breakers suitable for electrical isolation and be realised and tested as prescribed in DS/EN 60947-2.

5.2.5 Connection of emergency generator
The low voltage switchgear and controlgear assembly must be designed for cable connection of an emergency generator and synchronization to the grid.

The location of the connection point for the emergency generator must be coordinated with the location of the hatch in the substation enclosure through which the emergency generator cable is inserted, see section 4.1.6.

5.2.5 Installation of meter
If a meter is to be installed in the low voltage switchgear and controlgear assembly (see section 4.5), this must be indicated in the tender documents.

5.3 Verification

Verification of the low voltage switchgear and controlgear assembly must be carried out as prescribed in DS/EN 61439-1 and DS/EN 61439-2.

Documentation and test reports showing that the low voltage switchgear and controlgear assembly is in accordance with DS/EN 61439-1 and DS/EN 61439-2 shall be made available to the purchaser, see section 14.

5.4 Rating plate

The low voltage switchgear and controlgear assembly must be equipped with a rating plate, which must be positioned where it is easily accessible on the control panel side of the assembly.

The rating plate must contain the information prescribed in DS/EN 61439-1.

5.5 Installation of low voltage switchgear and controlgear assembly

The installation and marking of the low voltage switchgear and controlgear assembly must be carried out as prescribed in DS/HD 60364.

6. MEDIUM VOLTAGE SWITCHGEAR

Medium voltage switchgear must be realised and tested as prescribed in DS/EN 62271-200 for metal-enclosed gas-insulated switchgear and DS/EN 62271-201 for insulation-enclosed switchgear.

The switchgear must be touch-proof when installed in the substation.

In addition, the following must apply. Additional requirements or deviations from the following provisions may be specified in the tender documents.

6.1 Principal electrical data

6.1.1 Rated frequency

See section 3.2.

6.1.2 Rated voltage

See section 3.3.

6.1.3 System earthing

See section 3.4

6.1.4 Insulation level

Rated voltage [kV]	Short-duration power-frequency withstand voltage [kV]		Lightning impulse withstand voltage [kV]	
	Common value	Across the isolating distance	Common value	Across the isolating distance
12	28	32	75	85
17,5	38	45	95	110
24	50	60	125	145

6.1.5 Rated current

Unless otherwise specified in the tender documents, the medium voltage switchgear must be dimensioned for the following continuous load currents.

	Metal-enclosed gas-insulated equipment	Insulation-enclosed equipment
Busbar	630 A	400 A
Cable functional unit	630 A	400 A
Transformer functional unit	200 A	Specified in the tender documents

6.1.6 Ability to withstand short circuit

The medium voltage switchgear must be able to withstand the thermal and dynamic influences in the event of external short circuit and earth faults. For the dimensioning short circuit level of the medium voltage switchgear, see section 3.11.2

6.1.7 Internal arc classification

Unless otherwise specified in the tender documents, the medium voltage switchgear must have the following IAC classification: IAC-A-FLR 20 kA 1s according to DS/EN 62271-200.

Note: When installed in a prefabricated secondary distribution substation, it is the IAC classification of the substation which is applicable, see section 3.12, and not the IAC classification of the switchgear. If a prefabricated secondary distribution substation must have an IAC classification, it is an advantage if the medium voltage switchgear is IAC classified.

See section 3.12 for IAC classification of a prefabricated distribution substation.

6.1.8 LSC category (Loss of Service Continuity category)

Metal-enclosed gas-insulated equipment (DS/EN 62271-200) must have the LSC2 category, in which work can be carried out on a deenergized earthed connection compartment while the busbar and other functional units remain energized.

For insulation-enclosed equipment, the tender documents must specify whether the equipment is to have an LSC category in accordance with DS/EN 62271-201.

6.2 Constructional details

6.2.1 Standard reference

The tender documents must indicate whether the equipment is to be metal-enclosed gas-insulated switchgear (DS/EN 62271-200) or insulation-enclosed switchgear (DS/EN 62271-201).

6.2.2 Insulating gas (metal-enclosed gas-insulated switchgear)

If there are requirements concerning the type of insulating gas for metal-enclosed gas-insulated switchgear, this must be indicated in the tender documents.

6.2.3 Configuration

The tender documents must specifies which configurations of functional unit that must be included in the tender submitted. The following notation is used:

K	Cable functional unit
T	Transformer functional unit

For example, 2K+1T means two cable functional units and one transformer functional units.

6.2.4 Cable functional unit

Each cable functional unit must be equipped with a switch-disconnector and earthing switch. The earthing switch may be a part of the switch-disconnector, in which case the switch-disconnector can be in the positions "closed", "open" and "open and earthed".

It must be possible to interlock the switch-disconnector in the "open" and "open and earthed" positions with a padlock. The hole for the padlock must be at least ø10 mm.

Cable functional units must be dimensioned for a rated current as described in section 6.1.5.

The cable must enter from below (bottom) and it must be possible to install it from the front of the equipment.

Unless otherwise specified in the tender documents, electronic short circuit indicators must be built into all cable functional units. A detected short circuit current must be clearly indicated for at least 4 hours, even when the substation is in the de-energised state, before an automatic reset. It must be possible to reset electronic short circuit indicators manually.

6.2.5 Transformer functional unit

The tender documents must indicate whether a transformer functional unit must be equipped with a disconnector and circuit breaker, or a switch-disconnector and fuse combination.

