PD IEC TR 62271-312:2021

BSI Standards Publication

High-voltage switchgear and controlgear

Part 312: Guidance for the transferability of type tests of high-voltage/low-voltage prefabricated substations

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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High-voltage switchgear and controlgear – Part 312: Guidance for the transferability of type tests of high-voltage/ low-voltage prefabricated substations

INTERNATIONAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 312: Guidance for the transferability of type tests of high-voltage/low-voltage prefabricated substations

FOREWORD

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IEC TR 62271-312, which is a Technical Report, has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear.

The text of this Technical Report is based on the following documents:

Draft TR	Report on voting
17C/737/DTR	17C/753B/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

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This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62271 series, published under the general title *High-voltage switchgear and controlgear*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 312: Guidance for the transferability of type tests of high-voltage/low-voltage prefabricated substations

1 Scope

This document refers to high-voltage / low-voltage prefabricated substations (hereinafter prefabricated substations) as specified in IEC 62271-202:2014.

This document, among other options as agreed between manufacturer and user, can be used for the transferability of type tests performed on one or more prefabricated substations with a defined set of ratings and arrangement of components to another prefabricated substation with a different set of ratings or different arrangement of components. It supports the selection of appropriate representative test objects for that purpose in order to optimize the type testing procedure for a consistent conformity assessment.

This document utilises a combination of sound technical and physical principles, manufacturer and user experience and mutually agreed upon methods of calculation to establish pragmatic guidance for the transferability of type test results, covering various design and rating aspects.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-441:1984, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses*
IEC 60050-441:1984/AMD1:2000

IEC 60076-1:2011, *Power transformers – Part 1: General*

IEC 60076-2, *Power transformers – Part 2: Temperature rise for liquid-immersed transformers*

IEC 60076-7, *Power transformers – Part 7: Loading guide for mineral-oil-immersed power transformers*

IEC 60076-11, *Power transformers – Part 11: Dry-type transformers*

IEC 60076-12, *Power transformers – Part 12: Loading guide for dry-type power transformers*

IEC 60282-1:2020, *High-voltage fuses – Part 1: Current-limiting fuses*

IEC 61439-1:2020, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-200:2011, *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*

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IEC 62271-202:2014, *High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation*

IEC TR 62271-208:2009, *High-voltage switchgear and controlgear – Part 208: Methods to quantify the steady state, power-frequency electromagnetic fields generated by HV switchgear assemblies and HV/LV prefabricated substations*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-441, IEC 62271-202 and the following apply.

NOTE Some standard terms and definitions are recalled here for ease of reference.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
prefabricated substation
prefabricated and type-tested assembly comprising an enclosure containing in general power transformers, high-voltage and low-voltage switchgear and controlgear, high-voltage and low-voltage interconnections, auxiliary equipment and circuits

Note 1 to entry: The term type-tested assembly includes prefabricated substations verified based on the transferability of type test results in accordance with this document.

[SOURCE: IEC 62271-202:2014, 3.101, modified – New Note 1 to entry.]

3.2
prefabricated substation under consideration
prefabricated substation being verified based on the transferability of type test results in accordance with this document

3.3
component
essential part of the prefabricated substation, which serves one or several specific functions

Note 1 to entry: Examples of components include power transformer, high-voltage switchgear and controlgear, low-voltage switchgear and controlgear, etc.

[SOURCE: IEC 62271-202:2014, 3.105, modified – Addition of "power" in Note 1 to entry.]

3.4
enclosure
part of a prefabricated substation providing protection against external influences to the components and a specified degree of protection for operators and the general public with respect to approach to, or contact with, live parts and against contact with moving parts

[SOURCE: IEC 62271-202:2014, 3.103, modified – Replacing “substation” by “components" in the definition.]

3.5
class of enclosure
difference of temperature rise between the power transformer in the enclosure and the same power transformer outside the enclosure at normal operating conditions

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[SOURCE: IEC 62271-202:2014, 3.112, modified – In the definition, "power" was added, "normal service conditions as defined in 2.1" was replaced by "normal operating condition", and the note was deleted.]

3.6
compartment
part of a prefabricated substation enclosed except for openings necessary for interconnection, control or ventilation

Note 1 to entry: A compartment can be designated by the component contained therein, for example, power transformer, high-voltage switchgear and controlgear, low-voltage switchgear and controlgear respectively.

[SOURCE: IEC 62271-202:2014, 3.104, modified – In Note 1 to entry, addition of "power".]

3.7
prefabricated substation layout
three-dimensional spatial arrangement of main components, covers, doors, ventilation openings and compartments, if any

Note 1 to entry: Relative clearances and distances from main components to one another and to the enclosure can vary.

3.8
high-voltage switchgear compartment
compartment inside the prefabricated substation where the high-voltage switchgear and controlgear or high-voltage electrical protection of the circuit is installed

3.9
switchgear and controlgear
general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:1984, 441-11-01]

3.10
family of high-voltage switchgear and controlgear
functional units designed to be physically combined in assemblies and providing a range of ratings and characteristics (e.g. current, voltage, degree of protection)

[SOURCE: IEC TR 62271-307:2015, 2.102, modified – Addition of "high-voltage" in the term.]

3.11
main circuit
all conductive parts of a prefabricated substation included in a circuit which is intended to transmit electrical energy

[SOURCE: IEC 62271-202:2014, 3.107]

3.12
high-voltage interconnection
electrical connection between the terminals of the high-voltage switchgear and controlgear and the high-voltage terminals of the power transformer

[SOURCE: IEC 62271-202:2014, 3.105.1, modified – Replacing "high-voltage/low-voltage power transformer" by “power transformer” in the definition.]

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3.13
low-voltage interconnection
electrical connection between the low-voltage terminals of the power transformer and the incoming terminals of the low-voltage switchgear and controlgear

[SOURCE: IEC 62271-202:2014, 3.105.2, modified – Replacing "high-voltage/low-voltage power transformer" by “power transformer” in the definition.]

3.14
test object
item submitted to a test, including any accessories, unless otherwise specified

[SOURCE: IEC 60050-151:2001, 151-16-28]

3.15
transferability criteria
principle for evaluating based on the design parameters, which can be applied to validate the performance of an untested prefabricated substation based on the positive results of a test performed on another prefabricated substation for a specific characteristic

4 Use of transferability criteria

4.1 General

Because of the variety of types of prefabricated substations, size of enclosures, layout and different types of components, it is neither practical nor affordable to perform type tests with all the possible variations and combinations. Therefore, the performance of a particular prefabricated substation can be evaluated with reference to type test reports of other prefabricated substation(s). This document gives support for the transferability of type test results concerning the following characteristics according to 6.1 of IEC 62271-202:2014:

– temperature rise;
– dielectric;
– electromagnetic field;
– mechanical;
– short-circuit; and
– internal arc.

Subclauses 5.2 to 5.7 provide, for each kind of characteristic, a non-exhaustive list of design parameters, which should be analysed for the transferability of type test results.

The analysis should be based on sound technical and physical principles and may be supported by calculations, if applicable.

For each characteristic, the design parameters of the prefabricated substation under consideration, listed in the respective column of Table 2 to Table 7, should be compared with the design parameters of the already type-tested prefabricated substation(s) by applying the transferability criteria provided in the same tables. The affirmation of every transferability criteria for a determined characteristic supports the type test results transferability from the original prefabricated substation(s) to the prefabricated substation under consideration. The transferability of the type test results of a particular characteristic does not imply immediate acceptance of other characteristic(s), as each characteristic should be independently assessed. For example, the affirmation of item 7 in Table 2 for transferability assessment of temperature rise type test results reads: power transformer total losses of the prefabricated substation under consideration should be equal or smaller than those of the type-tested prefabricated substation.

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If any of the transferability criteria cannot be affirmed, further evidence e.g. by technical arguments, calculation or simulation, or specific tests may be used and it can be subjected to agreement between the manufacturer and the user. Calculations can only be applied in a comparative sense as indicated in 4.3.

4.2 Design parameters for transferability criteria

Some ratings of a prefabricated substation are not linked to the parameters of specific main components. For example, a layout change can significantly affect the performance of a prefabricated substation characteristic.

