

Australian Standard[®]

High-voltage switchgear and controlgear

Part 202: High-voltage/low-voltage prefabricated substation



This Australian Standard® was prepared by Committee EL-007, Power Switchgear. It was approved on behalf of the Council of Standards Australia on 8 November 2007. This Standard was published on 31 January 2008.

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 - Australian Electrical and Electronic Manufacturers Association
 - Australian Railway Association
 - Energy Networks Association
 - Engineers Australia
 - Testing interests
-

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Australian Standard[®]

High-voltage switchgear and controlgear

Part 202: High-voltage/low-voltage prefabricated substation

Originated as AS 61330—2005.
Revised and redesignated as AS 62271.202—2008.

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-007, Power Switchgear, to supersede AS 61330—2005, *High-voltage/low-voltage prefabricated substation*.

The objective of this Standard is to ensure that prefabricated substations meet the needs of the users in the areas of high-voltage and low-voltage.

This Standard is identical with, and has been reproduced from IEC 62271-202, Ed. 1.0 (2006), *High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation*.

Common numbering of Standards falling under the responsibility of EL-007

In accordance with the decision taken by Committee EL-007, a common numbering system will be established in order to align the numbering of Australian Standards falling under the responsibility of EL-007 with IEC Standards. All high-voltage switchgear and controlgear Standards will, at their next revision (or as equivalent Standards become available in IEC), become parts of the AS 62271 (High-voltage switchgear and controlgear) series. The table below gives the relationship between future numbering and existing Standard numbers. Standards current at the time of publication of this Standard are marked with an asterisk (*).

AS 62271 Series	High-voltage switchgear and controlgear	Previous AS Number
1	Common specifications	*AS 2650
100*	High-voltage alternating-current circuit-breakers	AS 2006
102*	Alternating current disconnectors and earthing switches	AS 1306
103	Switches for rated voltages above 1 kV and less than 52 kV	*AS/NZS 60265.1
104	Switches for rated voltages of 52 kV and above	*AS 60265.2
105	Alternating current switch-fuse combinations	*AS 2024
106	Alternating current contactors and contactor-based motor-starters	*AS 60470
110*	Inductive load switching	AS 4372
200*	AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	AS 2086
201*	AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV	AS 2264
202*	High-voltage/low voltage prefabricated substations	AS 61330
203*	Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV	AS 2263
301*	Dimensional standardization of terminals	AS 2395
303	Use and handling of sulphur hexafluoride (SF ₆) in high-voltage switchgear and controlgear	*AS 2791
304	Additional requirements for enclosed switchgear and controlgear from 1 kV to 72.5 kV to be used in severe climatic conditions	*AS 4243
308*	Guide for asymmetrical short-circuit breaking test duty T100a	

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (b) In the source text 'IEC 62271-202' should read 'AS 62271.202'.
- (c) A full point should be substituted for a comma when referring to a decimal marker.

The terms 'normative' and 'informative' are used to define the application of the annex to which they apply. A normative annex is an integral part of a standard, whereas an informative annex is only for information and guidance.

CONTENTS

	<i>Page</i>
1 General.....	1
1.1 Scope	1
1.2 Normative references.....	1
1.3 Terms and definitions.....	3
2 Service conditions.....	5
2.1 Normal service conditions	5
2.2 Special service conditions.....	5
3 Requirements for components.....	6
4 Ratings	6
4.1 Rated voltages.....	7
4.2 Rated insulation levels.....	7
4.3 Rated frequency and number of phases	7
4.4 Rated normal currents and temperature rise	7
4.5 Rated short-time withstand currents.....	8
4.6 Rated peak withstand currents.....	8
4.7 Rated duration of short circuit	8
4.8 Rated supply voltage of closing and opening devices and auxiliary and control circuits	8
4.9 Rated supply frequency of closing and opening devices and auxiliary and control circuits	8
4.10 Rated maximum power and class of enclosure.....	8
5 Design and construction.....	9
5.1 Earthing	9
5.2 Auxiliary equipment	10
5.3 Nameplate	10
5.4 Degree of protection and internal fault	10
5.5 Enclosure	12
5.6 Other provisions.....	14
5.7 Sound emission	15
5.8 Electromagnetic compatibility (EMC).....	15
6 Type tests	15
6.1 General.....	15
6.2 Dielectric tests	16
6.3 Temperature-rise tests.....	18
6.4 Short-time and peak withstand current tests on main and earthing circuits.....	21
6.5 Functional tests	21
6.6 Verification of the degree of protection.....	21
6.7 Calculations and mechanical tests	22
6.8 Internal arcing test.....	22
6.9 Electromagnetic compatibility test (EMC)	22

