

Australian Standard[®]

**A method of temperature-rise
assessment by extrapolation for
partially type-test assemblies (PTTA) of
low-voltage switchgear and controlgear
(IEC 60890, Ed. 1.0 (1987) MOD)**



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 - Australian Chamber of Commerce and Industry
 - Australian Electrical and Electronic Manufacturers Association
 - Bureau of Steel Manufacturers of Australia
 - Engineers Australia
 - National Electrical Switchboard Manufacturers Association
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-

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A method of temperature-rise assessment by extrapolation for partially type-test assemblies (PTTA) of low-voltage switchgear and controlgear (IEC 60890, Ed. 1.0 (1987) MOD)

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-006, Industrial Switchgear and Controlgear, to supersede AS 4388—1996, *A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear*, from the date of publication.

The objective of this Standard is to provide Australian and New Zealand electrical industries with methods to determine the temperature rise of air inside low-voltage switchgear and switchgear assemblies by extrapolation of results obtained by tests carried out on other assemblies.

This Standard was revised to introduce a new Annex ZA, which contains information on operating current, power loss and advisable maximum temperatures of copper busbars.

This Standard is an adoption with national modifications and has been reproduced from, IEC/TR 60890, Ed. 1.0 (1987), *A method of temperature-rise assessment by extrapolation for partially-tested assemblies (PTTA) of low-voltage switchgear and controlgear*, including its Corrigendum: 1988 and Amendment 1:1995, and has been varied as indicated to take account of Australian/New Zealand conditions.

Variations to IEC/TR 60890, Ed. 1.0 (1987) are indicated at the appropriate places throughout this standard. Strikethrough (~~example~~) identifies IEC text, tables and figures that, for the purposes of this Australian Standard, are deleted. Where text, tables or figures are added, each is set in its proper place and identified by shading (example). Added figures are not themselves shaded, but are identified by a shaded border.

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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.

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NOTES

STANDARDS AUSTRALIA

Australian Standard
A method of temperature-rise assessment by extrapolation for partially type-test assemblies (PTTA) of low-voltage switchgear and controlgear (IEC 60890, Ed. 1.0 (1987) MOD)

Any table, figure or text of the international standard that is struck through is not part of this standard. Any Australian/New Zealand table, figure or text that is added is part of this standard and is identified by shading.

1 Introduction

In IEC Publication 60439-1, in the series of type tests, a temperature-rise is specified. However, for certain types of assemblies for which the performance of a temperature-rise test is either not feasible or economically not justifiable a calculation of the temperature rise in the form of extrapolation from data found by tests on other assemblies may be made instead. Such assemblies are then called partially type-tested assemblies (PTTA).

Various methods of calculations can be conceived and are acceptable. 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. The method described in this report is therefore one possible method and may for partially type-tested assemblies be used to prove compliance with the requirements of sub-clauses 8.2.1 of IEC Publication 60439-1. This report applies to PTTAs only.

2 Scope

The following method is applicable to enclosed PTTA or partitioned sections of PTTA without forced ventilation.

NOTE 1 - The influence of the materials and wall thickness usually used for enclosures are negligible on the steady state temperatures. The method is therefore applicable to enclosures made of sheet steel, sheet aluminium, cast iron, insulating material and the like.

NOTE 2 - For open-type and dead-front PTTA, no temperature-rise assessment is needed if it is obvious that no excessive air temperatures are likely to arise.

3 Object

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

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.

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

4 Conditions for application

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

- there is an approximately even distribution of power losses inside the enclosure;

- the installed equipment is so arranged that air circulation is but little 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 3150 A;
- conductors carrying high currents and structural parts are so arranged that eddy-current losses are negligible;
- for enclosures with ventilating openings, 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 PTTA or a section of it;
- where enclosures with external ventilating openings have compartments, the surface of the ventilating 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 are 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, for example, with or without ventilation openings;
- number of internal horizontal partitions;
- effective power loss of equipment installed in the enclosure;
- effective power loss (P_n) of conductors according to Annex B.

NOTE - The effective power losses of the equipment installed in the circuits of the PTTA used for this calculation are the power losses at the rated currents of the various circuits to be taken from information provided by the manufacturer.

5.2 Calculation procedure

For the enclosure specified in columns 4 and 5 of Table 1, the calculations 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 I.

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

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

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 11.5m^2 or a width greater than about 1.5m, they should be divided for the calculation into fictitious sections, whose dimensions approximate to the foregoing values.

