IEC TR 60890

Edition 2.0 2014-05

TECHNICAL REPORT

RAPPORT TECHNIQUE

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

Méthode de vérification par calcul des échauffements pour les ensembles d'appareillage à basse tension

IEC TR 60890:2014-05(en-fr)

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

FOREWORD

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IEC/TR 60890, 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.

This second edition cancels and replaces the first edition published in 1987 and its Amendment 1:1995. It constitutes a technical revision.

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

– alignment with IEC 61439-1:2011;
– revision of Annex B;
– general editorial review.

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

Enquiry draft	Report on voting
17D/490/DTR	17D/499/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.

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- withdrawn,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.

INTRODUCTION

In IEC 61439-1, in the series of design verifications, a temperature-rise verification of low-voltage power switchgear and controlgear assemblies (hereafter called ASSEMBLIES) is specified. This may be by test, however, alternatives are acceptable in defined circumstances. Selection of the method used for temperature rise verification is the responsibility of the original manufacturer. Where applicable this technical report may also be used for temperature rise verification of similar products in accordance with other standards. The factors and coefficients, set out in this report 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.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61439-1 apply.

4 Conditions for application

This method of calculation is only applicable if the following conditions are fulfilled:

– the power loss data for all built in components is available;
– there is an approximately even distribution of power losses inside the enclosure;
– the installed equipment is so arranged that air circulation is not significantly impeded;
– the equipment installed is designed for direct current or alternating current up to and including 60 Hz with the total of supply currents not exceeding 3 150 A;
– conductors carrying currents in excess of 200 A, and the adjacent structural parts are so arranged that eddy-current and hysteresis losses are minimised;
– for enclosures with natural ventilation, the cross-section of the air outlet openings is at least 1,1 times the cross-section of the air inlet openings;

– there are no more than three horizontal partitions in the ASSEMBLY or in a section of it;
– where enclosures with external ventilation openings have compartments, the surface of the ventilation openings in each horizontal partition shall be at least 50 % of the horizontal cross-section of the compartment.

5 Calculation

5.1 Necessary information

The following data is needed to calculate the temperature rise of the air inside an enclosure:

– dimensions of the enclosure: height/width/depth;
– the type of installation of the enclosure according to Figure 4;
– design of enclosure, i.e. with or without ventilation openings;
– number of internal horizontal partitions;
– effective power loss of equipment installed in the enclosure;
– effective power losses (P_v) of conductors according to Annex B.

NOTE The effective power losses of the equipment installed in the circuits of the ASSEMBLY used for this calculation are the power losses at the rated currents of the various circuits.

5.2 Calculation procedure

5.2.1 General

For the enclosures specified in columns 4 and 5 of Table 1, the calculation of the temperature rise of the air inside the enclosures is carried out using the formulae laid down in columns 1 to 3 of Table 1.

The pertinent factors and exponents (characteristics) are obtained from columns 6 to 10 of Table 1.

The symbols, units and designations are to be taken from Table 2.

For enclosures having more than one section with vertical partitions the temperature rise of the air inside the enclosure shall be determined separately for each section.

Where enclosures without vertical partitions or individual sections have an effective cooling surface greater than 11,5 m^2 or a width greater than about 1,5 m, they should be divided for the calculation into fictitious sections, whose dimensions approximate to the foregoing values.

NOTE The form (see Figure 9) can be used as a calculation aid.

5.2.2 Determination of the effective cooling surface A_e of the enclosure

The calculation is carried out according to Formula (1) in column 1 of Table 1.

The effective cooling surface A_e of an enclosure is the sum of the individual surfaces A_o multiplied by the surface factor b. This factor takes into account the heat dissipation of the individual surfaces according to the type of installation of the enclosure.

5.2.3 Determination of the internal temperature rise $\Delta t_{0,5}$ of the air at mid-height of the enclosure

The calculation is carried out according to Formula (2) in column 2 of Table 1.

In Formula (2) the enclosure constant k allows for the size of the effective cooling surface for enclosures without ventilation openings and, in addition, for the cross-section of the air inlet openings for enclosures with ventilation openings.

The dependence of the temperature rises occurring in the enclosure on the effective power loss P is expressed by the exponent x.

The factor d allows for the dependence of the temperature rise on the number of internal horizontal partitions.

5.2.4 Determination of the internal temperature rise $\Delta t_{1,0}$ of air at the top of the enclosure

The calculation is made according to Formula (3) in column 3 of Table 1.

Factor c allows for the temperature distribution inside an enclosure. Its determination varies with the design and installation of the ASSEMBLY as follows:

a) For enclosures without ventilation openings and with an effective cooling surface:

$$A_e > 1{,}25\ \text{m}^2$$

The factor c from Figure 4, depends on the type of installation and the height/base factor f, where:

$$f = \frac{h^{1{,}35}}{A_b}$$

b) For enclosures with ventilation openings and with an effective cooling surface:

$$A_e > 1{,}25\ \text{m}^2$$

The factor c from Figure 6, depends on the cross-section of air inlet openings and the height/base factor f, where:

$$f = \frac{h^{1{,}35}}{A_b}$$

c) For enclosures without ventilation openings and with an effective cooling surface:

$$A_e \leq 1{,}25\ \text{m}^2$$

The factor c from Figure 8, depends on the height/width factor g, where:

$$g = \frac{h}{w}$$

where

h is the enclosure height, in m;

A_b is the surface area of the enclosure base, in m^2;

w is the enclosure width, in m.

5.2.5 Characteristic curve for temperature rise of air inside enclosure

5.2.5.1 General

To evaluate the design according to Clause 6, it is necessary to apply the calculated results of 5.2.3 and 5.2.4 with the proper characteristic curve for temperature rise of air inside the enclosure as a function of the enclosure height. The air temperatures within horizontal levels are practically constant.

5.2.5.2 Temperature-rise characteristic curve for enclosures with an effective cooling surface A_e exceeding 1,25 m²

As a general rule, the characteristic curve of temperature rise is adequately well defined by a straight line which runs through the points $\Delta t_{1,0}$ and $\Delta t_{0,5}$ (see Figure 1).

The internal air temperature rise at the bottom of the enclosure is close to zero, i.e. the characteristic curve flattens out towards zero. In practice, the dotted part of the characteristic curve is of secondary importance.

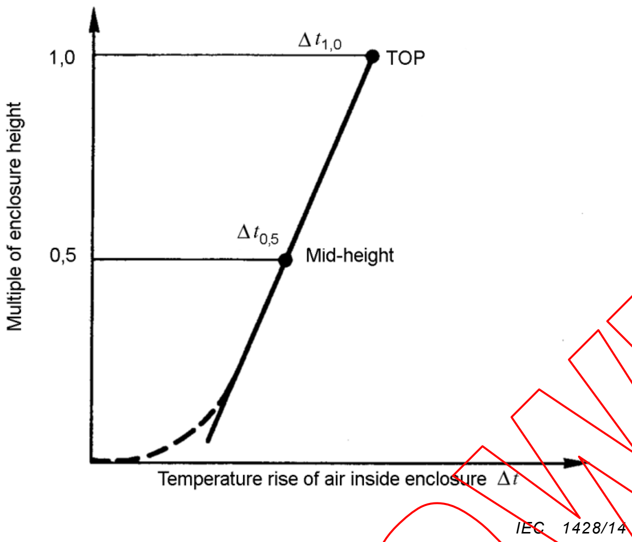

Figure 1 – Temperature-rise characteristic curve for enclosures with A_e exceeding 1,25 m²

5.2.5.3 Temperature rise characteristic curve for enclosures with an effective cooling surface A_e not exceeding 1,25 m²

For this type of enclosure, the maximum temperature rise in the upper quarter is constant and the values for $\Delta t_{1,0}$ and $\Delta t_{0,75}$ are identical (see Figure 2).

The characteristic curve is obtained by connecting the temperature-rise values at an enclosure level of 0,75 and 0,5 (see Figure 2).

The internal air temperature rise at the bottom of the enclosure is close to zero, i.e. the characteristic curve flattens out towards zero. In practice, the dotted part of the characteristic curve is of secondary importance.

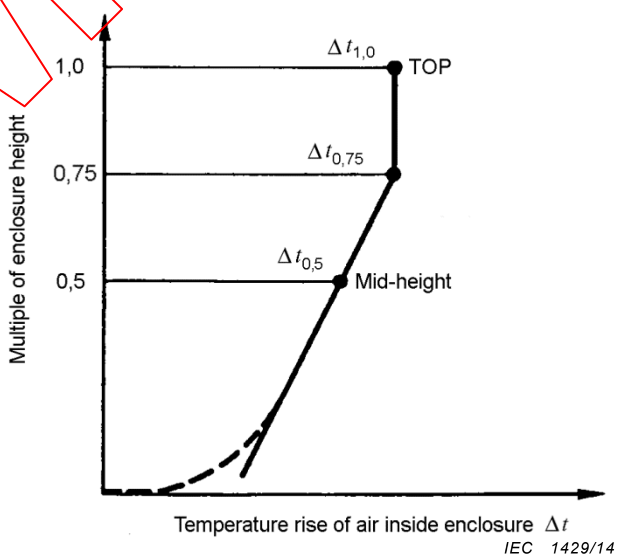

Figure 2 – Temperature-rise characteristic curve for enclosures with A_e not exceeding 1,25 m²

6 Evaluation of the design

It shall be determined whether the equipment within the ASSEMBLY can operate satisfactorily at the relevant calculated temperature rise.

If it is not so, the parameters will have to be changed and the calculation repeated.

Table 1 – Method of calculation, application, formulae and characteristics

1	2	3	4	5	6	7	8	9	10	11
Calculation formulae			Enclosure		Characteristics					Characteristic curve
Effective cooling surface A_e	Temperature rise of air		Effective cooling surface A_e		Factors				Exponent	Plotting of temperature-rise characteristics
	At mid-height of the enclosure	At (internal) top of enclosure			b see	k see	d see	c see	x	
$A_e = \Sigma (A_o \times b)$ (1)	$\Delta t_{0,5} = k \times d \times P^x$ (2)	$\Delta t_{1,0} = c \times \Delta t_{0,5}$ (3)	>1,25 m²	Enclosure without ventilation openings	Table 3	Figure 3	Table 4	Figure 4	0,804	See 5.2.5.2
				Enclosure with ventilation openings		Figure 5	Table 5	Figure 6	0,715	
			<1,25 m²	Enclosure without ventilation openings		Figure 7	–	Figure 8	0,804	See 5.2.5.3

For symbols, units and designations, see Table 2.

Table 2 – Symbols, units and designations

Symbol	Unit	Designation
A_o	m^2	Surfaces of external sides of enclosure
A_b	m^2	Enclosure base surface
A_e	m^2	Effective cooling surface of enclosure
b	–	Surface factor
c	–	Temperature distribution factor
d	–	Temperature-rise factor for internal horizontal partitions inside enclosure
f	–	Height/base factor
g	–	Height/width factor
h	m	Enclosure height
k	–	Enclosure constant
n	–	Number of internal horizontal partitions (up to three partitions)
P	W	Effective power loss of equipment installed inside enclosure
P_V	W	Effective power losses of conductors
w	m	Enclosure width
x	–	Exponent
A_t	K	Temperature rise of air inside enclosure in general
$\Delta t_{0,5}$	K	Temperature rise of air at (internal) mid-height of enclosure
$\Delta t_{0,75}$	K	Temperature rise of air at (internal) 3/4 height of enclosure
$\Delta t_{1,0}$	K	Temperature rise of air at (internal) top of enclosure

Table 3 – Surface factor b according to the type of installation

Type of installation	Surface factor b
Exposed top surface	1,4
Covered top surface, e.g. of built-in enclosures	0,7
Exposed side faces, e.g. front, rear and side walls	0,9
Covered side faces, e.g. rear side of wall-mounted enclosures	0,5
Side faces of central enclosures	0,5
Floor surface	not taken into account
Fictitious side faces of sections (see 5.2) which have been introduced only for calculation purposes are not taken into account	

Table 4 – Factor d for enclosures without ventilation openings and with an effective cooling surface A_e>1,25 m^2

Number of horizontal partitions n	0	1	2	3
Factor d	1,00	1,05	1,15	1,30

Table 5 – Factor d for enclosures with ventilation openings and an effective cooling surface A_e>1,25 m^2

Number of horizontal partitions n	0	1	2	3
Factor d	1,00	1,05	1,10	1,15