7	Routine tests.....	22
7.1	Dielectric test on the HV interconnection.....	23
7.2	Voltage withstand tests on auxiliary circuits	23
7.3	Functional tests	23
7.4	Verification of correct wiring.....	23
7.5	Tests after assembly on site	23
8	Guide to the selection of prefabricated substations for service	23
8.1	Selection of rated values.....	23
8.2	Selection of class of enclosure.....	24
8.3	Selection of internal arc classification	24
8.4	Information	27
9	Information to be given with enquiries, tenders and orders.....	32
9.1	Information with enquiries and orders	32
9.2	Information with tenders.....	33
10	Rules for transport, installation, operation, maintenance and end-of-service life.....	33
10.1	Conditions during transport, storage and installation	34
10.2	Installation	34
10.3	Operation.....	35
10.4	Maintenance	35
10.5	Dismantling, recycling and disposal at the end-of-service life	35
11	Safety	35
11.1	Electrical aspects.....	35
11.2	Mechanical aspects	35
11.3	Thermal aspects	35
	Annex A (normative) Method for testing the prefabricated substation under conditions of arcing due to an internal fault.....	38
	Annex B (normative) Test to verify the sound level of a prefabricated substation	51
	Annex C (normative) Mechanical impact test	53
	Annex D (informative) Rating of transformers in an enclosure	55
	Annex E (informative) Examples of earthing circuits	58
	Annex F (informative) Characteristics of enclosure materials.....	61
	Bibliography	63

INTRODUCTION

Prefabricated substations are defined as a type-tested assembly comprising an enclosure containing transformers, low-voltage and high-voltage switchgear, connections and auxiliary equipment to supply low-voltage energy from a high-voltage system or vice versa. These substations are in locations accessible to the public and should ensure protection to persons according to the specified service conditions.

This means that, in addition to the specified characteristics, ratings and relevant test procedures, particular attention has been paid to the specification concerning the protection of persons, both operators and general public. Use of type-tested components and suitable design and construction of the enclosure ensure this protection. The correct design and performance of the prefabricated substation are verified by means of relevant type tests described in this standard, including internal arc tests.

STANDARDS AUSTRALIA

Australian Standard

High-voltage switchgear and controlgear
Part 202: High-voltage/low-voltage prefabricated substation
1 General**1.1 Scope**

This part of IEC 62271 specifies the service conditions, rated characteristics, general structural requirements and test methods of HV/LV or LV/HV prefabricated substations, which are cable-connected, to be operated from inside (walk-in type) or outside (non-walk-in type) for alternating current of rated voltages above 1 kV and up to and including 52 kV on the HV side, and for one or more transformers for service frequencies up to and including 60 Hz for outdoor installation in locations with public accessibility.

Prefabricated substations can be situated at ground level or partially or completely below ground level.

In general, a prefabricated substation comprises the following main components (functions):

- enclosure;
- power transformers;
- HV and LV switchgear and controlgear;
- HV and LV interconnections;
- auxiliary equipment and circuits.

However, relevant provisions of this standard are applicable to designs where not all these components exist (for example, an installation consisting of power transformer and LV switchgear).

NOTE Non-prefabricated substations should comply with the applicable requirements of IEC 61936-1.

1.2 Normative references

The following referenced documents are indispensable for the application 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.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

IEC 60076 (all parts), *Power transformers*

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

AS 60076-1, *Power transformers—General* (IEC 60076-1, Ed.2.1(2000) MOD)

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

IEC 60076-5, *Power transformers – Part 5: Ability to withstand short circuit*

IEC 60076-10, *Power transformers – Part 10: Determination of sound levels*

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

AS 60076.11, *Power transformers—Dry-type transformers* (identical to IEC 60076-11:2004)

~~IEC 60364-4-41, *Electrical installations of buildings*~~ *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60439-1, *Low-voltage switchgear and controlgear assemblies – Part 1: Type-tested and partially type-tested assemblies*

IEC 60466, *AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 38 kV*

~~IEC 60529, *Degrees of protection provided by enclosures (IP Code)*~~

AS 60529, *Degrees of protection provided by enclosures (IP Code)* (identical to IEC 60529:2001)

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

~~IEC 60694, *Common specifications for high-voltage switchgear and controlgear standards*~~

AS 2650, *Common specifications for high-voltage switchgear and controlgear standards* (IEC60694, Ed.2.2(2002)MOD)

IEC 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

IEC 60721-2-2, *Classification of environmental conditions – Part 2-2: Environmental conditions appearing in nature – Precipitation and wind*

IEC 60721-2-4, *Classification of environmental conditions – Part 2-4: Environmental conditions appearing in nature – Solar radiation and temperature*

~~IEC 60815, *Guide for the selection of insulators in respect of polluted conditions*~~

AS 4436, *Guide for the selection of insulators in respect of polluted conditions* (identical to IEC 60815:1996)

~~IEC 60905, *Loading guide for dry-type power transformers*~~

AS 3953, *Loading guide for dry-type power transformers* (identical to IEC 60905:1991)

IEC 61166, *High-voltage alternating current circuit-breakers – Guide for seismic qualification of high-voltage alternating current circuit-breakers*

~~IEC 61180-1, *High-voltage test techniques for low-voltage equipment – Part 1: Definitions, test and procedure requirements*~~

AS 4362.1, *High-voltage test techniques for low-voltage equipment, Part 1: Definitions, test and procedure requirements* (identical to IEC 61180-1:1992)

IEC 61936-1, *Power installations exceeding 1 kV – Part 1: Common rules*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

~~IEC 62271-200, *High-voltage switchgear and controlgear – AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*~~

AS 62271.200, *High-voltage switchgear and controlgear, Part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV* (IEC 62271-200, Ed.1(2003) MOD)

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

ISO 1052, *Steels for general engineering purposes*

ISO 1182, *Reaction to fire tests for building products – Non-combustibility tests*

ISO 1716, *Reaction to fire tests for building products – Determination of the heat of combustion*

~~ISO 6508-1, *Metallic materials – Rockwell hardness test – Part 1: Test methods (scales A, B, C, D, E, F, G, H, K, N, T)*~~

AS 1815.1, *Metallic materials—Rockwell hardness test, Method 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

1.3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. For the definitions of general terms used in this document, reference is made to IEC 60050-441.

1.3.1

prefabricated substation

prefabricated and type-tested assembly comprising an enclosure containing components (functions) described in 1.1

1.3.2

transport unit

part of a prefabricated substation suitable for shipment without being dismantled

1.3.3

enclosure

part of a prefabricated substation providing protection against external influences to the substation 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

1.3.4

compartment

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

NOTE A compartment may be designated by the main component contained therein, for example, transformer, high-voltage switchgear and controlgear, low-voltage switchgear and controlgear respectively.

1.3.5**component**

essential part of the prefabricated substation, which serves one or several specific functions (for example, transformer, high-voltage switchgear and controlgear, low-voltage switchgear and controlgear, etc.)

1.3.6**partition**

part of a prefabricated substation separating one compartment from other compartments

1.3.7**main circuit**

all conductive parts of a prefabricated substation included in a circuit intended to transmit electrical energy

1.3.8**auxiliary circuit**

all conductive parts of a prefabricated substation included in a circuit (other than the main circuit) intended to control, measure, signal, regulate, illuminate, etc.

1.3.9**rated value**

quantity value assigned, generally by the manufacturer, for a specified operating condition of a prefabricated substation

[IEV 151-04-03, modified]

1.3.10**degree of protection**

extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or against ingress of water and verified by standardized test methods

1.3.11**ambient air temperature**

temperature, determined under prescribed conditions, of the air surrounding the enclosure of the prefabricated substation

1.3.12**class of enclosure**

difference of temperature rise between the transformer in the enclosure and the same transformer outside the enclosure at normal service conditions as defined in 2.1. The transformer rated values (power and losses) correspond to the maximum rated values of the prefabricated substation

1.3.13**transformer load factor**

per unit value of constant current that can be taken from the transformer at constant rated voltage

1.3.14**internal arc classified prefabricated substations**

prefabricated substations for which prescribed criteria for protection of persons are met in the event of an internal arc as demonstrated by the appropriate tests

1.3.14.1

internal arc classification IAC-A for substations providing protection to the operators during normal operations at the HV side of the substation

1.3.14.2

internal arc classification IAC-B for substations providing protection to the general public in the vicinity of the substation on all its sides

1.3.14.3

internal arc classification IAC-AB for substations providing protection to both operators and the general public

1.3.15**degree of protection against mechanical impacts**

extent (level) of protection of the equipment provided by an enclosure against harmful mechanical impacts and verified by standardized test methods

2 Service conditions**2.1 Normal service conditions**

Unless otherwise specified in this standard, the prefabricated substation is designed to be used under normal outdoor service conditions according to IEC 60694.

Inside the enclosure it is assumed that normal indoor conditions prevail according to IEC 60694. However, the ambient temperature inside the enclosure of the prefabricated substation will be different from the ambient temperature as defined in 1.3.11.

If the ambient temperature inside the substation is higher than the limits fixed for the components in their respective product standards, de-rating may be necessary, and testing conditions may be considered following the prescriptions of IEC 60060-1.

2.1.1 High-voltage switchgear and controlgear

IEC 60694 is applicable.

2.1.2 Low-voltage switchgear and controlgear

IEC 60439-1 is applicable.

2.1.3 Transformer

A transformer loaded with rated normal current inside an enclosure has a temperature rise, which is higher than in open-field conditions and the temperature limits as defined in IEC 60076-2 or IEC 60076-11 can be exceeded.

The service conditions of the transformer will be determined according to the local outside service conditions and the class of the enclosure (see 4.10.2).

This will enable the transformer manufacturer or user to calculate its possible derating (see Annex D).

2.2 Special service conditions

When a prefabricated substation is used under conditions different from the normal service conditions given in 2.1, the following applies.

2.2.1 Altitude

Precaution should be taken for the following equipment.

2.2.1.1 High-voltage switchgear and controlgear

For installation at an altitude higher than 1 000 m, refer to IEC 60694.

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2.2.1.2 Low-voltage switchgear and controlgear

For installation at an altitude higher than 2 000 m, refer to IEC 60439-1.

2.2.1.3 Transformer

For installation at an altitude higher than 1 000 m, refer to IEC 60076-2 or IEC 60076-11.

2.2.2 Pollution

In the case where there is exposed insulation inside the enclosure, the degree of pollution should be selected having consideration that airborne salt or industrial pollution introduced via the enclosure ventilation will not be washed off by rain. The degree of pollution inside the enclosure in such circumstances may be more onerous than existing outside the enclosure.

For substations that are intended to be installed in environments with pollution levels III or IV according to IEC 60815, the exposed insulation, if any, should be designed in order to withstand these pollution levels. Alternatively, measures should be taken in order to prevent the build-up of pollution on the exposed surfaces of the insulation.

For installation in polluted ambient air, the degree of pollution should be specified according to the relevant standards for the following equipment.

2.2.2.1 High-voltage switchgear and controlgear

Refer to 2.2 of IEC 60694.

2.2.2.2 Low-voltage switchgear and controlgear

Refer to IEC 60664-1 and IEC 60439-1.

2.2.2.3 Transformer

IEC 60076 and IEC 60076-11 do not address pollution as a special service condition.

2.2.3 Temperature

For a prefabricated substation situated where the ambient temperature can be significantly outside the normal service condition range for the enclosure stated in 2.1, the preferred ranges of temperature to be specified should be

–50 °C and +40 °C for very cold climates.

–5 °C and +50 °C for very hot climates.

3 Requirements for components

All the components shall comply with their relevant IEC standards.

In particular,

- transformers according to IEC 60076-1 or IEC 60076-11;
- high-voltage switchgear and controlgear according to IEC 62271-200 or IEC 60466;
- low-voltage switchgear and controlgear according to IEC 60947-1 and IEC 60439-1.

4 Ratings

The ratings of a prefabricated substation are the following:

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- a) rated voltages (U_r);
- b) rated insulation levels;
- c) rated frequency and number of phases (f_r);
- d) rated normal currents for main circuits (I_r);
- e) rated short-time withstand currents (I_k) for main and earthing circuits;
- f) rated peak withstand currents (I_p), if applicable, for main and earthing circuits;
- g) rated duration of short circuit (t_k) for main and earthing circuits;
- h) rated supply voltage of closing and opening devices and auxiliary and control circuits;
- i) rated supply frequency of closing and opening devices and auxiliary and control circuits;
- j) rated maximum power of the prefabricated substation;
- k) rated power of each transformer;
- l) transformer losses at rated voltage and rated current;
- m) rated class of enclosure.

4.1 Rated voltages

Refer to IEC 60694 for high-voltage switchgear and controlgear.

Refer to IEC 60947-1 and IEC 60439-1 for low-voltage switchgear and controlgear.

4.2 Rated insulation levels

For high-voltage switchgear and controlgear, refer to IEC 60694 and for low-voltage switchgear and controlgear refer to IEC 60439-1 and IEC 60947-1.

The minimum rated lightning impulse voltage withstand of the low-voltage switchgear and controlgear shall be at least the value given for overvoltage category IV in Table 1 of IEC 60664-1. Depending on the network in different countries, it may be necessary to choose a higher insulation level.

4.3 Rated frequency and number of phases

For high-voltage switchgear and controlgear, refer to IEC 60694, and for low-voltage switchgear and controlgear, refer to IEC 60947-1 and IEC 60439-1.

4.4 Rated normal currents and temperature rise

4.4.1 Rated normal currents

For high-voltage switchgear and controlgear, refer to IEC 60694 and for low-voltage switchgear and controlgear, refer to IEC 60439-1.

4.4.2 Temperature rise

For any accessible part of the enclosure of the substation the maximum permissible temperature shall not exceed 70 °C (see Table 3, point 9, of IEC 60694) excluding solar radiation effects.

For high-voltage switchgear and controlgear, refer to IEC 60694.

For low-voltage switchgear and controlgear, refer to IEC 60439-1.

Components in a prefabricated substation which are subject to individual specifications not covered by the scope of IEC 60694 and IEC 60439-1 shall not exceed the maximum permissible temperatures and temperature-rise limits stated in the relevant standard for each component.

The maximum permissible temperature rise for HV and LV interconnections are those specified in IEC 60694 and IEC 60439-1 as applicable for contacts, connections and metal parts in contact with insulation. For the transformer, the load factor will be taken into account to comply with Clause 2 of this standard. Refer to Annex D, and also to IEC 60354 and to IEC 60905.