NOTE - The form shown on page 12 may be used as an aid in calculation.

5.2.1 Determination of the effective cooling surface A_e of the enclosure

The calculation carried out according to formula (1) in column 1 of Table I.

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.

5.2.2 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 I.

The 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 ventilating 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.

5.2.3 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 I.

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 metres

A_b is the surface area of the enclosure base, in square metres

w is the enclosure width, in metres

5.2.4 Characteristic curve for temperature rise of air inside enclosure

To evaluate the design according to clause 6, it is necessary to apply the calculated results of sub-clauses 5.2.2 and 5.2.3 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.

5.2.4.1 Temperature-rise characteristic curve for enclosures with an effective cooling surface A_e exceeding 1.25m^2

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, so that the characteristics curve flattens out towards zero. (In practice, the dotted part of the characteristic curve is of secondary importance).

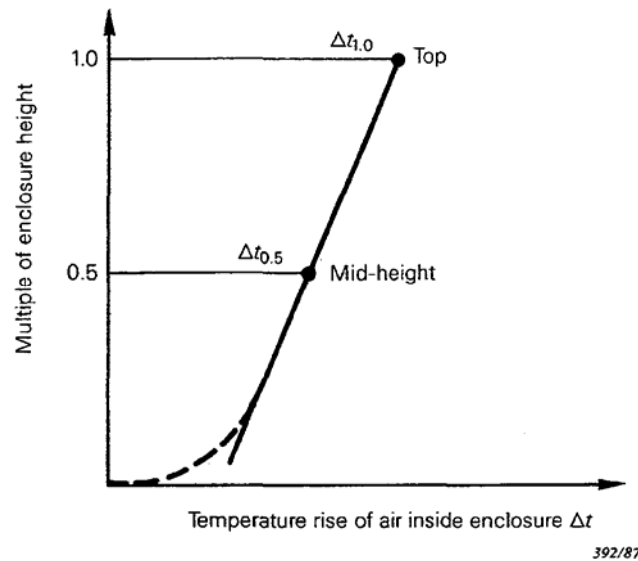


Figure 1 - Temperature-rise characteristic curve for enclosures with A_e exceeding 1.25m^2

5.2.4.2 Temperature-rise characteristic curve for enclosures with an effective cooling surface A_e not exceeding 1.25m^2

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, so that the characteristic curve flattens out towards zero. (In practice, the dotted part of the characteristic curve is of secondary importance.)

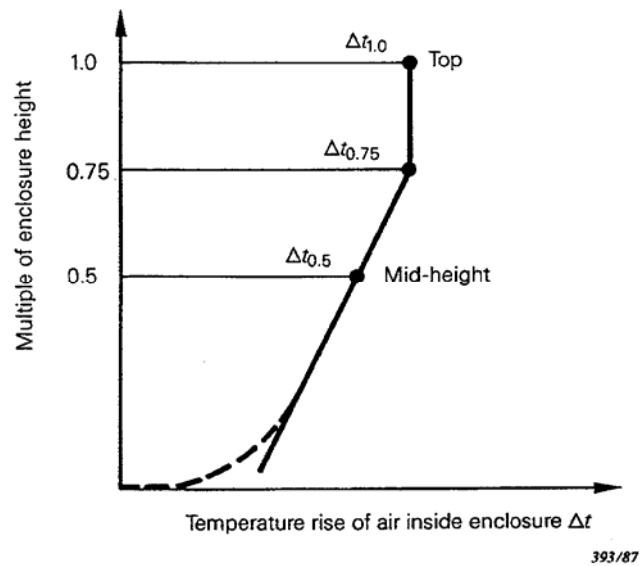


Figure 2 - Temperature-rise characteristic for enclosures with A_e not exceeding 1.25m^2

6 Evaluation of the design

It shall be determined whether the equipment within the PTTA 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 I - 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	
$A_e = \Sigma (A_o \cdot b)$ (1)	$\Delta t_{0.5} = k \cdot d \cdot P^x$ (2)	$\Delta t_{1.0} = c \cdot \Delta t_{0.5}$ (3)	> 1.25 m ²	Enclosure without ventilation openings	Table III	Figure 3	Table IV	Figure 4	0.804	See Sub-clause 5.2.4.1
				Enclosure with ventilation openings		Figure 5	Table V	Figure 6	0.715	
			≤ 1.25 m ²	Enclosure without ventilation openings		Figure 7	—	Figure 8	0.804	See Sub-clause 5.2.4.2

For symbols, units and designations, see Table II

Table II – 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
w	m	Enclosure width
x	—	Exponent
Δt	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 III - Surface factor b according to the type of installation

Type of installation	Surface factor b
Exposed top surface	1.4
Covered top surface, for example: of built-in enclosures	0.7
Exposed side faces, for example; front, rear and side walls	0.9
Covered side faces, for example: 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 sub-clause 5.2) which have been introduced only for calculation purposes are not taken into account.	