If fuses are used, they must support 3-pole fuse cut-out. Fuses must be of the 'general purpose' type.

6.2.6 Voltage indicators

All cable functional units must be equipped with voltage indicators. Voltage indicators must be realised as prescribed in DS/EN 62271-213.

6.2.7 Phase comparator

All cable functional units must have outlets for phase comparators.

6.2.8 Earthing system

The switchgear must be equipped with an earthing busbar, which must be accessible in all cable connection compartments. The earthing busbar must be prepared for the connection of earthing conductors from cable shields and an earthing conductor for connection to the main earthing busbar of the substation, see section 4.4.3.

6.2.9 For SF_6 gas-insulated equipment only

The gas compartment must be hermetically sealed and filled at the factory. Switchgear to be filled with SF_6 gas on-site will not be accepted.

The annual (tested) leakage rate shall be less than 0.1%; this must be stated on the rating plate.

The equipment must have a manometer to display the SF_6 gas pressure for a clear indication of safe operation (switching). The manufacturer must provide details of how the manometer is tested for correct function without causing the equipment to leak SF_6 gas into the atmosphere. The manufacturer must also provide details of how the manometer is replaced without SF_6 gas leaking into the atmosphere.

In the tender submitted, the supplier/manufacturer must provide details of the return programme for decommissioned switchgear containing SF_6 gas. The details provided must include a description of how the gas will be disposed of, including whether the gas will be processed to create new gas for re-use, or whether it will be destroyed.

6.2.10 Cable test voltage

The tender documents may specify whether a switchgear is to have a rated cable test voltage that allows a withstand voltage test to be performed on the cable while it remains connected to the switchgear.

As a minimum, the cable must be able to handle an AC cable test voltage of $3 \cdot U_0$ at a frequency of 0.1 Hz and an AC cable test voltage of $2 \cdot U_0$ at a frequency of 50 Hz. U_0 is the phase to earth voltage of the cable, and the values for Denmark appear below:

Nominal system voltage [kV]	U_0 [kV]
10	6
15	9
20	12

6.2.11 Cable fault locating

It must be possible to locate faults in the cable system with standard cable fault location equipment without the need to disassemble medium voltage cables from the switchgear.

6.2.12 Rating plate

The equipment must have a rating plate with at least the information stated in DS/EN 62271-200 for metal-enclosed equipment and DS/EN 62271-201 for insulation-enclosed equipment. Unless otherwise specified in the tender, the nameplate must be constructed of stainless steel.

For metal-enclosed SF_6 gas-insulated switchgear, the following information must also appear on the rating plate:

- Weight of the contained SF_6 gas [kg]
- Tested annual leakage rate of less than 0.1%
- CO_2 equivalent of the contained SF_6 gas and the GWP (Global warming potential) applied.

For metal-enclosed gas-insulated switchgear, the IAC classification must also appear if the equipment is IAC classified.

6.3 Tests

Before a delivery is approved, the routine tests described in DS/EN 62271-200 or DS/EN 62271-201 must be performed on the switchgear with a satisfactory result. In addition, type tests must be performed with a satisfactory result in accordance with DS/EN 62271-200 or DS/EN 62271-201 on a unit which is representative of the switchgear type.

If a metal-enclosed gas-insulated switchgear is specified with an IAC classification, a type test (internal arc test) must be performed as prescribed in DS/EN 62271-200.

If a cable test voltage is specified, a type test must be performed as prescribed in DS/EN 62271-200 or DS/EN 62271-201 to verify this rating.

Routine and type test reports for the switchgear must be made available to the purchaser, see section 14.

7. DISTRIBUTION AUTOMATION (DA) SOLUTION

7.1 Included in the substation

If specified in the tender documents, the substation shall be delivered with a DA solution.

The tender documents must specifies one of the following:

- Preferred DA solution, or
- Functional requirements for the DA solution, or
- The purchaser provides DA equipment to be installed in distribution substation.

DA equipment assembly shall be realised and tested as prescribed in the relevant parts of the DS/EN 61439 series, and installation of DA equipment and cabling must be in accordance with DS/HD 60364.

Installed DA equipment must be covered by the type approval of the substation.

7.2 Prepared for installation of Distribution automation (DA) equipment

If the tender documents specifies that a substation shall be prepared for the installation of DA equipment, a dedicated space must be set aside for the installation of the DA equipment.

The manufacturer must indicate the requirements for the DA equipment so that subsequent installation does not affect the type approval of the distribution substation.

8. SUSTAINABILITY

Considering sustainability in the design of a distribution substation is an important design criterion, as it concerns the environmental impact of a distribution substation over its entire life cycle.

In the current version of this recommendation, there are no requirements or recommendations as to how the purchaser can take account of sustainability when evaluating the tendered substation solutions. This is being considered and will possibly be added in later editions.

If sustainability is to be taken into account in the choice of a substation solution, this must be considered in the tendering process so that relevant regulation in this area are complied with.

9. TESTS

Before a delivery is approved, the routine tests described in DS/EN 62271-202 must be performed on the substation with a satisfactory result. In addition, type tests must be performed with a satisfactory result in accordance with DS/EN 62271-202 on a unit which is representative of the substation with all relevant equipment installed. Unless otherwise specified in the tender documents, the temperature rise test must be performed according to the preferred test method in DS/EN 62271-202.

If the distribution substation is specified with an IAC classification, a type test (internal arc test) must also be performed as prescribed in DS/EN 62271-202.