4.5 Rated short-time withstand currents

Refer to IEC 60694 for high-voltage switchgear and controlgear and to IEC 60439-1 for low-voltage switchgear and controlgear.

A rated short-time withstand current shall also be assigned to the earthing circuit. This value may differ from that of the main circuit.

4.6 Rated peak withstand currents

Refer to IEC 60694 for high-voltage switchgear and controlgear and to IEC 60439-1 for low-voltage switchgear and controlgear.

A rated peak withstand current shall also be assigned to the earthing circuit. This value may differ from that of the main circuit.

NOTE In principle, the rated short-time withstand current and the rated peak withstand current of a main circuit should not exceed the corresponding rated values of the weakest of its series connected components. However, for each circuit or compartment, advantage may be taken of devices limiting the short-circuit current, such as current-limiting fuses, reactors, etc.

4.7 Rated duration of short circuit

Refer to IEC 60694 for high-voltage switchgear and controlgear and to IEC 60439-1 for low-voltage switchgear and controlgear and IEC 60076-5 and IEC 60076-11 for transformers.

A rated duration of short circuit shall also be assigned to the earthing circuit. This value may differ from that of the main circuit.

4.8 Rated supply voltage of closing and opening devices and auxiliary and control circuits

For high-voltage switchgear and controlgear, refer to IEC 60694; for low-voltage switchgear and controlgear, refer to IEC 60439-1.

4.9 Rated supply frequency of closing and opening devices and auxiliary and control circuits

For high-voltage switchgear and controlgear, refer to IEC 60694; for low-voltage switchgear and controlgear, refer to IEC 60439-1.

4.10 Rated maximum power and class of enclosure

4.10.1 Rated maximum power of the prefabricated substation

The rated maximum power of the prefabricated substation is given by the maximum rated power and the total losses of the transformer(s) (as defined in IEC 60076-1 or IEC 60076-11) for which the substation has been designed.

4.10.2 Rated class of enclosure

The rated class of the enclosure is the class of the enclosure corresponding to the rated maximum power of the prefabricated substation.

The rated class of the enclosure is used to determine the load factor of the transformer without exceeding the temperature limits given in IEC 60076 or IEC 60076-11 and described in Annex D.

There are six rated classes of enclosure: classes 5, 10, 15, 20, 25 and 30 corresponding to a maximum value of difference of the temperature rise of the transformer of 5 K, 10 K, 15 K, 20 K, 25 K and 30 K, respectively (see Figures 1 and 2).

NOTE The manufacturer may assign to an enclosure several classes corresponding to different values of power and losses of the transformer. These additional classes should be confirmed by test according to 6.3 (see also 8.2)

5 Design and construction

Prefabricated substations shall be designed so that normal service, inspection and maintenance can be carried out safely. Additionally, the substation shall be designed and constructed in such a manner that the risk of unauthorized access is minimized. Attention shall be paid to hinges, vent covers, locking mechanisms, etc.

5.1 Earthing

A main earthing conductor system shall be provided to connect to the earth all metallic parts of the prefabricated substation not belonging to the main and/or secondary/auxiliary circuits of the equipment. It consists in a main earthing conductor on which each component is connected through a single circuit.

If the framework of the enclosure, or the reinforcement of the concrete, is made of metallic bolted or welded material, it may serve as the main earthing conductor system.

Annex E shows some typical examples of earthing systems.

The main earthing conductor system shall be designed to withstand the rated short-time and peak withstand current under the neutral earthing condition of the system.

The current density in the earthing conductor under the specified fault conditions, if of copper, shall not exceed 200 A/mm² for a rated duration of short circuit of 1 s and 125 A/mm² for a rated short-circuit duration of 3 s. However, its cross-section of area shall be not less than 30 mm². It shall be terminated by an adequate terminal intended for connection to the earth system of the installation. If the earthing conductor is not made of copper, equivalent thermal and mechanical requirements shall be met.

The continuity of the earth system shall be ensured, taking into account the thermal and mechanical stresses caused by the current it may have to carry.

NOTE The users may establish procedures to check the integrity of all parts of the earthing system (internal and external) either periodically or after a short-circuit current has flown into the earthing system.

Components to be connected to the earthing circuit shall include

- the enclosure of the prefabricated substation if it is metallic;
- the enclosure, if metallic, of the high-voltage switchgear and controlgear from the terminal provided for that purpose;
- the metal shields and the earthing conductors of the high-voltage cables;
- the transformer tank or metal frame of dry-type transformers;

- the frame and/or enclosure, if metallic, of the low-voltage switchgear and controlgear;
- the earthing connection of automatic controls and remote-control devices.

If the enclosure of the prefabricated substation is metallic, covers, doors and other accessible metallic parts of this enclosure shall be designed to carry 30 A (d.c.) from themselves to the prefabricated substation main earthing point, with a voltage drop of maximum 3 V. Adequate earthing measures around the prefabricated substation shall be provided to prevent dangerous touch and step voltages.