Table IV - Factor d for enclosures without ventilation openings and with an effective cooling surface $A_e > 1.25m^2$

Number of horizontal partitions n	0	1	2	3
Factor d	1.00	1.05	1.15	1.30

Table V - Factor d for enclosures with ventilation openings and an effective cooling surface $A_e > 1.25m^2$

Number of horizontal partitions n	0	1	2	3
Factor d	1.00	1.05	1.10	1.15

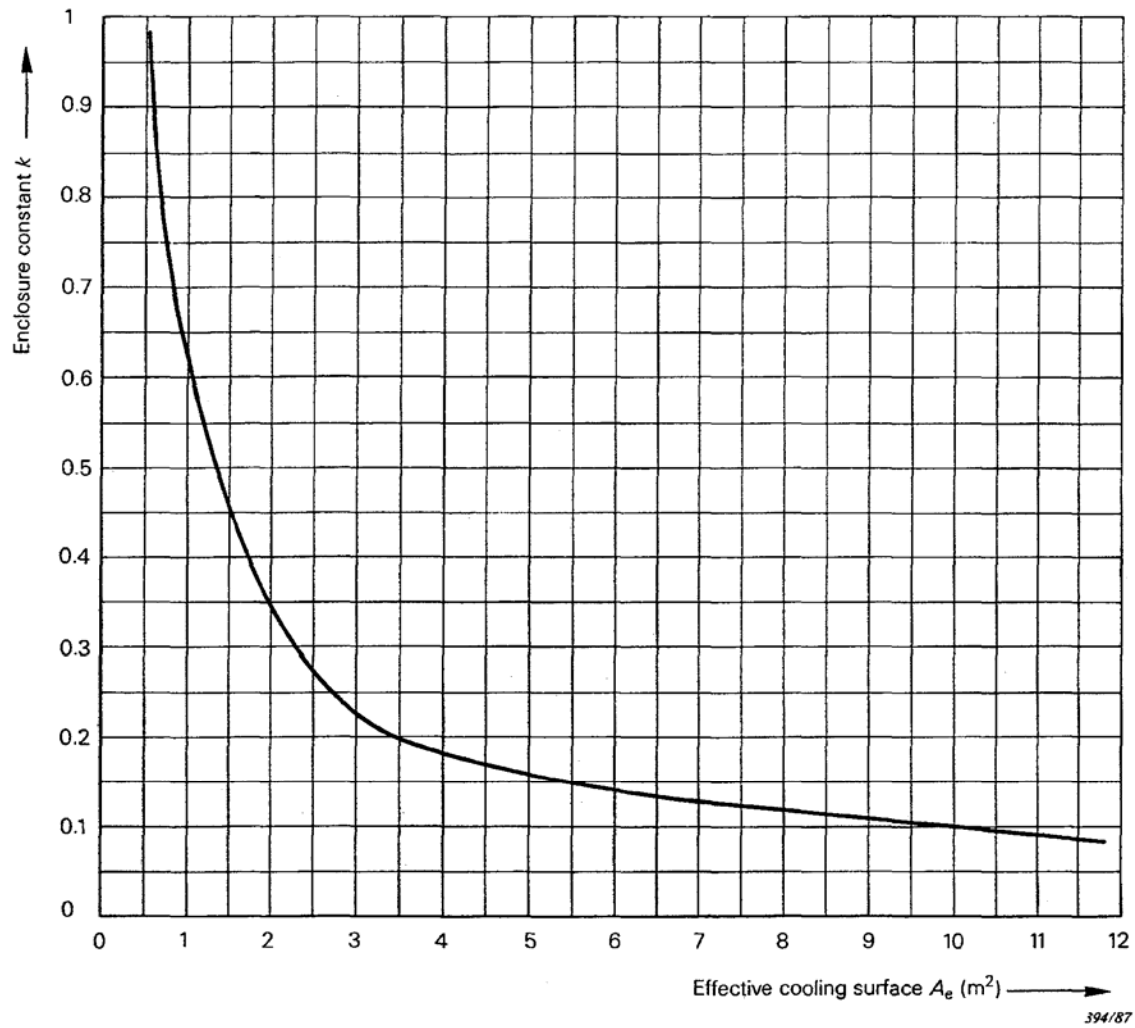


Figure 3 – Enclosure constant k for enclosures without ventilation openings, with an effective cooling surface $A_e > 1.25 \text{ m}^2$