The corrosion protection must be tested as set out in annex B2 (under consideration).

10. TRANSFERABILITY OF TYPE TESTS

In the tender submitted, the manufacturer must provide details of the extent to which DS/EN 62271-312 applies to the transferability of the type tests to other configurations of the substation, for example if the low voltage switchgear and controlgear assembly is expanded with additional fuse terminal blocks, high voltage switchgear is upgraded to DA equipment or extended with additional functional units, etc.

11. INFORMATION TO BE PROVIDED IN INVITATION TO TENDER

The following information must be provided in the invitation to tender:

- Reference to DS/EN 62271-202 and DEFU Recommendation 29
- Nominal and maximum operating voltage for the high voltage and low voltage sides, see section 3.3
- Rated frequency, see section 3.2
- System earthing on the high voltage and low voltage sides, see section 3.4
- Minimum and maximum ambient temperature, see section 3.1
- Details of any unusual installation conditions
- Rated voltage for high voltage and low voltage switchgear as well as the operating voltages of the transformer windings, see section 3.3
- Rated power (equal to the transformer rated power), see section 3.6
- Rated insulation level (high voltage and low voltage sides), see section 3.5
- Rated short time current and duration (high voltage and low voltage sides), see section 3.11
- Maximum earth fault current (high voltage and low voltage sides) and duration, see section 3.11
- Any requirements for internal arc classification, test current value [kA] and duration [s], see section 3.12
- Single-line circuit diagram of the electrical configuration of the substation
- Schematic diagram of the earthing system, see section 4.4 and appendix B1

- Class of the enclosure for distribution substation and load factor for transformer, see section 3.7
- Protection class for enclosure, see section 4.1
- Internal protection classes between compartments in the substation, if applicable, see section 4.1
- Whether the substation is to be installed at ground level or partly buried
- Whether the substation is to be operated from the outside or from the inside (walk-in)
- Requirements concerning enclosure materials, see section 4.1
- Requirements concerning corrosion protection, see section 4.1 and appendix B2
- Requirements concerning a socket outlet and internal fixed lighting, and also RCD protection, see section 4.6
- Requirements concerning meter installation, see section 4.5
- Maximum permissible dimensions, see section 4.1
- Maximum dimensions (height, width, length) and total weight of transformer, high voltage and low voltage equipment, see section 4.1
- Whether the distribution substation is to be installed with DA equipment or prepared for DA equipment, see section 7
- Expectations concerning service life
- Whether a fully equipped test station is to be delivered as part of the evaluation of the tender submitted.
- Special conditions that affect the configuration of a substation (installation environment, access conditions, sound level, dimensions, weight, appearance, etc.)

Information about low voltage equipment:

- Reference to DS/EN 61439-1 and DS/EN 61439-2
- Schematic diagram of the configuration of a low voltage switchgear and controlgear assembly, see section 5.2
- Whether there is to be separate neutral- and PE- busbars, see section 5.2
- If applicable, requirements concerning the possibility of expanding the low voltage switchgear and controlgear assembly
- Rating data for the low voltage switchgear and controlgear assembly and its subcomponents, see section 5.1

Information about the medium voltage switchgear:

- Reference to DS/EN 62271-200 or DS/EN 62271-201
- If applicable, requirements concerning insulation gas in gas-insulated switchgear
- Requirements concerning whether the transformer is to be protected by a circuit breaker or fuse
- Schematic diagram of the configuration of the high voltage switchgear (functional units and components)
- Rating data for the high voltage switchgear and its subcomponents, see section 6.1
- Whether the switchgear is to have a rated cable test voltage, see section 6.2
- Type of short circuit indicators and in which functional units they are to be installed, see section 6.2

Information about the transformer:

- Cf. data to be provided in invitation to tender in DEFU Recommendation 6A
- Any deviations from DEFU Recommendation 6A and/or additional requirements.

Information about distribution automation (DA) equipment (if included in the invitation to tender):

- Preferred DA solution, functional requirements for the DA solution, or
  if the customer provides DA equipment to be installed in distribution substation,

Information about delivery:

- Whether the substation is to be delivered with a transformer installed
- Whether the customer supplies the transformer for installation
- Place of delivery (warehouse or installation site)
- Requirements concerning delivery time.

12. DATA TO BE PROVIDED IN TENDERS SUBMITTED

The following information shall be provided in the tender submitted: Additional information may be requested in the tender documents.

- Confirmation that the tendered substation meets the requirements set out in the tender documents, including compliance with applicable Danish legislation and DS/EN 62271-202
- Rating data for substation, high voltage equipment and low voltage equipment
- List of type tests performed in accordance with DS/EN 62271-202 as well as declaration of conformity stating that the substation has completed type tests satisfactorily and type test reports
- Confirmation of the transferability of type tests in accordance with DS/EN 62271-312
- Manufacturer's quality assurance plan (procedure, methods and forms for quality checks, final checks, etc.)
- Transport weight of substation
- Total weight of substation
- Drawing of the substation configuration, exterior and interior, foundation and earthing system
- External dimensions, including how far out the doors protrude when in the 90º open position
- Requirements concerning the substrate on which the substation is to be installed
- Maximum dimensions of transformer/transformers
- Maximum number of fuse terminal blocks that can be added to the low voltage switchgear and controlgear assembly in the substation
- Information about external cable connections to the substation (the routing of cables into the substation must be shown in drawings of the distribution substation).
- Requirements for transport
- Installation, operating and maintenance instructions
- Minimum free space around the distribution substation
- Volume of oil retentions tank
- List of relevant spare parts and the period for which they are guaranteed to be supplied.