If the enclosure of the prefabricated substation is not metallic, it is not necessary to connect covers, doors and other accessible metallic parts of this enclosure to the earthing circuit unless there is a risk of live parts coming into contact with them.

5.2 Auxiliary equipment

For the low-voltage installation inside the prefabricated substation (for example, illumination, auxiliary supply, etc.), refer to IEC 60364-4-41 or IEC 60439-1, as appropriate.

5.3 Nameplate

Each prefabricated substation shall be provided with a durable and clearly legible nameplate, which shall contain at least the following information:

- manufacturer's name or trade mark;
- type designation;
- internal arc designation, where applicable
- serial number;
- number of this standard;
- year of manufacture.

5.4 Degree of protection and internal fault

5.4.1 Degree of protection

The protection of persons against access to hazardous parts is necessary and protection of equipment against ingress of solid foreign objects and against ingress of water is necessary.

The minimum degree of protection of the enclosures of the prefabricated substation shall be IP23D in accordance with IEC 60529. A higher degree of protection may be specified in accordance with IEC 60529.

For compartmented substations, the degrees of protection may be defined for each part of the enclosure corresponding to each compartment.

NOTE The degree of protection of the prefabricated substation may be reduced when substation/compartment doors are open (for example, for operation, inspection, etc.). Other precautions may be necessary for the protection of persons against approach to hazardous parts, fulfilling the safety measures of 8.1 of IEC 61936-1.

5.4.2 Protection of the prefabricated substation against mechanical stress

The enclosure of a prefabricated substation shall have sufficient mechanical strength and shall withstand the following loads and impacts:

- a) roof load:
 - minimum 2 500 N/m² (erection loads or other loads);

If the prefabricated substation is installed in places where higher stress can be expected (for example, underground substation placed in vehicle traffic areas, snow loads, etc.), this shall be taken into account and, where applicable, follow national or local regulations in force, or specification of the user.

- snow loads according to the local climatic conditions;
- b) wind loads on the enclosure:
 - wind loads according to 2.1.2 of IEC 60694;
- c) external mechanical impacts on covers, doors and ventilation openings:
 - external mechanical impacts with an energy of 20 J corresponding to a degree of protection IK10.

Accidental mechanical impacts above this value (for example, traffic collisions) are not covered by this standard and should be prevented, if necessary, by other means provided external to and around the prefabricated substation.

5.4.3 Protection of the environment due to internal defects

In the case of internal defects leading to hazardous liquids escaping from the equipment (example: oil of a transformer, oil of switchgear), provision shall be taken to retain hazardous liquids preventing the soil to be polluted.

If one or several retention tanks are part of the enclosure, their capacity shall be at least

- for each individual tank: the total hazardous liquid volume of the corresponding hazardous liquid containing part (for example, transformer, switchgear, etc.);
- for a common tank: the total hazardous liquid volume of the biggest hazardous liquid containing part (for example, transformer, switchgear, etc.).

5.4.4 Internal fault

A prefabricated substation that satisfies the requirements of this standard is designed, in principle, to prevent the occurrence of internal faults.

To achieve this objective the manufacturer of the prefabricated substation shall assure the correct manufacture, verifying it by carrying out routine tests according to Clause 7. In turn, the user shall make a proper selection, according to the characteristics of the network, operating procedures and service conditions (refer to Clause 8).

There should be little probability that an internal arc occurs during the entire service life, if the substation is installed, operated and maintained following the instructions provided by the manufacturer; however, this cannot be completely disregarded.

Failure within the enclosure of a prefabricated substation due either to a defect or an exceptional service condition or mal-operation may initiate an internal arc, which constitutes a hazard, if persons are present. Failures can occur in any part of the substation. However, as no internal arc testing procedure for LV switchgear and transformers are described in their respective relevant standards, only faults occurring within the enclosure of the enclosed HV switchgear and controlgear and in the HV interconnections are taken into consideration in this standard (see 6.8).

For substation arrangements without HV switchgear, see Clause A.3.

To consider this hazard, distinction must be made between operators and general public. The operator can be inside the substation (if operated from inside) or in front of it (if operated from outside). However, the general public may be around the substation at any time. The general public will never be inside the substation or in close proximity to the operating side when operations are being performed with the doors open (if operated from outside). These areas are considered to be of restricted access only for operators.

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Evidence of the effectiveness of the design at providing protection to general public and/or to operators in case of an internal fault may be required. This evidence shall be obtained by testing the substation according to Annex A. Substations that have been successfully tested qualify as class IAC-A or IAC-B or IAC-AB.

In the event of an internal arc, some gases with toxic characteristics may be present. However, it is not relevant to the safety of the operator because in such situation evacuation of the switching room is mandatory. Later on, ventilation of the room is necessary before re-entering.

The fast dispersal of any gases in the open air will result in their concentration being negligible in a very short time, thus not affecting the safety of the general public.