The criteria for the transferability of type test results available for a prefabricated substation depend on a number of design parameters such as the examples listed in Table 1. Every prefabricated substation is characterized by its own set of design parameters.

The transferability of type test results of a component with regard to its particular product standard is outside the scope of this document.

Table 1 – Examples of design parameters

Design parameter
Thermal conductivity of enclosure material (steel, reinforced concrete, polyester)
Insulation type of the power transformer (oil- or dry-type)
Effective cross-section of ventilation openings (inlet and outlet)
Degree of protection (IP code) of the enclosure
Distance from components incorporating the main circuits of a prefabricated substation to the enclosure
Mechanical strength of the enclosure roof material
Material of high voltage interconnections conductors
Design, position and cross-section area of gas flow cooling device(s)
NOTE This table includes examples only; it is not intended to be complete.

4.3 Use of calculations

4.3.1 General

For the purpose of this document, calculations and simulations may only be applied in a comparative sense. Calculation results available for a type-tested prefabricated substation can be used for validation and be compared with calculation results obtained for the prefabricated substation under consideration. The comparison is always based on the design parameters and the acceptance criteria provided in Table 2 to Table 7.

In many cases the performance of a given prefabricated substation, with respect to a particular type test, cannot be evaluated by a single value of a design parameter due to the complexity of the design. For example, the low-voltage interconnection layout can vary considerably along the current path. Calculations have the potential to compare the respective design parameter with spatial resolution supporting a comparison using technical arguments and expertise.

Depending on the type test and the particular design parameter, sometimes a simple model of the relevant prefabricated substation can be sufficient using an analytical or empirical formula, and sometimes a complete three-dimensional simulation model should be required using a complex numerical tool provided that the results of the simulation tool are consistent and repeatable.

The validation of software tools and calculation methods themselves is outside the scope of this document. Some of these calculation methods are briefly mentioned below as examples.

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4.3.2 Temperature rise calculations

The assessment procedure is applied to the prefabricated substation under consideration taking into account the total losses generated inside the prefabricated substation, the layout, and the area and mounting conditions of the enclosure walls and the effective area of the ventilation openings. The air temperature inside the enclosure in various locations is the parameter to compare.

For complex geometries, a comparison may be performed by thermal networks, where the whole assembly with all components is divided into discrete elements built from heat generating resistors and heat conducting and convection elements. Furthermore, more complex CFD tools (computational fluid dynamics) or other techniques such as nodal tools may be applied requiring a complete three-dimensional model of the prefabricated substation and main components.

IEC 61439-1 gives conditions for the verification of temperature rise by calculation and IEC TR 60890 [1][1] provides calculation procedures for low voltage assemblies, which can also be applied to a prefabricated substation while having due regard for the particular limitations of this calculation method.

4.3.3 Electric field calculations

Since IEC 62271-202:2014 only requires dielectric type tests on interconnections between the main components (i.e. interconnection between the high-voltage switchgear and controlgear and the power transformer and interconnection between the power transformer and the low-voltage switchgear and controlgear), the dielectric withstand performance of two prefabricated substations may be assessed by an electric field simulation of both designs comparing the resulting electric field strengths.

When the installation conditions can affect their dielectric withstand, finite element (FE) or finite volume (FV) software tools exist, which allows the simulation of complex three-dimensional geometries. It should be noted that this document does not provide information for the extrapolation but only for the interpolation of design parameters, e.g. extending validity to higher values of electric field strengths is not covered.

4.3.4 Electromagnetic field calculations

In case the reference prefabricated substation has been evaluated following the calculation methodology described in IEC TR 62271-208, the same procedure should be applied to the prefabricated substation under consideration in a comparative sense.

4.3.5 Mechanical stress calculations

The mathematical methods of calculation make provision for the full assessment in relation to the mechanical withstand capability of the enclosure. Furthermore, national structural codes and other local regulations may also make provision for the assessment in relation to the mechanical withstand capability of the enclosure.

