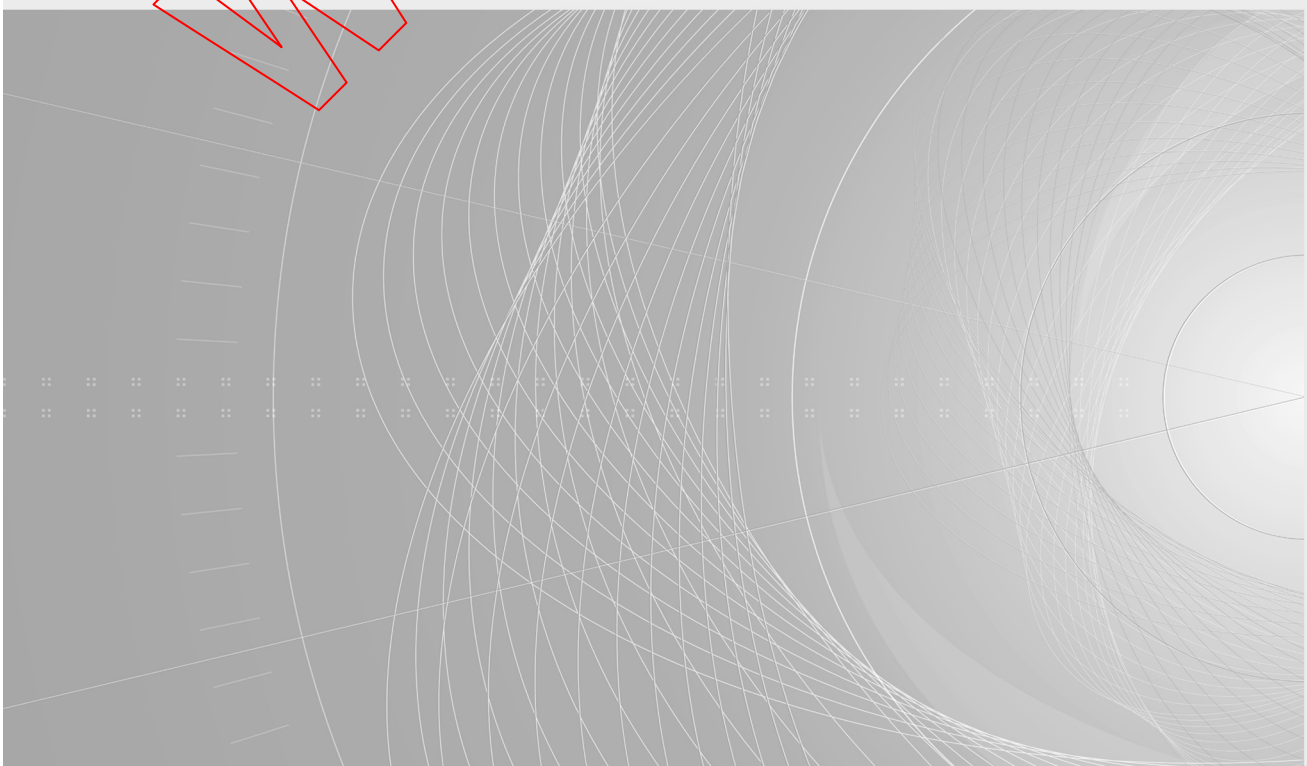
IEC/TR 61439-0

Edition 1.0 2010-10

TECHNICAL REPORT

Low-voltage switchgear and controlgear assemblies – Part 0: Guidance to specifying assemblies



IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC/TR 61439-0

Edition 1.0 2010-10

TECHNICAL REPORT

Low-voltage switchgear and controlgear assemblies – Part 0: Guidance to specifying assemblies

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE XA

ICS 29.130.20

ISBN 978-2-88912-209-7

CONTENTS

FOREWORD 5
INTRODUCTION 7
1 Scope 9
2 Normative references 9
3 Terms and definitions 9
4 Application of ASSEMBLIES within the IEC 61439 series 10
4.1 General 10
4.2 ASSEMBLY design and verification 10
4.3 Service conditions and interface characteristics 10
4.4 Design 11
5 Electrical system 11
5.1 General 11
5.2 Earthing system 11
5.3 Nominal voltage 11
5.4 Overvoltage category (OVC) 12
5.5 Unusual voltage transients, temporary overvoltages 12
5.6 Rated frequency f_n (Hz) 13
5.7 Additional on-site testing requirements: wiring, operational performance and function 13
6 Short-circuit withstand capability 13
6.1 General 13
6.2 Prospective short-circuit current at supply terminals I_{cp} (kA) 14
6.3 Prospective short-circuit current in the neutral 14
6.4 Prospective short-circuit current in the protective circuit 14
6.5 Short-circuit protective device (SCPD) 14
6.6 Co-ordination of short-circuit protective devices including external short-circuit protective device details 15
6.7 Data associated with loads likely to contribute to the short-circuit current 16
7 Protection of persons against electric shock 16
7.1 General 16
7.2 Basic protection (protection against direct contact) 16
7.2.1 General 16
7.2.2 Basic insulation provided by insulating material 16
7.2.3 Barriers or enclosures 16
7.3 Fault protection (protection against indirect contact) 17
7.3.1 General 17
7.3.2 Protection by automatic disconnection of the supply 17
7.3.3 Electrical separation 18
7.3.4 Protection by total insulation 18
8 Installation environment 19
8.1 General 19
8.2 Location type 19
8.3 Protection against ingress of solid foreign bodies and ingress of water 19
8.4 External mechanical impact 20
8.5 Resistance to UV radiation 20
8.6 Resistance to corrosion 20

8.7 Ambient air temperature 20
8.8 Maximum relative humidity 21
8.9 Pollution degree 21
8.10 Altitude 22
8.11 EMC environment 22
8.12 Special service conditions 23
8.12.1 General 23
8.12.2 Climatic conditions 23
8.12.3 Protection against ingress of solid foreign bodies and ingress of water 23
8.12.4 Shock, vibration, and external mechanical impact (IK) 23
8.12.5 Fire and explosion hazards 24
8.12.6 Exceptional overvoltages 24
8.12.7 EMC environment 24
9 Installation method 24
9.1 General 24
9.2 Assembly type 24
9.3 Portability 25
9.4 Maximum overall dimensions and weight 25
9.5 External conductor type(s) 25
9.6 Direction(s) of external conductors 25
9.7 External conductor material 26
9.8 External phase conductor, cross-sections, and terminations 26
9.9 External PE, N, PEN conductors cross-sections, and terminations 26
9.10 Special terminal identification requirements 27
10 Storage and handling 27
10.1 General 27
10.2 Maximum dimensions and weight of transport units 27
10.3 Methods of transport (e.g. forklift, crane) 27
10.4 Environmental conditions different from the service conditions 27
10.5 Packing details 27
11 Operating arrangements 28
11.1 General 28
11.2 Access to manually operated devices 28
11.3 Isolation of functional units for maintenance or service 28
12 Maintenance and upgrade capabilities 29
12.1 General 29
12.2 Requirements related to accessibility for inspection and similar operations 29
12.3 Requirements related to accessibility in service by authorized persons 29
12.4 Requirements related to extension under voltage 30
12.5 Protection against direct contact with hazardous live internal parts during maintenance or upgrade 30
12.6 Removable functional units – methods of connection 30
12.7 Operating and maintenance gangways within an ASSEMBLY 31
12.8 Internal separation 31
13 Current carrying capability 31
13.1 General 31
13.2 Rated current I_{nA} (A) (maximum current allowable) 32
13.3 Rated current of circuits I_{nc} (A) 32

