

TECHNICAL REPORT



A method of temperature-rise verification of low-voltage switchgear and controlgear assemblies by calculation

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.130.20

ISBN 978-2-8322-5822-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD	5
INTRODUCTION	7
1 Scope	8
2 Normative references	8
3 Terms and definitions	9
4 Verification conditions for application	9
5 Calculation method	10
5.1 Assumptions made in this calculation	10
5.2 Necessary information	10
5.3 Calculation procedure	11
5.3.1 General	11
5.3.2 Determination of the effective cooling surface A_e of the enclosure	11
5.3.3 Determination of the internal temperature-rise $\Delta t_{0,5}$ of the air at mid-height of the enclosure	11
5.3.4 Determination of the internal temperature-rise $\Delta t_{1,0}$ of air at the top of the enclosure	11
5.3.5 Characteristic curve for temperature-rise of air inside enclosure	12
5.4 Maximum internal air temperature limits	14
6 Further considerations	14
6.1 General	14
6.2 Guidance on the effects of an uneven power distribution	14
6.3 Guidance on the additional temperature-rise effect due to solar radiation	14
7 Evaluation of the design	15
Annex A (informative) Examples for the calculation of the temperature-rise of air inside enclosures	34
A.1 Example 1	34
A.2 Example 2	38
Annex B (informative) Guidance on the effects of an uneven power distribution	43
B.1 Horizontal partition	43
B.2 Calculation of internal air temperature-rise for assemblies with ventilation openings with even power distribution and less than 50 % perforation in horizontal partitions	43
B.3 Calculation of internal air temperature-rise with an uneven power distribution	44
Annex C (informative) Guidance on the additional temperature-rise effect due to solar radiation	45
C.1 General	45
C.2 Solar radiation phenomena	45
C.3 Solar radiation – consequences for thermal calculation	46
C.4 Solar radiation of enclosures with air ventilation openings	47
Annex D (informative) Guidance on the effect of different enclosure materials, construction and finishes	48
D.1 General	48
D.2 Validity criteria	48
D.3 Material of enclosure	48
D.4 Results	48

Annex E (informative) Guidance on the effects of different natural ventilation arrangements.....	50
Annex F (informative) Guidance on forced ventilation management	52
F.1 General.....	52
F.2 Forced ventilation installation system.....	52
F.3 Installation considerations.....	52
Annex G (informative) Power loss values calculation	54
G.1 General.....	54
G.2 Power losses of low-voltage switchgear and controlgear	54
G.3 Power losses of conductors connecting low-voltage switchgear and controlgear	54
G.4 Power losses of busbars	55
G.5 Power losses of electronic devices.....	55
Annex H (informative) Guidance on the impact of an adjacent wall on the assembly cooling surfaces.....	56
Annex I (informative) Operating current and power losses of copper conductors	58
Annex J (informative) Guidance to magnetic and eddy-current power losses.....	63
Annex K (informative) Forced ventilation airflow calculation	64
K.1 General.....	64
K.2 Ventilation airflow calculation	65
Bibliography.....	67

Figure 1 – Temperature-rise characteristic curve for enclosures with A_e exceeding $1,25 \text{ m}^2$	13
Figure 2 – Temperature-rise characteristic curve for enclosures with A_e not exceeding $1,25 \text{ m}^2$	13
Figure 3 – Enclosure constant k for enclosures without ventilation openings, with an effective cooling surface $A_e > 1,25 \text{ m}^2$	19
Figure 4 – Temperature distribution factor c for enclosures without ventilation openings and with an effective cooling surface $A_e > 1,25 \text{ m}^2$	21
Figure 5 – Enclosure constant k for enclosures with ventilation openings and an effective cooling surface $A_e > 1,25 \text{ m}^2$	23
Figure 6 – Temperature distribution factor c for enclosures with ventilation openings and an effective cooling surface $A_e > 1,25 \text{ m}^2$	25
Figure 7 – Enclosure constant k for enclosures without ventilation openings and with an effective cooling surface $A_e \leq 1,25 \text{ m}^2$	28
Figure 8 – Temperature distribution factor c for enclosures without ventilation openings and with an effective cooling surface $A_e \leq 1,25 \text{ m}^2$	30
Figure 9 – Calculation of temperature-rise of air inside enclosures	33
Figure A.1 – Example 1, calculation for an enclosure with exposed side faces without ventilation openings and without internal horizontal partitions	34
Figure A.2 – Example 1, calculation for a single enclosure.....	37
Figure A.3 – Example 2, calculation for an enclosure for wall-mounting with ventilation openings.....	38
Figure A.4 – Example 2, calculation for one enclosure half	39