4.3.6 Short-circuit current calculations

This subclause may only be applied to the interconnection between the components, (i.e. interconnection between the high-voltage switchgear and controlgear and the power transformer and interconnection between the power transformer and the low-voltage switchgear and controlgear) and the earthing circuit of the prefabricated substation.

[1] Numbers in square brackets refer to the Bibliography.

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With respect to the short-time and peak current withstand performance, guidance and calculation formulas for bus-bar designs can be found in IEC 60865-1 [4] and IEC TR 60865-2 [5]. This includes the determination of mutual electromagnetic forces between phase conductors and the resulting mechanical stresses, which may overstress conductors and damage insulators. The mechanical stresses on conductors and forces on the supports may be assessed through stress analysis programs, when applying the calculated electro-magnetic forces. Additionally, a calculation of the thermal stress using $I_k^2 t_k$ can be done when the assessment is made for a lower I_k and higher t_k than those tested, considering that short-time withstand current (I_k) and duration of short-circuit (t_k) are in accordance with 4.5 and 4.7 of IEC 62271-202:2014.

4.3.7 Internal arc calculations

The assessment of the effects of an internal arc inside of a prefabricated substation may be substantiated by pressure-rise calculations and hot gas flow simulations for the compartments, exhausting ducts and pressure relief volumes [7, 8].

The calculations are able to provide the pressure-rise in the compartments under consideration. They also provide parameters for the mechanical strength design of pressure relief device elements, if any. An assessment of the strength of the enclosure walls under the pressure stress can be made for simple geometries using calculation formula, or otherwise using finite element mechanical stress analysis.

The flow of hot gases expelled from the high-voltage switchgear and controlgear or high-voltage interconnection in the event of an internal arc, may be simulated by computational fluid dynamics (CFD) programs.

However, it is, at the time of the publication of this document, not possible to simulate the ignition of indicators, which is an important acceptance criterion in the type test.

4.4 Information needed for transferability of type test results

Prefabricated substation type test reports include general arrangement drawings and component ratings. However, it may not contain sufficient or precise information about some design aspects (e.g. layout, clearance distances) necessary for the transferability assessment of a given characteristic. For the transferability of type test results, the Table 2 to Table 7 should be used to provide the required information for each design parameter of both prefabricated substations. Only the table that is relevant for the characteristic under evaluation may be used.

The applicable type test reports of the type-tested prefabricated substation should be provided in as far as they are concerned with the transferability assessment.

It is recommended that the manufacturer provides the relevant information on the design parameters of the type-tested prefabricated substation to be included in any type test report in addition to the information required by the product standards. See Annex B for general guidance on information that should be included in a type test report.

Most often single value design parameters are not sufficient to perform the evaluation. In this case, relevant drawings of both objects may be necessary.

If a comparison is substantiated by calculations, numerical data or by formula, the type of software used, the reference number of the calculation report and short summary of the input parameters and results should be given.

Documents providing traceability of the analysis performed may be established. Such documents should form part of the report for the transferability of type test results to the prefabricated substation under consideration.

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5 Application of transferability criteria

5.1 General

Various design parameters have been considered in addition to those provided in 5.2 to 5.7, the impact of which are considered to be sufficiently negligible. To facilitate a practical transferability process, only those design parameters which could reasonably influence the transferability of type test results from the type-tested object to the prefabricated substation under consideration have been provided in this document.

5.2 Temperature rise tests

The transferability criteria for the temperature rise performance of a prefabricated substation are summarised in Table 2. The objective is to ensure that the temperature rise of each component within the prefabricated substation under consideration is equal or lower when compared to the type-tested prefabricated substation. Furthermore, the design parameters and associated acceptance criteria are intended to ensure that each component operates at an internal ambient temperature equal to or lower than that of the type-tested object.

For transferability of temperature rise type test results, the rated class of enclosure shall be the same. Therefore, it is not possible to assign a different class of enclosure without further type testing.

A temperature rise assessment of the high voltage switchgear and controlgear is not required. Refer to 6.5.102 of IEC 62271-202:2014.

NOTE The assessment of the low-voltage assemblies used within prefabricated substations can be done in accordance with 10.10.3 of IEC 61439-1:2020.