13.4 Rated diversity factor (RDF) 32
13.5 Ratio of cross-section of the neutral conductor to phase conductors 32
13.5.1 General 32
13.5.2 Phase conductors up to and including 16 mm^2 33
13.5.3 Phase conductors above 16 mm^2 33
14 ASSEMBLY design and routine verification processes 33
14.1 Design verification 33
14.1.1 Object 33
14.1.2 Methods 33
14.1.3 Records 33
14.2 Routine verification 34
14.2.1 General 34
14.2.2 Records 34
Annex A (informative) Cross-section of copper conductors suitable for connection to terminals for external conductors 36
Annex B (informative) Forms of internal separation (see 12.8) 37
Annex C (informative) Items subject to agreement between the ASSEMBLY manufacturer and the user for IEC 61439-2 ASSEMBLIES 41
Annex D (informative) Specification guidance for future IEC 61439-3 47
Annex E (informative) Specification guidance for future IEC 61439-4 48
Annex F (informative) Specification guidance for future IEC 61439-5 49
Annex G (informative) Specification guidance for future IEC 61439-6 50
Bibliography 51

Figure 1 – Required rated impulse withstand voltage 35
Figure B.1 – Symbols used in Figures B.2 and B.3 38
Figure B.2 – Forms 1 and 2 39
Figure B.3 – Forms 3 and 4 40

Table A.1 – Cross-section of copper conductors suitable for connection to terminals for external conductors 36
Table B.1 – Forms of internal separation 37
Table C.1 – Items subject to agreement between the ASSEMBLY manufacturer and the user 41
Table C.2 – Examples of optional items subject to agreement between the ASSEMBLY manufacturer and the user 45

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES –

Part 0: Guidance to specifying assemblies

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC/TR 61439-0, which is a technical report, has been prepared by subcommittee 17D: Low-voltage switchgear and controlgear assemblies, of IEC technical committee 17: Switchgear and controlgear.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
17D/402/DTR	17D/421/RVC

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.

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

A list of all parts of the IEC 61439 series, under the general title *Low-voltage switchgear and controlgear assemblies*, can be found on the IEC web site.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

For the purposes of this technical report, the user is the party who specifies or selects the ASSEMBLY characteristics. The user may be the same party as the one who will use and operate the ASSEMBLY, or someone acting on their behalf. The aim of this technical report is to provide the user with guidance on the specification that should be provided in order to achieve the desired design of an assembly. Throughout this technical report, the term ASSEMBLY is used for a low-voltage switchgear and controlgear assembly. The term "manufacturer" refers to the ASSEMBLY manufacturer unless specifically noted otherwise.

The purpose of the IEC 61439 series of standards is to harmonize as far as practicable, all the general rules and requirements that apply to ASSEMBLIES. The series further seeks, in order to obtain uniformity of requirements for ASSEMBLIES, consistency in the verification of ASSEMBLIES and to avoid the need for verification to other standards.

All those requirements for the various ASSEMBLIES that can be considered as general, together with specific subjects of wide interest and application, e.g. temperature rise, dielectric properties, have therefore been gathered in Part 1 of IEC 61439 as general rules. For each type of ASSEMBLY only two main standards are necessary to determine all requirements and the corresponding methods of verification:

1) the standard giving the general rules and designated "Part 1", and
2) the specific ASSEMBLY standard, hereinafter referred to as the relevant ASSEMBLY standard.

The IEC 61439 series of standards encompasses ASSEMBLIES for a wide variety of uses, some of which have specific needs as dictated by their particular application. In order to define clearly these specific needs, relevant ASSEMBLY standards focussed on a particular type of application have been (or are being) developed. These are identified as IEC 61439-2 to IEC 61439-6, inclusive (see list below). Each relevant ASSEMBLY standard with reference to IEC 61439-1, the general rules, as appropriate, specifies the characteristics and performance required by an ASSEMBLY within its defined scope of application. Each relevant ASSEMBLY standard includes, as an annex, a template for "items subject to agreement between the ASSEMBLY manufacturer and the user" to facilitate the specifying of an ASSEMBLY. These are reproduced and explained in this technical report.