In addition, if the production facilities are to be audited in the context of evaluation of the tender submitted, the manufacturer must make the necessary time and personnel available.

Information about the low voltage switchgear and controlgear assembly:

- Confirmation that the tendered low voltage switchgear and controlgear assembly meets the requirements set out in the tender documents, including compliance with applicable Danish legislation and DS/EN 61439-1 and DS/EN 61439-2
- List of completed verifications of the low voltage switchgear and controlgear assembly and declaration of conformity stating that the verifications have been completed with an acceptable result
- Drawing of the configuration of the low voltage switchgear and controlgear assembly including dimensions and single-line diagram.
- Installation, operating and maintenance instructions
- List of relevant spare parts and the period for which they are guaranteed to be supplied.

Information about the medium voltage switchgear:

- Confirmation that the tendered high voltage equipment meets the requirements set out in the tender documents, including compliance with applicable Danish legislation and DS/EN 62271-200 or DS/EN 62271-201
- List of completed type tests and declaration of conformity stating that the tests have been completed with an acceptable result
- Drawing of the configuration of the high voltage equipment including dimensions and single-line diagram.
- Installation, operating and maintenance instructions
- List of relevant spare parts and the period for which they are guaranteed to be supplied.

For SF_6 gas-insulated switchgear only:

- Weight of SF_6 gas
- That the equipment has a tested annual leakage rate of less than 0.1%

- Details of how the manometer is tested for correct function without causing the equipment to leak SF_6 gas into the atmosphere.
- Details of how the manometer is replaced without SF_6 gas leaking into the atmosphere.
- Details of a programme to return decommissioned equipment with SF_6 gas. The details provided must include a description of how the gas will be disposed of, including whether the gas will be processed to create new gas for re-use, or whether it will be destroyed.

Information about distribution automation (DA) equipment, if relevant:

- Confirmation that DA equipment meets the requirements in the tender documents.

13. CHANGES TO THE TENDERED SUBSTATION

If changes are made to the design, construction and/or materials of the tendered distribution substation during an agreement period, the customer shall be informed of this and must approve the changes.

14. DOCUMENTATION UPON DELIVERY

The following documentation must accompany a delivered substation. The tender documents may contain requirements concerning additional documentation. The documentation shall be an integral part of the delivery.

Unless otherwise specified in the tender documents, documentation must be submitted as one printed copy and also in electronic form.

- Declaration of conformity confirming that the distribution substation complies with applicable Danish legislation and DS/EN 62271-202
- Type test report
- Routine test report
- Quality assurance report
- Verification report according to DS/HD 60364-6
- Product data sheet
- Drawing of the distribution substation configuration, exterior and interior, foundation and earthing system, and single-line drawing of the distribution substation
- Installation instructions in Danish
- Operating instructions in Danish
- Maintenance instructions in Danish
- List of recommended SATs (Site Acceptance Tests) if not already included in the installation instructions
- List of spare parts

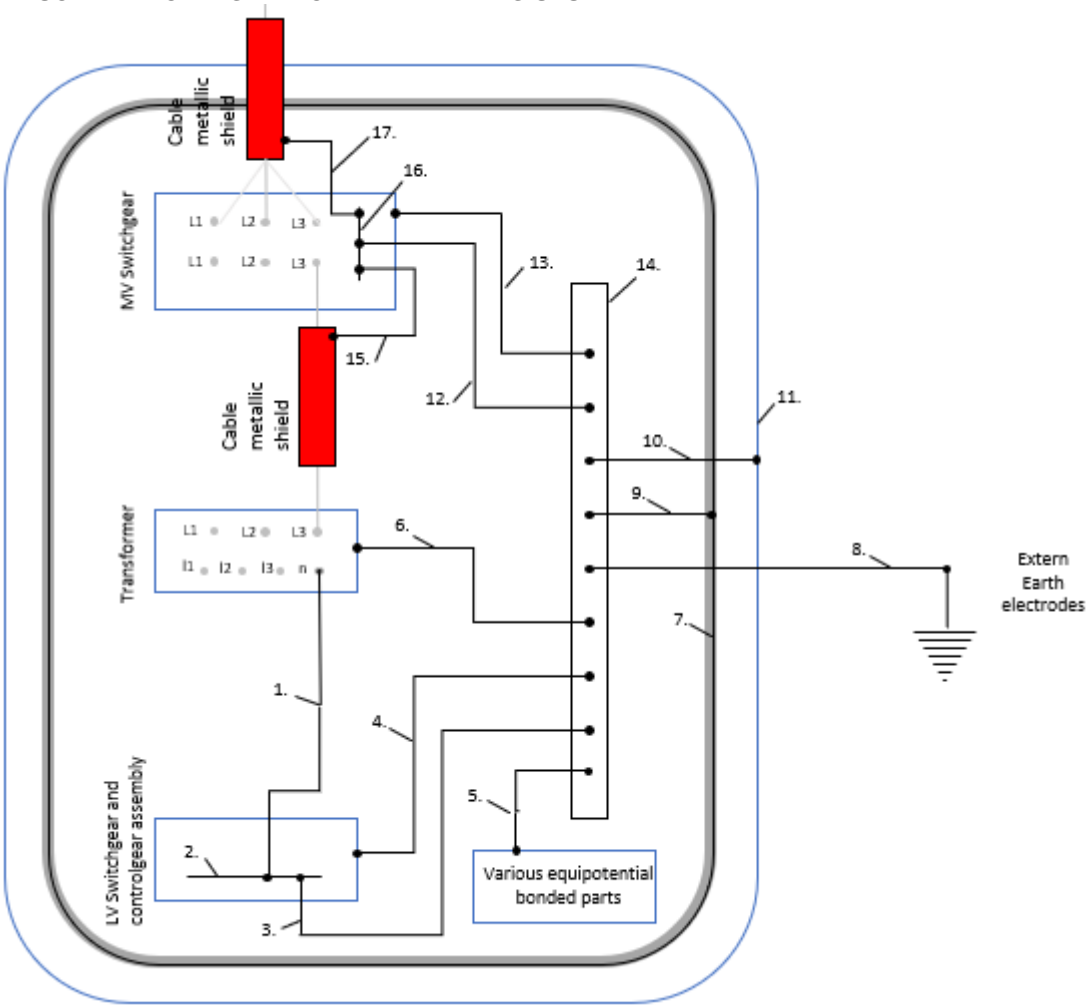
For the low voltage switchgear and controlgear assembly:

- Declaration of conformity confirming that the low voltage switchgear and controlgear assembly meets the applicable Danish legislation and DS/EN 61439-1 and DS/EN 61439-2
- Product data sheet
- Drawing of the configuration of the low voltage switchgear and controlgear assembly and single-line diagram
- Installation instructions in Danish
- Operating instructions in Danish
- Maintenance instructions in Danish
- List of spare parts.

For medium voltage switchgear:

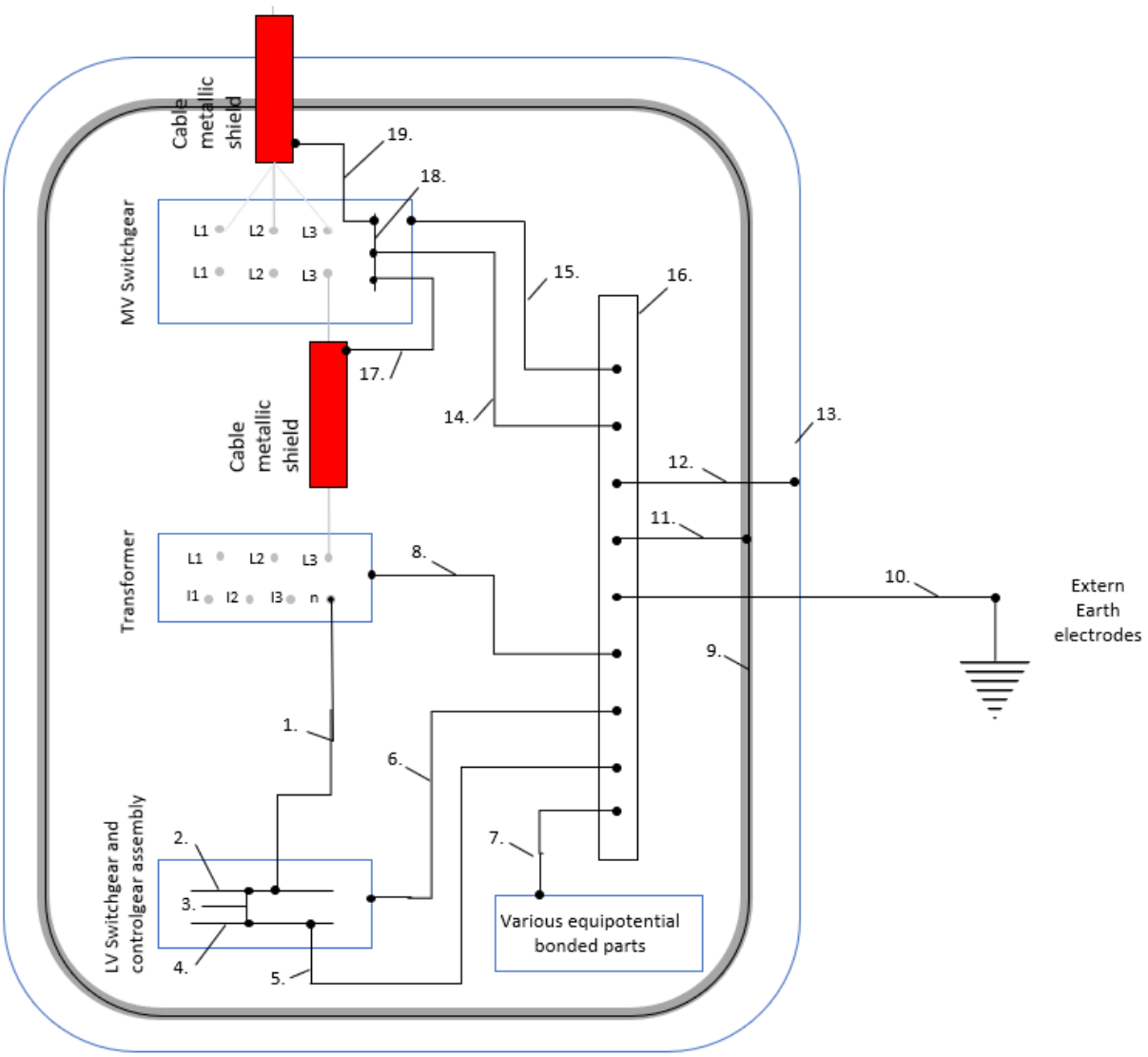
- Declaration of conformity confirming that the high voltage equipment meets the applicable Danish legislation and DS/EN 62271-200 or DS/EN 62271-201
- Routine test report
- Product data sheet
- Drawing of the configuration of the high voltage equipment and single-line diagram.
- Installation instructions in Danish
- Operating instructions in Danish
- Maintenance instructions in Danish
- List of spare parts.

B1. SCHEMATIC DIAGRAM OF THE EARTHING SYSTEM



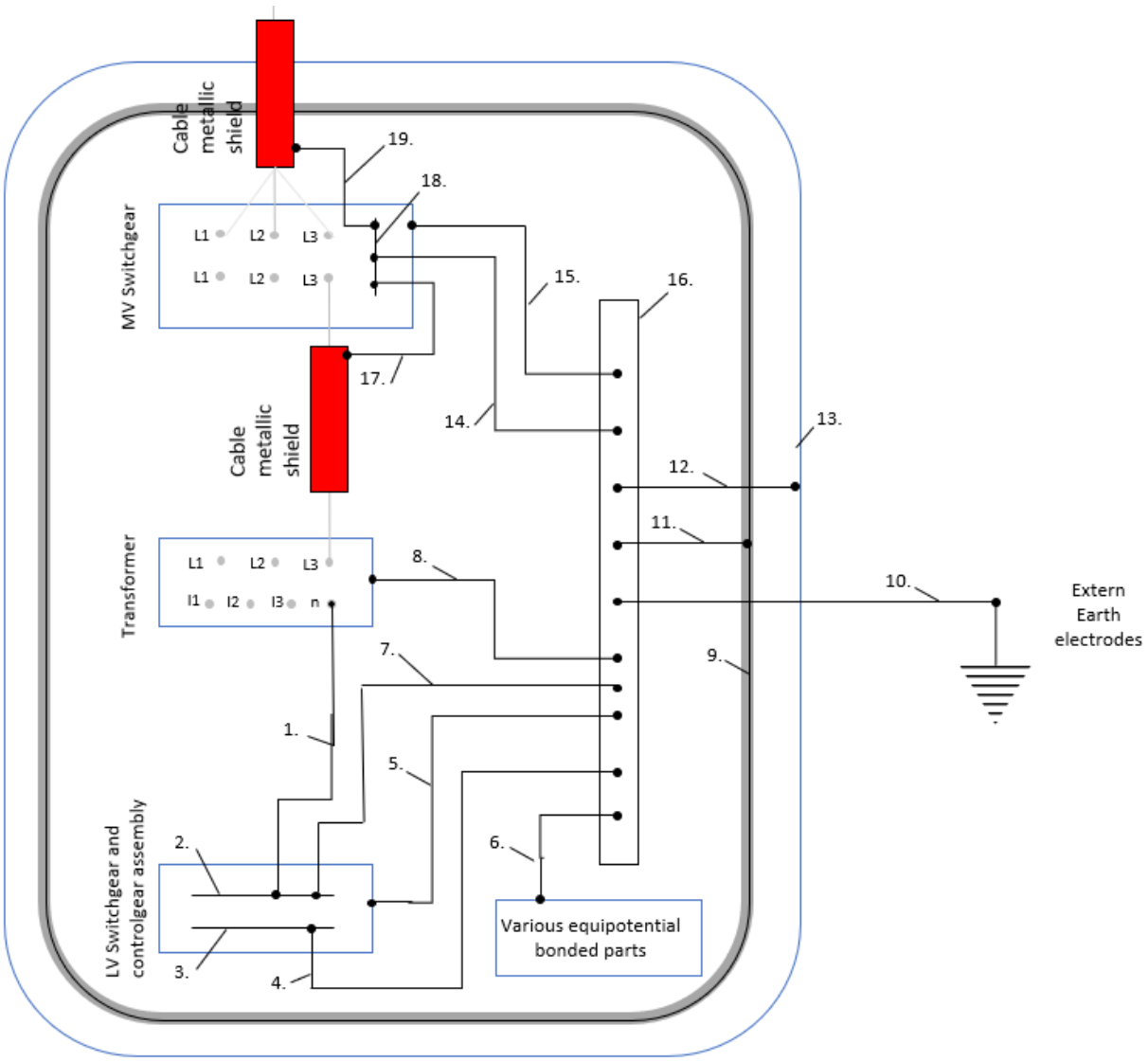
Ref. no.	Description
1.	Neutral conductor between transformer and low voltage switchgear and controlgear assembly.
2.	PEN busbar in low voltage switchgear and controlgear assembly.
3.	Earthing conductor between PEN busbar in low voltage switchgear and controlgear assembly and main earthing busbar.
4.	Protective bonding conductor for ensuring equipotential bonding between the frame of the low voltage switchgear and controlgear assembly and the main earthing busbar.
5.	Protective bonding conductor for ensuring equipotential bonding. Each individual equipotential bonded part must have its own direct protective bonding conductor for ensuring equipotential bonding to the main earthing busbar, see section 4.4.
6.	Earthing conductor between transformer tank and main earthing busbar.
7.	Foundation reinforcement.
8.	Connection of external earth electrodes to main earthing busbar. Part of the external installation, but the main earthing busbar must be prepared for them. The number must be specified in the tender documents.
9.	Protective bonding conductor for ensuring equipotential bonding between main earthing busbar and foundation reinforcement. The protective bonding conductor must be connected to the iron reinforcement bars.
10.	Protective bonding conductor for ensuring equipotential bonding between main earthing busbar and substation enclosure.
11.	Enclosure.
12.	Earthing conductor between earthing busbar in medium voltage switchgear and main earthing busbar.
13.	Protective bonding conductor for ensuring equipotential bonding between the enclosure of the medium voltage switchgear and the main earthing busbar.
14.	Main earthing busbar.
15.	Connection of the shield of the medium voltage transformer cables to the earthing busbar in the medium voltage switchgear. Each individual cable shield must be connected directly to the earthing busbar in the medium voltage switchgear.
16.	Earthing busbar of the medium voltage switchgear.
17.	Connection of the metallic shield of the incoming medium voltage cables to the earthing busbar in the medium voltage switchgear. Each individual cable shield must be connected directly to the earthing busbar in the medium voltage switchgear (part of the external installation, but the earthing busbar in the medium voltage switchgear must be prepared for the installation of shield connections).