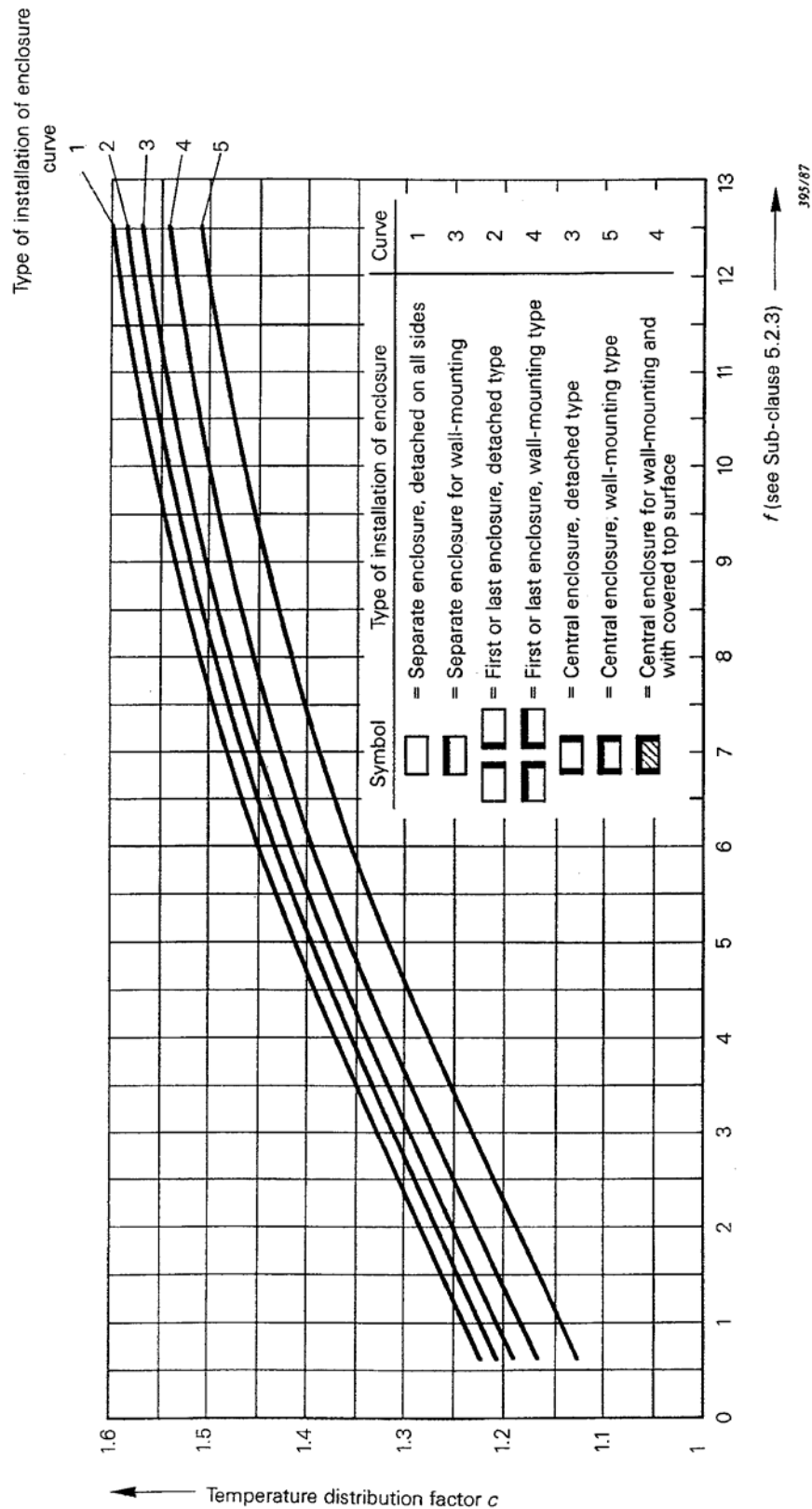
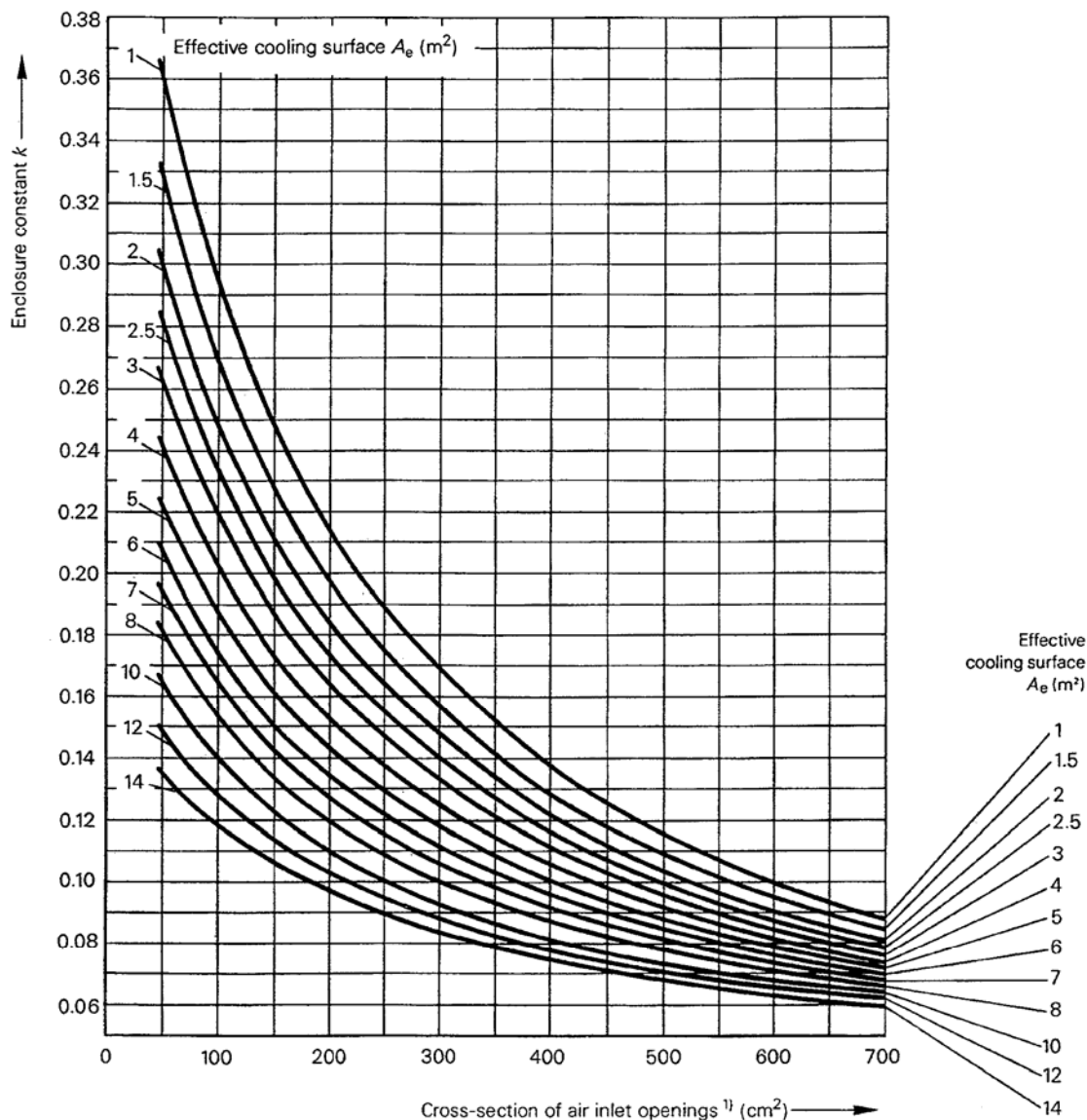


Figure 4 – Temperature distribution factor c for enclosures without ventilation openings, and with an effective cooling surface $A_e > 1.25\text{m}^2$



1) The cross-section of the corresponding air outlet openings should be at least 1.1 times that of the air inlet openings.

Figure 5 – Enclosure constant k for enclosures with ventilation openings and an effective cooling surface $A_e > 1.25 m^2$