Within this technical report, reference to IEC 61439 means the series of ASSEMBLY standards, including:

- IEC 61439-1(2009), *Low-voltage switchgear and controlgear assemblies – Part 1:General rules*
- IEC 61439-2(2009), *Low-voltage switchgear and controlgear assemblies – Part 2:Power switchgear and controlgear assemblies*
- IEC 61439-3 (in preparation), *Low-voltage switchgear and controlgear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO)* (to supersede IEC 60439-3)
- IEC 61439-4 (in consideration), *Low-voltage switchgear and controlgear assemblies – Part 4: Assemblies for construction sites* (to supersede IEC 60439-4)
- IEC 61439-5 (to be published), *Low-voltage switchgear and controlgear assemblies – Part 5:Assemblies for power distribution in public networks* (to supersede IEC 60439-5)
- IEC 61439-6 (in preparation), *Low-voltage switchgear and controlgear assemblies – Part 6:Busbar trunking systems (busways)* (to supersede IEC 60439-2)

A reference to "general rules" means a reference to IEC 61439-1(2009).

A reference to "ASSEMBLY standard" means the relevant part of the IEC 61439 series (e.g. Part 2, 3, etc.).

A reference to "product standard" means the relevant part or parts of the IEC standard for the components used in the ASSEMBLY (e.g. IEC 60947-2 for circuit breakers).

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES –

Part 0: Guidance to specifying assemblies

1 Scope

Within the IEC 61439 series of standards for low-voltage switchgear and controlgear assemblies (ASSEMBLIES), there are system and application details that need to be specified by the user to enable the manufacturer to produce an ASSEMBLY that meets the needs and expectations of the user. This technical report identifies, from the user's perspective, those functions and characteristics that should be defined when specifying ASSEMBLIES. It provides:

– an explanation of the ASSEMBLY characteristics and options within the IEC 61439 series;

– a guidance on how to select the appropriate option and to define characteristics so as to meet specific application needs, using a functional approach; and

– an assistance in the specification of ASSEMBLIES.

References within this technical report to the interface characteristics of an ASSEMBLY and the requirements with which they will comply assume that the ASSEMBLY is designed, manufactured, and verified in accordance with the relevant IEC 61439 standard.

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.

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

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

IEC 60364-6, *Low-voltage electrical installations – Part 6: Verification*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

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

IEC 61439-1:2009, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the relevant ASSEMBLY standard apply (e.g. IEC 61439-2).

4 Application of ASSEMBLIES within the IEC 61439 series

4.1 General

ASSEMBLIES manufactured in accordance with the relevant ASSEMBLY standard of the IEC 61439 series of standards are suitable for installation in the majority of operating environments. Many of the characteristics of ASSEMBLIES are fully defined within the standard and do not require further consideration by the user. In some instances there may be a default condition specified within the standard and a range of other identified alternative options, from which the user may choose to suit the application. For other characteristics, the user may be required to choose from a list of options within the standard.

Where special and exceptionally onerous conditions exist, the user should identify these in their specification. Examples of these onerous conditions include: high UV radiation applications, conditions of high particulates/pollutants, more stringent short circuit conditions, special fault protection, special protection due to risk of fire, explosions, burns, etc.

In some instances, the user may wish to seek the advice of experts in order to identify their requirements correctly, e.g. with regard to system harmonics.

The annexes from Annex C onward provide specification templates that the user should complete when defining the interface characteristics and application requirements for an ASSEMBLY in accordance with the relevant ASSEMBLY standard. An explanation of each interface characteristic is given in the subsequent clauses.

4.2 ASSEMBLY design and verification

An ASSEMBLY is intended to be used within an electrical installation of defined characteristics. The ASSEMBLY may be designed and verified with a specific set of application criteria, to suit a particular use, or more usually, it may be designed and verified to meet typical application criteria that make it usable in a range of common applications.

The configuration for a particular user application of an ASSEMBLY usually requires four main steps:

a) definition or selection of service conditions and interface characteristics. The user should specify these characteristics;

b) design of the ASSEMBLY by the manufacturer to meet the arrangements, characteristics, and functions particular to the application. The design will generally be based on previously developed standard ASSEMBLY arrangements, characteristics, and functions;

c) for ASSEMBLIES or parts of ASSEMBLIES where the design is not previously proven, design verification carried out by the manufacturer;

d) routine verification, carried out on each ASSEMBLY by the manufacturer.