Figure A.5 – Example 2, calculation for an enclosure for wall-mounting with ventilation openings.....	42
Figure B.1 – Examples of assemblies with horizontal partitions.....	43
Figure B.2 – Temperature-rise verification of a higher-power circuit.....	44
Figure C.1 – Solar radiation phenomena.....	45
Figure C.2 – Interpolation curve.....	46
Figure D.1 – Results of comparison tests.....	49
Figure E.1 – Examples of crossing diagonal installation.....	50
Figure E.2 – Effect of additional filters.....	51
Figure F.1 – Examples of forced ventilation arrangements.....	53
Figure H.1 – Wall-mounted assembly.....	56
Figure H.2 – Floor-standing assembly.....	57
Figure J.1 – Power losses distribution for different gland plates with the same rating.....	63
Table 1 – Method of calculation, application, formulas and characteristics.....	15
Table 2 – Symbols, units and designations.....	16
Table 3 – Surface factor b according to the type of installation.....	17
Table 4 – Factor d for enclosures without ventilation openings and with an effective cooling surface $A_e > 1,25 \text{ m}^2$	17
Table 5 – Factor d for enclosures with ventilation openings and an effective cooling surface $A_e > 1,25 \text{ m}^2$	17
Table 6 – Equation for Figure 3.....	19
Table 7 – Equations for Figure 4.....	21
Table 8 – Equations for Figure 5.....	23
Table 9 – Equations for Figure 6.....	26
Table 10 – Equation for Figure 7.....	28
Table 11 – Equation for Figure 8.....	30
Table C.1 – Approximate solar absorption radiation coefficients (according to colour).....	46
Table I.1 – Operating current and power loss of single-core copper cables with a permissible conductor temperature of 70 °C (ambient temperature inside the enclosure: 55 °C).....	59
Table I.2 – Reduction factor k_1 for cables with a permissible conductor temperature of 70 °C (extract from IEC 60364-5-52:2009, Table B.52.14).....	60
Table I.3 – Operating current and power loss of bare copper bars with rectangular cross-section, run horizontally and arranged with their largest face vertical, for DC and AC frequencies 16 2/3 Hz, 50 Hz to 60 Hz (ambient temperature inside the enclosure: 55 °C, temperature of the conductor 70 °C).....	61
Table I.4 – Factor k_4 for different temperatures of the air inside the enclosure and/or for the conductors.....	62
Table K.1 – Factor k for altitudes above sea level.....	65

INTERNATIONAL ELECTROTECHNICAL COMMISSION

A METHOD OF TEMPERATURE-RISE VERIFICATION OF LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES BY CALCULATION

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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TR 60890:2014. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

IEC TR 60890 has been prepared by subcommittee 121B: Low-voltage switchgear and controlgear assemblies, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low-voltage. It is a Technical Report.

This third edition cancels and replaces the second edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- alignment with IEC 61439-1:2020;
- addition of individual annexes for guidance of technical explanations related to:
 - effect of an uneven power distribution;
 - additional temperature-rise due to solar radiation;
 - effect of different enclosure materials;
 - effect of different natural ventilation management;
 - forced ventilation management;
 - power losses calculation;
 - impact of an adjacent wall can have on the assembly cooling surface(s);
- maximum internal ambient temperature limit into an assembly;
- validity area of the calculation extended from 3 150 A to 3 200 A;
- addition of an algebraic equation to the different curves included in the document.

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

Draft	Report on voting
121B/136/DTR	121B/147/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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
- amended.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

In the series of design verifications of IEC 61439-1 a temperature-rise verification of low-voltage power switchgear and controlgear assemblies ~~(hereafter called ASSEMBLIES)~~ is specified. This ~~may~~ can be by test, however, alternatives are acceptable under defined circumstances. Selection of the method used for temperature-rise verification is the responsibility of the original manufacturer. Where applicable this document ~~may~~ can also be used for temperature-rise verification of similar products in accordance with other standards (e.g. IEC 60204-1). The method of calculation can also be used to determine the thermal power dissipation capability of an enclosure in accordance with IEC 62208 for a given internal air temperature-rise. The factors and coefficients, set out in this document have been derived from measurements on numerous assemblies and the method has been verified by comparison with test results.