This list of design parameters does not consider prefabricated substations with forced ventilation for the transferability of temperature rise type test results because this type of ventilation is out of the scope of IEC 62271-202:2014.

Table 2 – Transferability criteria for temperature rise performance

Item	Design parameter	Acceptance criterion	Condition
(1)	(2)	(3)	(4)
1	Layout and enclosure		
1.1	Type of the substation	same	Same type of substation (non-walk-in type vs. walk-in type). Same prefabricated substation layout. Same class of enclosure
1.2	Prefabricated substation compartment volume(s)	≥	
1.3	Thermal conductivity of material(s) – walls – roof – doors and covers	≥	NOTE 1
1.4	Degree of protection (IP code)	≤	IEC 60529 [11]
2	Ventilation openings		
2.1	Air inlet cross-section area	≥	NOTE 2
2.2	Air outlet cross-section area	≥	NOTE 2
2.3	Air outlet/air inlet cross-section ratio	≥	

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Item	Design parameter	Acceptance criterion	Condition
(1)	(2)	(3)	(4)
2.4	Air drag coefficient [ζ] of the ventilation openings, if any	≤	In the absence of air-drag coefficient, the type of ventilation openings should be the same. NOTE 3
3	Difference in height between mid-points of the air inlet and air outlet ventilation openings	≥	
4	Clearance between low-voltage switchgear and controlgear and the power transformer	≥	Only applicable if both components are in the same compartment
5	Difference in height from mid-point of the tank of the oil-filed power transformer or the mid-point of the winding of a dry-type power transformer to the mid-point of the corresponding air outlet ventilation opening	≥	
6	Power transformer insulation type (oil or dry-type)	same	
7	Power transformer total losses	≤	
8	Maximum current of the low-voltage circuit	≤	Rated current of the low-voltage assembly, according to IEC 61439-1, may be equal or higher than the maximum current of the low-voltage circuit. NOTE 4
9	Type and arrangement of interconnections (e.g. solid bars vs. cable, vertical bars vs. horizontal bars)	same	NOTE 4

NOTE 1 Solar radiation is not considered.

NOTE 2 The cross-section area of a ventilation opening is the smallest area perpendicular to the air flow direction.

NOTE 3 See A.2.2 for air-drag coefficient [ζ] definition.

NOTE 4 The conductor material, cross-section, number of conductors/phase and lengths can vary with due consideration of the temperature rise limits of high-voltage and low-voltage interconnections given in Table 14 of IEC 62271-1:2011 and Table 6 of IEC 61439-1:2011 respectively.

5.3 Dielectric tests

The prefabricated substation shall be verified with respect to its dielectric performance. In accordance with 6.2 of IEC 62271-202:2014, since the high-voltage switchgear and controlgear, power transformer(s) and low-voltage switchgear and controlgear contained in a prefabricated substation should be type-tested with respect to their own relevant standards, this subclause primarily applies to the interconnections between the main components when changes to their design and/or installation arrangements affects their dielectric withstand capability.

NOTE The assessment of high-voltage metal-enclosed switchgear and controlgear and of high-voltage solid-insulation enclosed [2] switchgear and controlgear assemblies used within prefabricated substations can be done in accordance with IEC TR 62271-307 [3].

The criteria listed in Table 3 should be affirmed, where applicable, for

– the interconnection between the high-voltage switchgear and controlgear and the power transformer;
– the interconnection between the power transformer and the low-voltage switchgear and controlgear.

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For the high-voltage interconnection, the transferability criteria are only applicable when the interconnection is required to be subjected to dielectric tests according to 6.2.101.1 of IEC 62271-202:2014. Exempted are therefore those interconnections made of earth-shielded high-voltage cables connected using type-tested earth-shielded connectors or by other types of terminations which have been type-tested on both sides, the high-voltage switchgear and controlgear and the power transformer, in the same installation conditions within the prefabricated substation.

If necessary for dielectric performance, insulating barriers and supplementary insulation may have been included in the type-tested object(s) according to 6.2.101 and 6.2.102 of IEC 62271-202:2014 and therefore transferability of type test assessment may only be performed on interconnections having a similar arrangement and design of such insulation.