For further information on the design and routine verification carried out by the manufacturer, see Clause 14.

4.3 Service conditions and interface characteristics

The characteristics of the ASSEMBLY should be compatible with the ratings of the circuits to which it is connected and the installation conditions.

Where no user specification is provided, information given in the manufacturer's documentation may take the place of an agreement between the manufacturer and the user.

It is assumed that the user will provide an electrical single line diagram, or equivalent, to define the incoming and outgoing circuit arrangements, loads, external conductors, and selected interface characteristics that are required for the application of a specific ASSEMBLY.

4.4 Design

Once the user has specified any arrangements, characteristics, or functions particular to the application, the manufacturer is responsible for the design of the ASSEMBLY and ensuring it complies with the relevant ASSEMBLY standard in the IEC 61439 series. From the information provided by the user, the manufacturer will derive additional ASSEMBLY characteristics in order to provide an ASSEMBLY that fulfils the user's stated application requirements.

5 Electrical system

5.1 General

The electrical system includes all of the elements of the electrical network within which the ASSEMBLY is intended to operate. The electrical system determines the characteristics (capabilities) an ASSEMBLY should possess in order to perform its required duty safely. The characteristics of the ASSEMBLY should at all times be at least equal to the needs of the application and, where essential, they may exceed those offered in the standard options detailed in the IEC 61439 series.

The user should provide an electrical single line diagram and/or any other information necessary to define their requirements for the ASSEMBLY, as detailed in 5.2 to 5.6 below.

5.2 Earthing system

The means of earthing a low-voltage network, when, how and where, differs from application to application. For a particular network, the earthing system used may be dictated by local regulation, the supply authority, legacy requirements, or the benefits of one system relative to others.

The standard configurations of earthing system are TT, TN-C, TN-C-S, IT, TN-S. Specific systems require and/or permit different solutions. For example, during the isolation of a supply for maintenance:

- in TN-C systems, the PEN conductor is not permitted to be isolated or switched, but,
- in TN-S systems and TN-C-S systems the neutral conductors may or may not be isolated or switched (see IEC 60364-5-53, 536.1.2).

The design of the auxiliary circuits should take into account the supply earthing system to ensure that an earth-fault does not cause unintentional operation.

It is therefore essential that users specify the earthing system.

5.3 Nominal voltage

The nominal voltage of the electrical system determines a number of the ASSEMBLY characteristics.

The user should specify the nominal voltage of the system.

When provided with the nominal voltage, the manufacturer will determine the appropriate values for other voltages including:

- the rated operational voltage U_e (of a circuit of an ASSEMBLY)

This is the voltage at which all the devices in a circuit, or a group of circuits, are capable of performing a specified function, for example switching a particular load a given number of times. In all cases, the rated operational voltage will be at least equal to the rated voltage of the ASSEMBLY.

- the rated insulation voltage U_i

  Like U_e, the rated insulation voltage also applies to a circuit or group of circuits of the ASSEMBLY. It is the long-term voltage withstand capability of the insulation and is never less than the rated operational voltage. Generally an insulation voltage equal to the operational voltage is sufficient, but where particularly arduous conditions apply, a higher insulation voltage may be appropriate.

5.4 Overvoltage category (OVC)

All networks experience occasional transient overvoltages caused by switching, lightning, etc. Generally, within a low-voltage network, the magnitude of the overvoltages is reduced as the distance from the source of supply is increased. It is therefore possible to have ASSEMBLIES suitable for different levels of overvoltage as determined by their location in the electrical network.

Various levels of overvoltage category are defined using a series of roman numbers.