Figure B1.1.



Ref. no.	Description
1.	Neutral conductor between transformer and low voltage switchgear and controlgear assembly.
2.	Neutral busbar in low voltage switchgear and controlgear assembly.
3.	Earthing conductor between neutral busbar and PE busbar in low voltage switchgear and controlgear assembly.
4.	PE busbar in low voltage switchgear and controlgear assembly.
5.	Earthing conductor between PE busbar in low voltage switchgear and controlgear assembly and main earthing busbar.
6.	Protective bonding conductor for ensuring equipotential bonding between the frame of the low voltage switchgear and controlgear assembly and the main earthing busbar.
7.	Protective bonding conductor for ensuring equipotential bonding between the main earthing busbar and various parts. Each individual part must have its own direct protective bonding conductor for ensuring equipotential bonding to the main earthing busbar, see section 4.4.
8.	Earthing conductor between transformer tank and main earthing busbar.
9.	Foundation reinforcement.
10.	Connection of external earth electrodes to main earthing busbar. Part of the external installation, but the main earthing busbar must be prepared for them. The number must be specified in the tender documents.
11.	Protective bonding conductor for ensuring equipotential bonding between main earthing busbar and foundation reinforcement. The protective bonding conductor must be connected to the iron reinforcement bars.
12.	Protective bonding conductor for ensuring equipotential bonding between main earthing busbar and substation enclosure.
13.	Enclosure.
14.	Protective earth conductor between earthing busbar in medium voltage switchgear and main earthing busbar.
15.	Protective bonding conductor for ensuring equipotential bonding between the enclosure of the medium voltage switchgear and the main earthing busbar.
16	Main earthing busbar.
17.	Connection of the shield of the medium voltage transformer cables to the earthing busbar in the medium voltage switchgear. Each individual cable shield must be connected directly to the earthing busbar in the medium voltage switchgear.
18.	Earthing busbar of the medium voltage switchgear.
19	Connection of the metallic shield of the incoming medium voltage cables to the earthing busbar in the medium voltage switchgear. Each individual cable shield must be connected directly to the earthing busbar in the medium voltage switchgear (part of the external installation, but the earthing busbar in the medium voltage switchgear must be prepared for the installation of shield connections)

Figure B1.2.



Ref. no.	Description
1.	Neutral conductor between transformer and low voltage switchgear and controlgear assembly.
2.	Neutral busbar in low voltage switchgear and controlgear assembly.
3.	PE busbar in low voltage switchgear and controlgear assembly.
4.	Earthing conductor between PE busbar in low voltage switchgear and controlgear assembly and main earthing busbar.
5.	Earthing conductor between frame in low voltage switchgear and controlgear assembly and main earthing busbar.
6.	Protective bonding conductor for ensuring equipotential bonding between the main earthing busbar and various parts. Each individual part must have its own direct protective bonding conductor for ensuring equipotential bonding to the main earthing busbar, see section 4.4.
7.	Earthing conductor between neutral busbar in low voltage switchgear and controlgear assembly and main earthing busbar.
8.	Earthing conductor between transformer tank and main earthing busbar.
9.	Foundation reinforcement.
10.	Connection of external earth electrodes to main earthing busbar. Part of the external installation, but the main earthing busbar must be prepared for them. The number is specified in the tender documents.
11.	Protective bonding conductor for ensuring equipotential bonding between main earthing busbar and foundation reinforcement. The protective bonding conductor must be connected to the iron reinforcement bars.
12.	Protective bonding conductor for ensuring equipotential bonding between main earthing busbar and substation enclosure.
13.	Enclosure
14.	Earthing conductor between earthing busbar in medium voltage switchgear and main earthing busbar.
15.	Protective bonding conductor for ensuring equipotential bonding between the enclosure of the medium voltage switchgear and the main earthing busbar.
16	Main earthing busbar.
17.	Connection of the shield of the medium voltage transformer cables to the earthing busbar in the medium voltage switchgear. Each individual cable shield must be connected directly to the earthing busbar in the medium voltage switchgear.
18.	Earthing busbar of the medium voltage switchgear.
19.	Connection of the metallic shield of the incoming medium voltage cables to the earthing busbar in the medium voltage switchgear. Each individual cable shield must be connected directly to the earthing busbar in the medium voltage switchgear (part of the external installation, but the earthing busbar in the medium voltage switchgear must be prepared for the installation of shield connections)

Figure B1.3.