5.5 Enclosure

5.5.1 General

The enclosure shall meet the following conditions.

- The degree of protection shall comply with 5.4.
- Parts of the enclosure made of non-conductive materials shall meet special dielectric requirements. Tests to verify compliance are described in 6.2.1.3.3.
- Measures shall be taken in order to avoid deformation, which could be caused by transport or handling when carried out according to the manufacturer's instructions.
- Means shall be provided to guarantee safe access to operations concerning transformer tap-changer or for inspection, for example, by opening a door or, if necessary, by removing a cover.
- Cooling of the prefabricated substation shall be by natural ventilation.
NOTE Prefabricated substations employing other means of cooling (for example, forced cooling) should be subject to an agreement between manufacturer and user.
- It is acceptable that part of the enclosure of a component becomes part of the substation enclosure. In such a case, this part shall comply with the applicable requirements of both this standard and the relevant product standard of the component.

5.5.2 Fire behaviour

The materials used in the construction of the enclosure of the prefabricated substation shall have the following minimum level of behaviour against fire occurring inside or outside of the prefabricated substation.

The materials shall be either non-flammable or, if synthetic materials are used, they shall be in accordance with 5.5.2.2.

NOTE 1 In fire behaviour, only reaction to fire is considered. Fire resistance may be considered, according to local regulations, subject to agreement between manufacturer and user.

NOTE 2 For aesthetic reasons, additional cladding materials which may not comply with non-flammability tests could be used. These materials should not form any part of the structure of the enclosure of the substation.

5.5.2.1 Traditional materials

The materials listed below are suitable for prefabricated substations and considered as non-flammable:

- concrete;
- metal (steel, aluminium, etc.);
- plaster;
- glass fibre or rockwool.

5.5.2.2 Synthetic materials

Synthetic materials shall be tested according to ISO 1182 and ISO 1716 complying as a minimum with the values given in Table 1.

Table 1 – Synthetic material characteristics

Performance characteristics	Requested values	Standard
PCS gross heat of combustion [in MJ/kg]	$\leq 3,0$ MJ/kg	ISO 1716
Temperature rise (T) [in °C]	≤ 50 °C	ISO 1182
Loss of mass (Δm) [in %]	≤ 50 %	ISO 1182
Flaming time (t_f) [in s]	20 s	ISO 1182

5.5.2.3 Other materials

The manufacturer shall prove the non-flammability of the materials used which shall be at least equivalent to 5.5.2.2.

5.5.3 Corrosion

The enclosure can be made of different materials (concrete, metal, synthetic materials, etc.). The materials of the enclosure should resist deterioration under the environmental conditions (see Clause 2) during its expected lifetime, provided that the maintenance recommendation given by the manufacturer is followed.

An additional coating or surface treatment can be used.

To assess the performance of such treatments appropriate relevant international standards may be used.

The IEC 60068 series gives information on environmental testing procedures and severity of tests.

Characteristics of materials coatings and painting should be stated by the manufacturer. Additional information is given in Annex F.

If the enclosure is part of the main earthing conductor system, precautions shall be taken to prevent corrosion of the elements and contact surfaces in the earthing current path, in order to maintain the current-carrying capacity during its expected service lifetime.

5.5.3.1 Concrete

Concrete shall be protected against the effects of water penetration, carbonation, frost, chloride diffusion and chemical attacks.

Painting or roughcast painting may be used as appropriate. The adherence, ageing (damp heat) and abrasion resistance should be considered.

5.5.3.2 Metals

Protection against corrosion shall be ensured by the use of suitable materials or by the application of suitable protective coatings to the exposed surfaces.

Properties of coating or painting are: adherence, ageing (damp heat) and abrasion resistance.

Stainless steel or aluminium may be used without protection.

5.5.3.3 Synthetic and composite materials

Ageing (dry heat and damp heat) and ultraviolet radiation should be considered. Additionally, these materials may be protected by appropriate painting or coating.

5.5.4 Covers and doors

Covers and doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. When ventilation openings are incorporated in covers or doors, reference is made to 5.5.5.

Two categories of covers or doors are recognized with regard to access to the compartments of the prefabricated substation.

- a) Those which need to be opened for normal operation (removable covers, doors). These shall not require tools for their opening or removal. They shall be provided with locking facilities unless the safety of persons is assured by a suitable interlocking device.
- b) All other covers, doors or roof. They shall be provided with locking facilities or it shall not be possible to open or remove them before doors used for normal operation have been opened. They shall require tools for their opening or removal.

The doors shall open outwards at an angle of at least 90° and be equipped with a device able to maintain them in an open position. Below ground-level prefabricated substations require an access hatch, providing adequate safety for personnel and the passer-by. It shall be possible for a single person to operate this hatch.

It shall be possible to secure the access hatch to prevent closure whilst operators are within the substation or working on the equipment from outside the substation.