A METHOD OF TEMPERATURE-RISE VERIFICATION OF LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES BY CALCULATION

1 Scope

~~This Technical Report specifies a method of temperature-rise verification of low-voltage switchgear and controlgear assemblies by calculation.~~

~~The method is applicable to enclosed ASSEMBLIES or partitioned sections of ASSEMBLIES without forced ventilation. It is not applicable where temperature-rise verification to the relevant product standard of the IEC 61439 series has been established.~~

~~NOTE 1—The influence of the materials and wall thicknesses usually used for enclosures can have some effect on the steady-state temperatures. However, the generalised approach used in this technical report ensures it is applicable to enclosures made of sheet steel, sheet aluminium, cast iron, insulating material and the like.~~

~~The proposed method is intended to determine the temperature-rise of the air inside the enclosure.~~

~~NOTE 2—The air temperature within the enclosure is equal to the ambient air temperature outside the enclosure plus the temperature-rise of the air inside the enclosure caused by the power losses of the installed equipment.~~

~~Unless otherwise specified, the ambient air temperature outside the ASSEMBLY is the air temperature indicated for the installation (average value over 24 h) of 35 °C. If the ambient air temperature outside the assembly at the place of use exceeds 35 °C, this higher temperature is deemed to be the ambient air temperature.~~

This document specifies a method of air temperature-rise calculation inside enclosures for low-voltage switchgear and controlgear assemblies or similar products in accordance with their respective standard.

The method is primarily applicable to enclosed assemblies or partitioned sections of assemblies without forced ventilation. However, some technical guidance to adapt it for the use of forced ventilation is given in this document. The results obtained by using this method are directly influenced by the accuracy of the evaluation of power losses used as inputs to perform the thermal calculations.

NOTE The air temperature within the enclosure is equal to the ambient air temperature outside the enclosure plus the temperature-rise of the air inside the enclosure caused by the power losses of the installed equipment.

For the method to be applied, the maximum daily average ambient air temperature outside the assembly at the place of installation is specified between 10 °C and 50 °C. The maximum daily temperature does not exceed the maximum daily average temperature by more than 5 K.

Several annexes in this document provide guidance on how temperature-rise within assemblies can be affected by influences which are not considered in the calculation method included in this document, for example, when the assembly is subject to solar radiation. In such cases, different means of verification to that given in this document can be applied to ensure a definitive result and verification of the design.

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 61439-1:2011, Low-voltage switchgear and controlgear assemblies—Part 1: General rules~~

IEC 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEEE C37.24-2017, *IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear*

TECHNICAL REPORT



A method of temperature-rise verification of low-voltage switchgear and controlgear assemblies by calculation

CONTENTS

FOREWORD	5
INTRODUCTION	7
1 Scope	8
2 Normative references	8
3 Terms and definitions	8
4 Verification conditions	9
5 Calculation method	9
5.1 Assumptions made in this calculation	9
5.2 Necessary information	10
5.3 Calculation procedure	10
5.3.1 General	10
5.3.2 Determination of the effective cooling surface A_e of the enclosure	10
5.3.3 Determination of the internal temperature-rise $\Delta t_{0,5}$ of the air at mid-height of the enclosure	10
5.3.4 Determination of the internal temperature-rise $\Delta t_{1,0}$ of air at the top of the enclosure	11
5.3.5 Characteristic curve for temperature-rise of air inside enclosure	11
5.4 Maximum internal air temperature limits	13
6 Further considerations	13
6.1 General	13
6.2 Guidance on the effects of an uneven power distribution	13
6.3 Guidance on the additional temperature-rise effect due to solar radiation	14
7 Evaluation of the design	15
Annex A (informative) Examples for the calculation of the temperature-rise of air inside enclosures	26
A.1 Example 1	26
A.2 Example 2	29
Annex B (informative) Guidance on the effects of an uneven power distribution	33
B.1 Horizontal partition	33
B.2 Calculation of internal air temperature-rise for assemblies with ventilation openings with even power distribution and less than 50 % perforation in horizontal partitions	33
B.3 Calculation of internal air temperature-rise with an uneven power distribution	34
Annex C (informative) Guidance on the additional temperature-rise effect due to solar radiation	35
C.1 General	35
C.2 Solar radiation phenomena	35
C.3 Solar radiation – consequences for thermal calculation	36
C.4 Solar radiation of enclosures with air ventilation openings	37
Annex D (informative) Guidance on the effect of different enclosure materials, construction and finishes	38
D.1 General	38
D.2 Validity criteria	38
D.3 Material of enclosure	38
D.4 Results	38