The overvoltage category (OVC) options are:

- Category I: Specially protected level (internal to equipment, not normally applicable to an ASSEMBLY)
- Category II: Load level (appliance, equipment, not normally applicable to an ASSEMBLY)
- Category III: Distribution circuit level (typical industrial applications)
  Examples: Equipment which is part of the fixed electrical installation and other equipment where a high degree of availability is expected, e.g. distribution boards, motor control centres.
- Category IV: Origin of installation level (service entrance)
  Examples: Equipment to be used at or in the proximity of the origin of the electrical installation upstream of the main distribution board, e.g. electricity meter, primary overcurrent protective device.

The manufacturer will determine the likely overvoltage category from the electrical system, single line diagram. Where exceptional overvoltage conditions apply, the user should specify the required overvoltage category option for his application.

From the overvoltage category, the nominal voltage and the type of electrical supply system the manufacturer will determine the appropriate values for the rated impulse withstand voltage (U_{imp}). This relationship is illustrated for information in Figure 1.

The rated impulse withstand voltage U_{imp} is a measure of the ASSEMBLY's tolerance to transient overvoltages. In normal networks, it will be equal to or higher than the transient overvoltages occurring in the system(s) to which the circuit is designed to be connected.

5.5 Unusual voltage transients, temporary overvoltages

The ASSEMBLY will be capable of withstanding:

- transient overvoltage – short duration overvoltage of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped, and
- temporary overvoltage – overvoltage at power frequency of relatively long duration (several seconds).

The rated impulse withstand voltage (U_{imp}) defines the transient overvoltage to be withstood, ranging from 0,33 kV to 12 kV.

The rated insulation voltage (U_i) defines the level of temporary overvoltage to be withstood.

If unusual voltage transients or temporary overvoltages are anticipated, the user should specify the conditions to be met. Where such unusual conditions apply, it is important that they are identified in order that the appropriate ASSEMBLY can be provided. (Guidance is provided e.g. in IEC 61643-12 for transient overvoltages.)

5.6 Rated frequency f_n (Hz)

ASSEMBLIES are designed to operate at a particular (rated) frequency or over a range of frequencies. Connecting a circuit of an ASSEMBLY to a supply with a frequency outside its intended range can result in devices not operating correctly, altered interrupting capacity and in the case of higher current, the current carrying ability may be affected. Standard frequencies are 50 Hz, and 60 Hz.

Unless otherwise stated, the manufacturer of the ASSEMBLY will assume it is suitable for a frequency within the limits of 98 % to 102 % of the rated frequency.

The user should specify the nominal frequency of the system as the required rated frequency of the ASSEMBLY. If any of the circuits within the ASSEMBLY are required to operate at different frequencies, this should be identified accordingly by the user in the specification.

5.7 Additional on-site testing requirements: wiring, operational performance and function

The routine verification is intended to detect faults in materials and workmanship, to confirm an ASSEMBLY has been manufactured in accordance with the design specification and to ascertain proper functioning of the complete ASSEMBLY. It is made on each ASSEMBLY normally at the manufacturer's premises.

ASSEMBLIES do not require any on-site testing to re-confirm the integrity of the ASSEMBLY. In cases where the ASSEMBLIES are delivered in sections, the manufacturer may recommend tests to confirm the ASSEMBLY has been correctly coupled on site.

IEC 60364-6 defines on-site verification to check the correct integration of the ASSEMBLY into the electrical system. Where additional on-site testing by the manufacturer is required, the user should specify these tests.

6 Short-circuit withstand capability

6.1 General

Short-circuits within correctly designed and managed networks are a very rare occurrence, but when they occur, they place abnormal demands on ASSEMBLIES. Short-circuit currents and short-circuit current breaking may cause different kinds of stresses:

- extremely high forces between conductors,
- very high temperature rise in a very short time,
- air ionisation due to arc breaking, resulting in lower air insulation,
- overpressure due to arc breaking, resulting in high forces applied to the enclosure.

ASSEMBLIES should be capable of withstanding the thermal and dynamic stresses resulting from short-circuit currents emanating from the supplies to which they are connected.

Unless otherwise specified in the manufacturer's operating and maintenance instructions, ASSEMBLIES that have been subjected to a short-circuit should be subject to inspection and/or maintenance by skilled personnel to determine the suitability of the ASSEMBLY for further service.