The impact of insulating barriers and/or additional insulation is difficult to assess. Changes in the design of such insulating parts can normally impede the transferability of type test results, unless it can be evinced that the design change is insignificant.

The transferability criteria of Table 3 are also applicable to the following two situations where dielectric type tests are required by IEC 62271-202:

– where non-earth-shielded high-voltage interconnections are used within enclosures made of non-conductive material, the insulation between the non-earth-shielded live parts of the interconnection and the enclosures shall withstand the dielectric tests in accordance with 6.2.101.2.2 of IEC 62271-202:2014;
– where the low-voltage interconnections are partially or totally covered by a non-metallic enclosure, the arrangement shall withstand the dielectric tests in accordance with 6.2.102 of IEC 62271-202:2014.

Table 3 – Transferability criteria for dielectric withstand performance

Item	Design parameter	Acceptance criterion	Condition
(1)	(2)	(3)	(4)
1	Rated voltage(s) and insulation level(s)	≤	
2	Clearance between phases	≥	
3	Clearance to earth	≥	
4	Creepage distance	≥	NOTE 1
5	Electrical properties of insulating material(s) of interconnections and enclosures of non-conductive material	≥	A comparative result between two materials might be required (e.g. Comparative Tracking Index according to IEC 60112 [9], evaluating resistance to tracking and erosion according IEC 60587 [10])
6	Surface roughness of live parts	≤	
7	Radius of conductive parts	≥	Not only the radius of live parts, but also the radius of all other conductive parts facing live parts (e.g. earthing devices, enclosure, LV wiring, supporting structures) should be considered. NOTE 2

NOTE 1 The field distribution along the insulating surface is also relevant.

NOTE 2 The geometry of insulated conductive parts and other insulating materials affects the electric field as well.

5.4 Electromagnetic field tests

Guidance for measurement of electromagnetic fields generated by prefabricated substations is given in IEC TR 62271-208.

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The transferability of electromagnetic type test results only applies to electromagnetic field outside the prefabricated substation with all covers and doors in closed position in normal service conditions.

NOTE Apart from the main components (e.g. switchgear and controlgear, power transformer, etc.) and high-voltage and low-voltage interconnections placed within a prefabricated substation, the electric and magnetic fields in service are dependent on the physical arrangement and installation conditions of incoming and outgoing cables and their loads, which is outside the scope of this document.

The evaluation of a prefabricated substation can be carried out based on an existing report from a type-tested prefabricated substation. The transferability criteria listed in Table 4 should be taken into consideration for the assessment.

Table 4 – Transferability criteria for electromagnetic field performance

Item	Related to	Design parameter	Acceptance criterion	Condition
(1)	(2)	(3)	(4)	(5)
1	Substation	Layout	same	
2	Substation	Distance from components incorporating the main circuits of a prefabricated substation to the external surface of the enclosure	≥	
3	Substation	Rated voltages of high-voltage circuits	≤	Only applicable to non-earth-shielded high-voltage circuits. The type of high-voltage switchgear and controlgear (i.e. metal-enclosed or solid insulation enclosed) should be the same. NOTE 1
4	Substation	Rated normal currents	≤	NOTE 1
5	Substation	Rated frequency	50 Hz or 60 Hz	Tests performed at 50 Hz or 60 Hz prove both frequencies
6	Enclosure	Permeability and conductivity of the enclosure material(s)	≥	
7	Interconnections	Type of interconnection shielding	same	NOTE 2
8	Interconnections	Distance between phases	≤	
9	Interconnections	Phase sequence by 2 or more cables / phase	same	
10	Power transformer	Type of insulation	same	NOTE 3
11	Low-voltage switchgear and controlgear	Distance between main circuit phases	≤	
12	Low-voltage switchgear and controlgear	Permeability and conductivity of the enclosure material	≥	If any

NOTE 1 More than one rated value is applicable: see Clause 4 of IEC 62271-202:2014.

NOTE 2 Non-shielded interconnections can be replaced by shielded interconnections in the prefabricated substation under consideration, considering that a shield is always better than no shield.

NOTE 3 Refer to type of insulation: liquid-immersed or dry-type.

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