Annex E (informative) Guidance on the effects of different natural ventilation arrangements.....	40
Annex F (informative) Guidance on forced ventilation management	42
F.1 General.....	42
F.2 Forced ventilation installation system.....	42
F.3 Installation considerations.....	42
Annex G (informative) Power loss values calculation	44
G.1 General.....	44
G.2 Power losses of low-voltage switchgear and controlgear	44
G.3 Power losses of conductors connecting low-voltage switchgear and controlgear	44
G.4 Power losses of busbars	45
G.5 Power losses of electronic devices.....	45
Annex H (informative) Guidance on the impact of an adjacent wall on the assembly cooling surfaces.....	46
Annex I (informative) Operating current and power loss of copper conductors.....	48
Annex J (informative) Guidance to magnetic and eddy-current power losses.....	53
Annex K (informative) Forced ventilation airflow calculation	54
K.1 General.....	54
K.2 Ventilation airflow calculation	55
Bibliography.....	57
Figure 1 – Temperature-rise characteristic curve for enclosures with A_e exceeding $1,25 \text{ m}^2$	12
Figure 2 – Temperature-rise characteristic curve for enclosures with A_e not exceeding $1,25 \text{ m}^2$	13
Figure 3 – Enclosure constant k for enclosures without ventilation openings, with an effective cooling surface $A_e > 1,25 \text{ m}^2$	18
Figure 4 – Temperature distribution factor c for enclosures without ventilation openings and with an effective cooling surface $A_e > 1,25 \text{ m}^2$	19
Figure 5 – Enclosure constant k for enclosures with ventilation openings and an effective cooling surface $A_e > 1,25 \text{ m}^2$	20
Figure 6 – Temperature distribution factor c for enclosures with ventilation openings and an effective cooling surface $A_e > 1,25 \text{ m}^2$	21
Figure 7 – Enclosure constant k for enclosures without ventilation openings and with an effective cooling surface $A_e \leq 1,25 \text{ m}^2$	22
Figure 8 – Temperature distribution factor c for enclosures without ventilation openings and with an effective cooling surface $A_e \leq 1,25 \text{ m}^2$	23
Figure 9 – Calculation of temperature-rise of air inside enclosures	25
Figure A.1 – Example 1, calculation for an enclosure with exposed side faces without ventilation openings and without internal horizontal partitions	26
Figure A.2 – Example 1, calculation for a single enclosure.....	28
Figure A.3 – Example 2, calculation for an enclosure for wall-mounting with ventilation openings.....	29
Figure A.4 – Example 2, calculation for one enclosure half	30