B2. PROTECTION AGAINST CORROSION

Under consideration.

B3. CHECKLIST ON RECEIPT OF THE DISTRIBUTION SUBSTATION

The purchaser is recommended to carry out an incoming inspection when a prefabricated secondary distribution substation is delivered. This is to ensure that the distribution substation has been delivered as agreed and meets requirements concerning safety and quality, etc. The incoming inspection can, for example, be designed as a checklist of points to be checked.

This annex lists a number of checkpoints to help the purchaser compile a list of checkpoints on receipt of a prefabricated secondary distribution substation. The list is not exhaustive and is primarily included as an inspiration for the purchaser.

- Check that all documentation has been supplied as agreed, see section 14.
- Check for visible scratches, defects, damage or leaks, and that all doors and hatches can move freely.
- Check that the corrosion protection is undamaged.
- Check that the substation is clean and tidy inside.
- Check that the roof is fitted correctly and securely.
- Check that the medium voltage switchgear is intact, undamaged, fastened and supported correctly.
- Check that the low voltage switchgear and controlgear assembly is intact, fully shielded, fastened and marked correctly.
- Check that all relevant earthing conductors and protective bonding conductor for ensuring equipotential bonding have the correct cross sections, are undamaged and attached to the main earthing busbar, and are marked correctly.
- Check that all cable connections in the main circuit have the correct cross sections, are undamaged and attached and marked correctly.
- Check that all barriers between compartments in distribution substations are installed correctly.
- Check if there is a bar in front of the transformer at the door into the transformer compartment.
- For distribution substations with distribution automation (DA) equipment. Check that equipment and cabling are installed correctly.

B4. CLASS OF ENCLOSURE FOR A PREFABRICATED SECONDARY DISTRIBUTION SUBSTATION

When a transformer is installed in a prefabricated substation, steps must be taken to ensure that its max allowable hot spot temperature is not exceeded. This means that a derating of the transformer is necessary depending on the load pattern of the transformer and the ambient temperature of the prefabricated distribution substation. The load pattern is expressed by the load factor of the transformer:

$$\mu = \frac{I}{I_r}$$

where,

I, is the load current
I_r, is the rated current

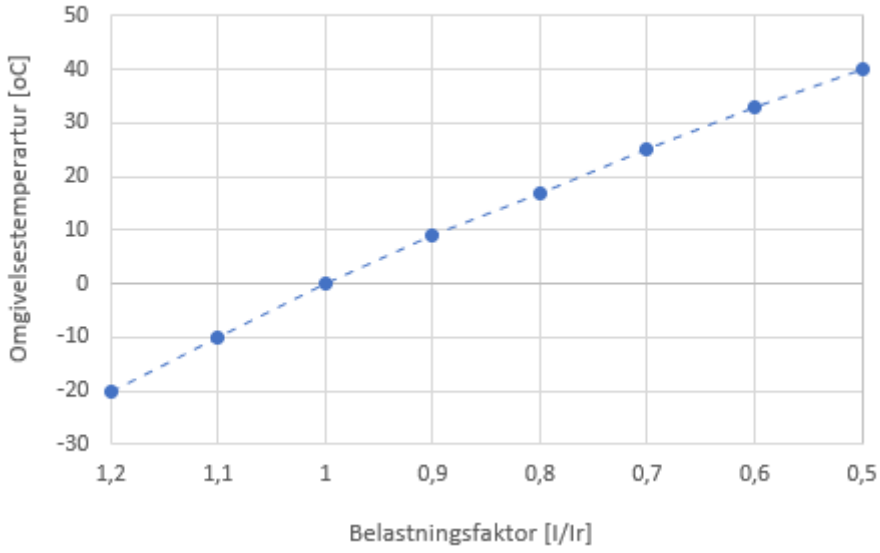
In the case of a cyclic load, in which the load pattern is repeated over a 24 hour period – the typical case – the load factor is given by the following, which is based on hourly values:

$$\mu = \frac{I_1/I_r + I_2/I_r + \ldots\ldots + I_{24}/I_r}{24}$$

where,

I_1, I_2 …. I_{24}, are the hourly values of the load current over a reference period of 24 hours.
I_r, is the rated current.

DS/EN 62271-202 introduced a number of enclosure classes, in which the relationship between the load factor of a transformer and the ambient temperature is given in the form of a curve. They can be used to select the class of enclosure of a prefabricated distribution substation. To illustrate the relationship, the curve for a prefabricated distribution substation with an enclosure class of 20 and an oil-immersed transformer with a permissible oil and winding temperature rise of 60ºC-65ºC O/W is shown below.



Assuming, for example, an average temperature during a summer month of 20ºC, the maximum load factor of the transformer must be around 0.75.

In this recommendation, an enclosure class of 20 is suggested for a prefabricated distribution substation. The suggestion was obtained by calculating an expected load factor for distribution substations in 2040, taking account of the expected increase in the electricity consumption of ordinary households up to 2040 (to ensure that the substations are future-proof with regard to their enclosure class).

In Denmark, the average summer temperature is around 17ºC, which corresponds to a maximum load factor of 0.8 in the case of a prefabricated distribution substation with an enclosure class of 20.

If a prefabricated distribution substation is to be used at a location in the network where the load factor is higher than 0.8, the enclosure class of 20 may have to be reconsidered.