5.5.5 Ventilation openings

Ventilation openings shall be so arranged or shielded that the same degree of protection (IP code) and the same degree of protection against mechanical impacts (IK code) as specified for the enclosure are maintained.

Such openings may make use of wire mesh or similar, provided that the IK level is maintained.

5.5.6 Partitions

The degree of protection of partitions, if any, shall be specified according to IEC 60529.

5.6 Other provisions

5.6.1 Provisions for dielectric tests on cables

Safe means of access shall be provided to the high-voltage cable-boxes and/or cable test points of the HV switchgear and controlgear in order to perform dielectric tests on the cables.

5.6.2 Accessories

Adequate space should be provided for keeping accessories, for example, earthing devices, operating handles, etc.

5.6.3 Operation aisle

The width of an operation aisle inside a prefabricated substation shall be adequate for performing any operation or maintenance. The width of such an aisle shall be 800 mm or greater. Doors of switchgear and controlgear inside the prefabricated substation shall either close in the direction of the exit or rotate such that they shall not reduce the width of the aisle.

Doors in any open fixed position or mechanical drives protruding from the switchgear and controlgear shall not reduce the width of the aisle to less than 500 mm.

5.6.4 Labels

Labels for warning, manufacturers' instructions, etc., and those according to local standards and regulations shall be durable and clearly legible.

5.7 Sound emission

By agreement between manufacturer and user on the sound emission level, a test to evaluate the effect of the enclosure on the transformer emitted sound may be performed. The method of testing shall be in accordance with Annex B.

5.8 Electromagnetic compatibility (EMC)

Subclause 5.18 of IEC 60694 for high-voltage switchgear and controlgear and 7.10 of IEC 60439-1 for low-voltage switchgear and controlgear are applicable.

6 Type tests

6.1 General

Subclause 6.1 of IEC 60694 is applicable with the following addition.

In principle, the type tests shall be made on a representative configuration of the components of a complete prefabricated substation. Components contained in a prefabricated substation shall be tested according to the relevant standards (refer to Clause 3).

Because of the variety of types, ratings and possible combinations of components, it is not practical to make type tests with all the possible configurations of a prefabricated substation. The performance of any particular configuration may be substantiated by test data of comparable configurations.

Care shall be taken that none of the tested parameters of the substation are negatively affected.

The type tests and verifications comprise the following:

Mandatory type tests: Subclause

- a) tests to verify the insulation
level of the prefabricated substation 6.2
- b) tests to prove the temperature rise of the main components contained in
a prefabricated substation 6.3
- c) tests to prove the capability of the main and earthing circuits to be subjected
to the rated peak and the rated short-time withstand currents..... 6.4
- d) functional tests to prove satisfactory operation of the assembly..... 6.5
- e) tests to verify the degree of protection..... 6.6
- f) tests to verify the withstand of the enclosure of the prefabricated substation
against mechanical stress 6.7
- g) for prefabricated substations class IAC-A, IAC-B or IAC-AB,
tests to assess the effects of arcing due to an internal fault..... 6.8
- h) EMC compatibility tests 6.9

Special type tests (subject to agreement between manufacturer and user):

- i) tests to verify the sound level of a prefabricated substation..... Annex B

Type tests may impair the suitability of the tested parts for subsequent use in service. Therefore, specimens used for type test shall not be used in service without agreement between manufacturer and user.

6.1.1 Grouping of tests

Subclause 6.1.1 of IEC 60694 is applicable with the following modifications.

The mandatory type tests (not including items g) and h)) shall be carried out in a maximum of four specimens.

6.1.2 Information for identification of specimens

Subclause 6.1.2 of IEC 60694 is applicable.

6.2 Dielectric tests

Since the HV switchgear, transformer(s) and LV switchgear contained in a prefabricated substation have been type-tested according to the relevant standards, this subclause applies only to the interconnection between the components when the installation conditions can affect their dielectric withstand. Therefore, the equipment to be subjected to dielectric tests is as follows:

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

6.2.1 Tests on the high-voltage interconnection

6.2.1.1 General conditions

The dielectric tests are not required when the high-voltage interconnection is made of high-voltage cables connected by type-tested earth-shielded connectors or by other types of terminations which have been type-tested on both the high-voltage switchgear and the transformer sides in the installation conditions of the prefabricated substation.

In all other cases, the interconnection shall be subjected to dielectric tests according to 6.2.1.2 to 6.2.1.5.

The tests may be carried out with the transformer replaced by a replica reproducing the field configuration of the transformer bushings.

For the tests, the high-voltage connection is connected to the test supply through the high-voltage switchgear. Only the switching devices that are in series in the supply circuit are closed. All other switching devices are open.

Voltage-limiting devices shall be disconnected during dielectric tests.

Secondary terminals of current transformers shall be short-circuited and connected to earth. Voltage transformers shall be disconnected.

6.2.1.2 Ambient air conditions during tests

Refer to 6.2.1 of IEC 60694.