Figure A.5 – Example 2, calculation for an enclosure for wall-mounting with ventilation openings.....	32
Figure B.1 – Examples of assemblies with horizontal partitions.....	33
Figure B.2 – Temperature-rise verification of a higher-power circuit.....	34
Figure C.1 – Solar radiation phenomena.....	35
Figure C.2 – Interpolation curve.....	36
Figure D.1 – Results of comparison tests.....	39
Figure E.1 – Examples of crossing diagonal installation.....	40
Figure E.2 – Effect of additional filters.....	41
Figure F.1 – Examples of forced ventilation arrangements.....	43
Figure H.1 – Wall-mounted assembly.....	46
Figure H.2 – Floor-standing assembly.....	47
Figure J.1 – Power losses distribution for different gland plates with the same rating.....	53
Table 1 – Method of calculation, application, formulas and characteristics.....	15
Table 2 – Symbols, units and designations.....	16
Table 3 – Surface factor b according to the type of installation.....	17
Table 4 – Factor d for enclosures without ventilation openings and with an effective cooling surface $A_e > 1,25 \text{ m}^2$	17
Table 5 – Factor d for enclosures with ventilation openings and an effective cooling surface $A_e > 1,25 \text{ m}^2$	17
Table 6 – Equation for Figure 3.....	18
Table 7 – Equations for Figure 4.....	19
Table 8 – Equations for Figure 5.....	20
Table 9 – Equations for Figure 6.....	22
Table 10 – Equation for Figure 7.....	23
Table 11 – Equation for Figure 8.....	24
Table C.1 – Approximate solar absorption radiation coefficients (according to colour).....	36
Table I.1 – Operating current and power loss of single-core copper cables with a permissible conductor temperature of 70 °C (ambient temperature inside the enclosure: 55 °C).....	49
Table I.2 – Reduction factor k_1 for cables with a permissible conductor temperature of 70 °C (extract from IEC 60364-5-52:2009, Table B.52.14).....	50
Table I.3 – Operating current and power loss of bare copper bars with rectangular cross-section, run horizontally and arranged with their largest face vertical, for DC and AC frequencies 16 2/3 Hz, 50 Hz to 60 Hz (ambient temperature inside the enclosure: 55 °C, temperature of the conductor 70 °C).....	51
Table I.4 – Factor k_4 for different temperatures of the air inside the enclosure and/or for the conductors.....	52
Table K.1 – Factor k for altitudes above sea level.....	55

INTERNATIONAL ELECTROTECHNICAL COMMISSION

A METHOD OF TEMPERATURE-RISE VERIFICATION OF LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES BY CALCULATION

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.

IEC TR 60890 has been prepared by subcommittee 121B: Low-voltage switchgear and controlgear assemblies, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low-voltage. It is a Technical Report.

This third edition cancels and replaces the second edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- alignment with IEC 61439-1:2020;
- addition of individual annexes for guidance of technical explanations related to:
 - effect of an uneven power distribution;
 - additional temperature-rise due to solar radiation;
 - effect of different enclosure materials;
 - effect of different natural ventilation management;
 - forced ventilation management;

- power losses calculation;
- impact of an adjacent wall can have on the assembly cooling surface(s);
- maximum internal ambient temperature limit into an assembly;
- validity area of the calculation extended from 3 150 A to 3 200 A;
- addition of an algebraic equation to the different curves included in the document.

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

Draft	Report on voting
121B/136/DTR	121B/147/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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
- amended.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

In the series of design verifications of IEC 61439-1 a temperature-rise verification of low-voltage power switchgear and controlgear assemblies is specified. This can be by test, however, alternatives are acceptable under defined circumstances. Selection of the method used for temperature-rise verification is the responsibility of the original manufacturer. Where applicable this document can also be used for temperature-rise verification of similar products in accordance with other standards (e.g. IEC 60204-1). The method of calculation can also be used to determine the thermal power dissipation capability of an enclosure in accordance with IEC 62208 for a given internal air temperature-rise. The factors and coefficients, set out in this document have been derived from measurements on numerous assemblies and the method has been verified by comparison with test results.

A METHOD OF TEMPERATURE-RISE VERIFICATION OF LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES BY CALCULATION

1 Scope

This document specifies a method of air temperature-rise calculation inside enclosures for low-voltage switchgear and controlgear assemblies or similar products in accordance with their respective standard.

The method is primarily applicable to enclosed assemblies or partitioned sections of assemblies without forced ventilation. However, some technical guidance to adapt it for the use of forced ventilation is given in this document. The results obtained by using this method are directly influenced by the accuracy of the evaluation of power losses used as inputs to perform the thermal calculations.

NOTE The air temperature within the enclosure is equal to the ambient air temperature outside the enclosure plus the temperature-rise of the air inside the enclosure caused by the power losses of the installed equipment.

For the method to be applied, the maximum daily average ambient air temperature outside the assembly at the place of installation is specified between 10 °C and 50 °C. The maximum daily temperature does not exceed the maximum daily average temperature by more than 5 K.

Several annexes in this document provide guidance on how temperature-rise within assemblies can be affected by influences which are not considered in the calculation method included in this document, for example, when the assembly is subject to solar radiation. In such cases, different means of verification to that given in this document can be applied to ensure a definitive result and verification of the design.

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 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEEE C37.24-2017, *IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear*