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BSI Standards Publication

Mechanical structures for electrical and electronic equipment — Thermal management for cabinets in accordance with IEC 60297 and IEC 60917 series

Part 5: Cooling performance evaluation for indoor cabinets

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National foreword

This British Standard is the UK implementation of EN 62610-5:2016. It is identical to IEC 62610-5:2016.

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European foreword

The text of document 48D/591/CDV, future edition 1 of IEC 62610-5, prepared by SC 48D “Mechanical structures for electrical and electronic equipment” of IEC/TC 48 “Electrical connectors and mechanical structures for electrical and electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62610-5:2016.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MECHANICAL STRUCTURES FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – THERMAL MANAGEMENT FOR CABINETS IN ACCORDANCE WITH IEC 60297 AND IEC 60917 SERIES –

Part 5: Cooling performance evaluation for indoor cabinets

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International Standard IEC 62610-5 has been prepared by subcommittee 48D: Mechanical structures for electrical and electronic equipment, of IEC technical committee 48:Electrical connectors and mechanical structures for electrical and electronic equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
48D/591/CDV	48D/604/RVC

Full information on the voting for the approval of this standard 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 in the IEC 62610 series, published under the general title *Mechanical structures for electrical and electronic equipment – Thermal management for cabinets in accordance with IEC 60297 and IEC 60917 series*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

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- withdrawn,
- replaced by a revised edition, or
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INTRODUCTION

Indoor cabinets containing electronic equipment in subrack(s) and/ or chassis provide cooling by several different means, depending on the heat load of the equipment in the cabinet. In most cases air convection is used for cooling. The cabinets can be sealed or non-sealed, and may be equipped with fans for forced air cooling or rely on natural convention cooling without fans. In addition the subrack(s) or chassis may contain their own fans or rely on natural convention. Air convection systems are used to cool low to medium heat load applications. Indoor cabinets containing subrack(s) and/ or chassis assembled with high heat load electronic equipment typically are cooled by air to air heat exchangers or water supplied heat exchangers, and are not considered in this standard.

Sealed cabinets are used for systems operated in an industrial atmosphere, to protect the equipment against harsh environments, such as dust or water (IP), or provisions for EMC or acoustic noise. Non-sealed cabinets are used in offices, laboratories or data centres, where the environment is controlled.

The cooling performance of an electronic cabinet depends on the type of the cabinet, either sealed or non-sealed, with or without air moving devices, ventilated or re-circulated, and also, on the heat loads and the additional cooling systems (if any) of the equipment inside the cabinet.

Therefore, it is difficult to determine properly the cooling capabilities of empty electronic cabinets for various applications. This standard introduces a simplified method for an overall cooling performance evaluation for empty indoor cabinets in accordance with IEC 60917 or IEC 60297 series.

The purpose of this standard is to classify the cooling methods of empty indoor cabinets, to simplify the thermal hydraulic formulae for the evaluation and classification of cabinet cooling performances, and to exemplify the cooling performances for representative cabinet sizes based on IEC 60917 or IEC 60297.

This enables the users to select the appropriate cabinet cooling solutions for their applications.

MECHANICAL STRUCTURES FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – THERMAL MANAGEMENT FOR CABINETS IN ACCORDANCE WITH IEC 60297 AND IEC 60917 SERIES –

Part 5: Cooling performance evaluation for indoor cabinets

1 Scope

This part of IEC 62610 specifies a method for evaluating the cooling capacity mainly for air convection cooling of empty cabinets in accordance with IEC 60297 and IEC 60917 series.

2 Normative references

Void.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
ventilation
movement of the air inside a cabinet, causing replacement of the inside air by the cabinet external ambient air

3.2
buoyancy
force of air in the opposite direction of gravity that is produced by the difference in density due to the temperature differences between the air inside and external to the cabinet

3.3
natural ventilation
air movement produced by buoyancy

3.4
forced air cooling
forced ventilation
ventilation by air moving devices

3.5
natural convection cooling
cooling by natural air convection and radiation

3.6
air moving device
device creating air movement, e.g. fans, blowers, and other forced air movement equipment

3.7
sealed cabinet, without air moving devices
cabinet not provided with ventilation holes, not equipped with air moving devices, where the heat is transferred to the external environment by natural convection and radiation from the external surfaces of the cabinet

Note 1 to entry: The internal air temperature gradually increases from the bottom to the top of the cabinet.

3.8
sealed cabinet, with air moving devices
cabinet not provided with ventilation holes, equipped with air moving devices for re-circulating internal air, where the heat is transferred from the surface of the cabinet towards the outside of the cabinet both by convection (forced inside, natural outside) and by radiation

Note 1 to entry: A sealed cabinet without air moving devices which contains subracks or chassis systems with air moving devices may be equivalent to a sealed cabinet with air moving devices.

Note 2 to entry: The cooling performance of this type of cabinet is equal to that of "the sealed cabinet, without air moving devices" because the heat transfer mechanism to the external environment is identical, however the internal air temperature is equalized.

3.9
non-sealed cabinet, without air moving devices
cabinet where the heat is transferred by natural convection from the provided ventilation holes and, in addition, the heat is transferred to the external environment by natural convection and radiation from the external surfaces of the cabinet

Note 1 to entry: The source of the natural ventilation airflow is only by buoyancy of the cabinet internal air, even if there are some subracks or chassis systems with air moving devices, except if the air moving devices airflow goes directly outside of the cabinet.

3.10
non-sealed cabinet, with air moving devices
cabinet equipped with air moving devices and ventilation holes

Note 1 to entry: Two cooling modes, re-circulation and forced ventilation, are utilized for this type of cabinet, depending on the location of the air moving devices.

3.11
air moving devices on the subrack <re-circulation>
cabinet equipped with subracks and/or chassis with air moving devices

Note 1 to entry: The air inside the cabinet is re-circulated by subrack or chassis mounted fans, but is not ventilated by the fans.

3.12
air moving devices on a cabinet <forced ventilation>
cabinet equipped with air moving devices on the top cover, bottom cover or the rear cover of the cabinet, it does not matter if the fans are mounted internal or external to the cabinet

Note 1 to entry: The air moving devices force the air to exit the cabinet through ventilation holes. If the cabinet mounted air moving devices airflow is larger than the combined airflow of the cabinet mounted subrack and/or chassis systems the temperature rise inside the cabinet may be zero.

Note 2 to entry: If the cabinet mounted air moving devices airflow is smaller than the combined airflow of the cabinet mounted subrack and/or chassis systems, this will cause cabinet internal air re-circulation. The maximum cabinet internal air temperature will be equal to the maximum cabinet mounted subrack and/or chassis system air exit temperature.

3.13
simplified cooling performance evaluation
method to estimate the heat load of a cabinet based upon the chosen cooling mechanism, the cabinet internal temperature limit, typical ambient temperature / humidity, and the overall cabinet size chosen for the application

Note 1 to entry: The criteria definition of conditions for the simplified cooling performance are shown in Clause 5.

Note 2 to entry: It is assumed that the cabinets are used in an standalone application. If cabinets are arranged side-by-side, placed along a building wall or back to back the cooling performance may be reduced due to loss of heat transfer surface area.

3.14
typical temperature rise
cabinet with a 10 K internal temperature rise with respect to the cabinet external ambient temperature

Note 1 to entry: This level should be applied for cabinets which do not contain high heat tolerant components in subrack and/or chassis systems. The cabinet application would be installed in a relatively high ambient temperature environment.

3.15
extended temperature rise
cabinet with a 20 K internal temperature rise with respect to the cabinet external ambient temperature

Note 1 to entry: This level should be applied for cabinets which contain high heat tolerant components in subrack and/or chassis systems. The cabinet application would be installed in a low ambient temperature environment typically controlled by air conditioners.

4 Cabinet cooling class criteria

To be able to estimate the cooling performance of a cabinet the following criteria are used to classify the type of cabinet.

- If the cabinet is sealed (Figure 1a and Figure 1b) or non-sealed (ventilated) (Figure 2a, Figure 2b and Figure 3).
- If the cabinet has no air moving devices (Figure 1a, Figure 2a) or has air moving devices (Figure 1b, Figure 2b and Figure 3).
- If the cabinet has air moving devices on the top cover or the rear cover (Figure 3).

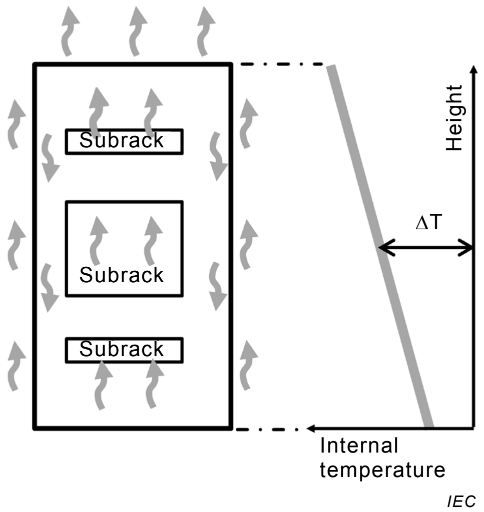


Figure 1a – Sealed cabinet without air moving devices – natural convection

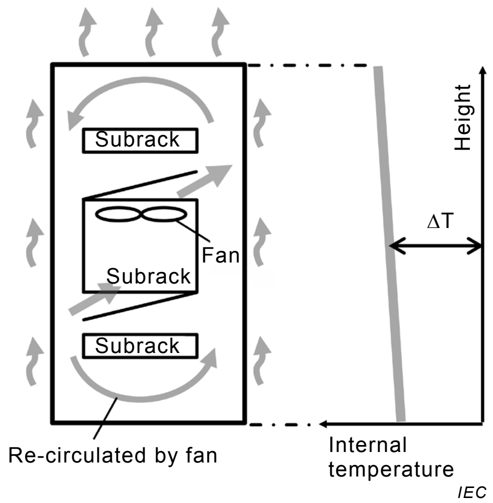


Figure 1b – Sealed cabinet with air moving devices – natural convection

Figure 1 – Natural convection cooling

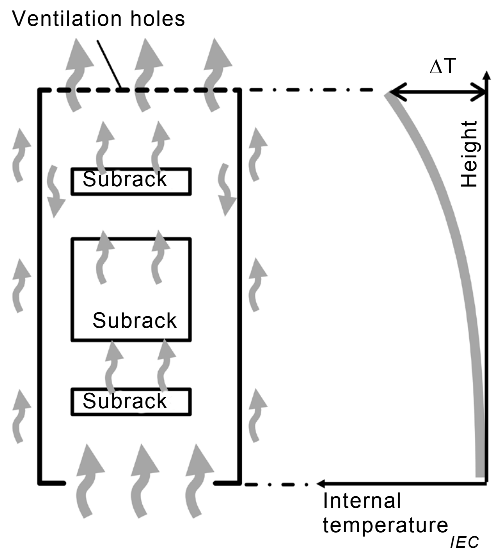


Figure 2a – Non-sealed cabinet without air moving devices – ventilated

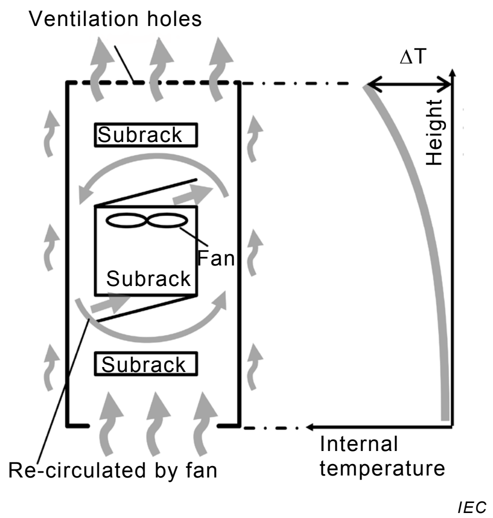
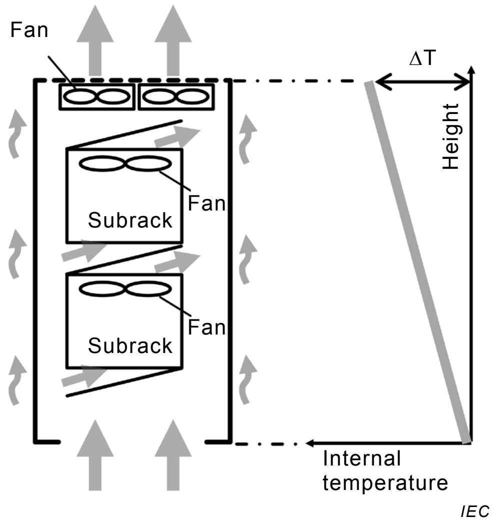


Figure 2b – Non-sealed cabinet with subrack and/or chassis system mounted air moving devices – ventilated

Figure 2 – Natural ventilation cooling



Non-sealed cabinet mounted air moving devices and with subrack and/or chassis system mounted air moving devices – ventilated

Figure 3 – Forced air cooling

5 Cooling performance of cabinets

5.1 General

In this clause, the cooling methods of indoor cabinets are classified, and the calculation procedures for each cooling performance of the cabinets are shown.

5.2 Cooling method of indoor cabinets

5.2.1 Classification of cooling methods

Classification of cooling methods is summarized as follows, see Table 1:

Table 1 – Classification of cooling method

Type	Definition	Sealed	Air moving devices	Ventilation	Reference figure	Cooling method and formula of cooling performance
A	see 3.7	yes	no	no	Figure 1a	natural convection
B	see 3.8		yes		Figure 1b	see 5.3
C	see 3.9	no	no	natural	Figure 2a	natural ventilation
D	see 3.11		yes		Figure 2b	see 5.4
E	see 3.12			forced	Figure 3	forced air cooling see 5.5

5.2.2 Cooling performances

The basic air-cooling calculation which is used in this standard is shown as follows.

$$Q = Q_s + Q_v$$

where

Q is the cooling performance of the indoor cabinet;

Q_s is the heat dissipation from surfaces of the cabinet;

Q_v is the heat dissipation by ventilation.

5.2.3 Concept for temperature rise

Let ΔT be the temperature rise of the inside air of the cabinet. Let ΔT_s be the temperature rise of the surface of the cabinet. The relation between the two can be estimated that ΔT_s is the half of ΔT.

$$\Delta T_s = \Delta T/2$$

In case of the sealed cabinet, the temperature rise inside the cabinet is to be measured by an average temperature. In case of the non-sealed cabinet, the temperature rise is to be measured at the cabinet air exit.

5.2.4 Temperature rise limits

The tolerated temperature rise of the cabinet depends on how components mounted inside are tolerant to high temperature. The cabinet temperature rise should be classified into two levels listed below:

typical temperature rise ΔT = 10 K

extended temperature rise ΔT = 20 K

5.3 Natural convection cooling

The cooling performance of natural convection is applicable to a sealed cabinet without air moving devices and a sealed cabinet with air moving devices.

The cooling performance of natural convection is calculated with the following formula.

$$Q_s = h_s \times A \times \Delta T_s$$

where

h_s is the heat transfer coefficient of the surface, the value of h_s shall be 8 W/m^{2}K;

A is sum of the external surfaces area of the cabinet except the bottom.

NOTE The h_s value accounts for heat transfer due to both natural convection and radiation.

5.4 Natural ventilation cooling

The cooling performance of natural ventilation is applicable to a non-sealed cabinet without air moving devices and a non-sealed cabinet with air moving devices on the subrack or chassis (re-circulating). The cooling performance of natural convection is calculated with the following formula.

$Q = Q_s + Q_v$

$Q_s = h_s \times A \times \Delta T_s$

$Q_v = \rho \times C_p \times u \times A_p \times \Delta T$

where

ρ is the density of the ambient air, the value should be 1,2 kg/m^3;

C_p is the specific heat of the ambient air at constant pressure, the value should be 1 005 J/kgK;

U is the air velocity of natural convection;

A_p is the surface area on top of the cabinet.

The velocity *u* varies according to the cabinet height and cabinet temperature rise. The value of *u* is determined from Figure 4.

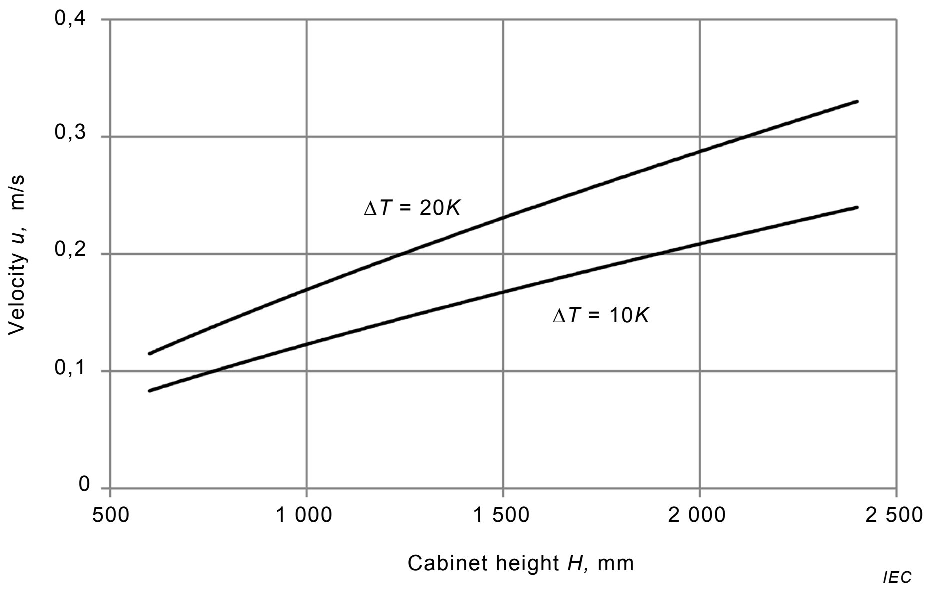


Figure 4 – Velocity of natural convection as a function of cabinet height

The graph shows the velocity *u* of natural ventilation as a function of the cabinet height in the typical temperature rise $\Delta T = 10K$ and the extended temperature rise $\Delta T = 20\ K$.

5.5 Forced air cooling (forced ventilation)

The cooling performance of the ventilated cabinet cooled via forced convection is calculated with the following formula. The cooling performance of forced air cooling is applicable to a non-sealed cabinet with air moving devices for ventilation on the top or rear of the cabinet.

$Q = Q_s + Q_v$

$Q_s = h_s \times A \times \Delta T_s$

$Q_v = \rho \times C_p \times F \times \Delta T$

where

ρ is the density of the ambient air, the value should be 1,2 kg/m^3;

C_p is the specific heat of the ambient air at constant pressure, the value should be 1 005 J/kgK;

F is the flow rate of the cabinet fans.

5.6 Representative examples of calculated cooling performance

The cooling performance of a cabinet cooling method, typical and extended temperature rise and cabinet size is shown in Table 2. According to the sealed cabinet, the temperature increase of the air in the upper part of the cabinet may be higher than the value of ΔT, which is the average temperature of the cabinet. The arrangement of subrack and chassis systems should be considered.

Table 2 – Representative examples of calculated cooling performances

Cabinet dimensions mm			**Typical temperature rise ΔT=10 K (see 5.2.4)**			**Extended temperature rise ΔT=20 K (see 5.2.4)**		
W width	D depth	H height	Natural convection see 5.3 W	Natural ventilation see 5.4 W	Forced air cooling see 5.5 W	Natural convection see 5.3 W	Natural ventilation see 5.4 W	Forced air cooling see 5.5 W
600	600	2 000	210	1 100	3 600	410	2 900	7 100
800	900	2 200	330	2 300	3 700	660	6 000	7 400
600	600	1 200	130	740	3 500	260	2 000	7 000

NOTE In the forced air cooling, the cooling performances are calculated at flow rate of 1 000 m^3/h (0,28m^3/s).

Annex A
(informative)

Background information

A.1 Air velocity calculation of natural ventilation

The graphs of Figure 4 come from the balanced force analysis. In a ventilated natural convection cabinet, the velocity of air should be balanced by buoyancy against flow resistance as shown in Figure A.1.

The buoyancy is proportional to cabinet height and temperature rise. Flow resistance is mainly proportional to the ratio of the inlet and outlet openings of the cabinet. In this standard, it is assumed that the bottom has a full opening and the top cover of the cabinet has a 50 % opening.

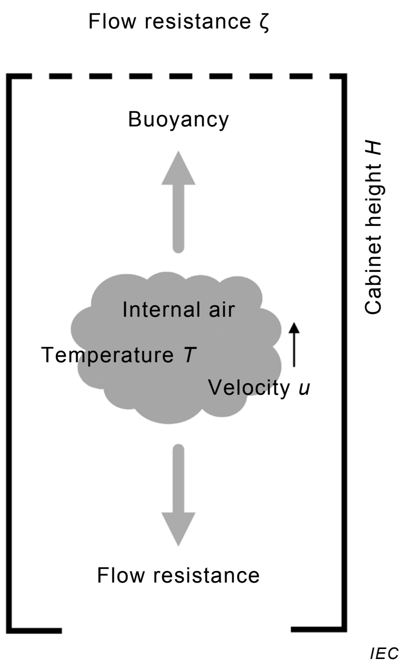


Figure A.1 – Balanced force on internal air of a cabinet

A.2 Background information of the validation test results by CFD simulations

The representative examples of thermal simulations in order to check the validation are shown below (see Figures A.2 to A.6). The cabinet types are A to E, corresponding to the classification in Table 1.

a) Sealed cabinet, without air moving devices, natural convection – type A

size:	600 mm × 600 mm × 2 000 mm
equipment:	7 subracks, 10 cards / subrack
thermal:	3 W / card, total heat dissipation 210 W
level:	typical temperature rise (ΔT = 10 K)

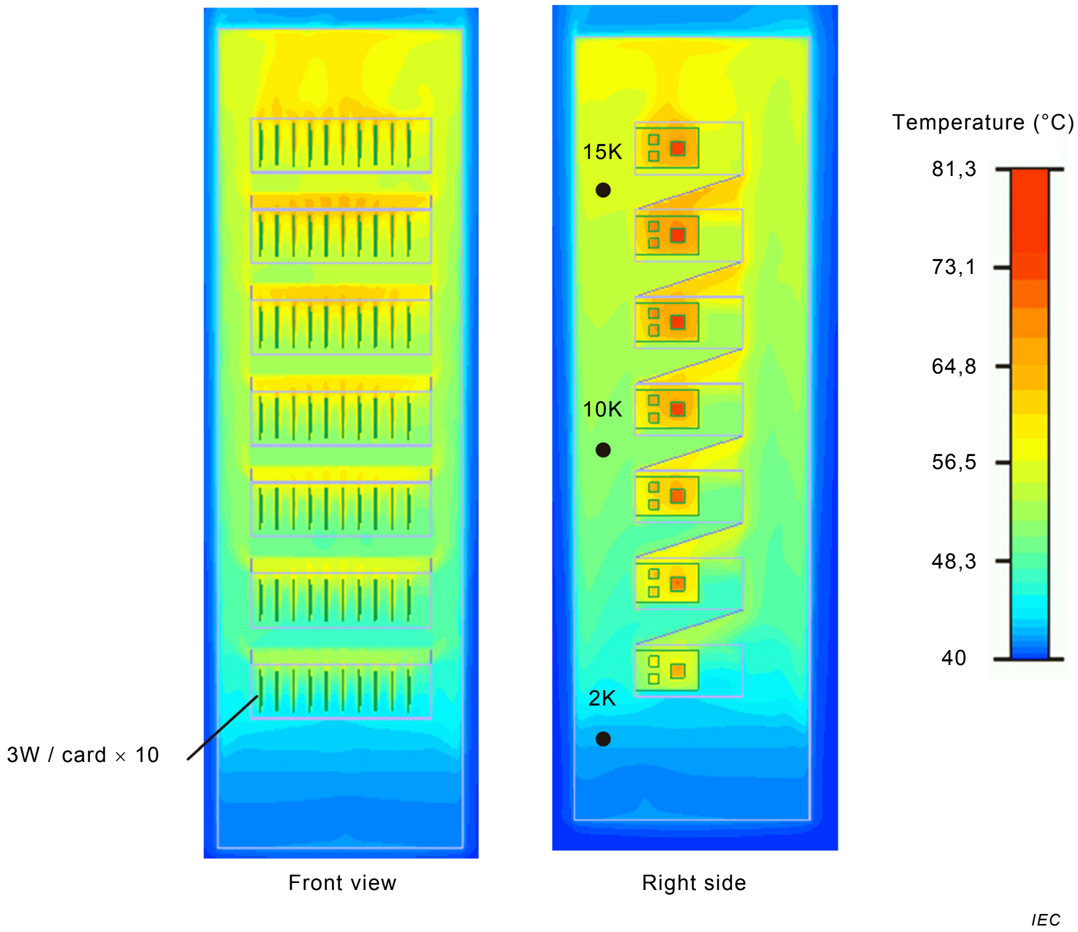


Figure A.2 – Thermal simulation example – Type A

b) Sealed cabinet, with air moving devices, natural convection – type B

size:	600 mm × 600 mm × 2 000 mm
equipment:	5 subracks, 3 W card × 10, total 30 W / subrack 1 subrack, 10 W card × 2, 4 W card × 10, total 60 W / subrack, with fans
thermal:	total heat dissipation 210 W
level:	typical temperature rise (ΔT = 10 K)

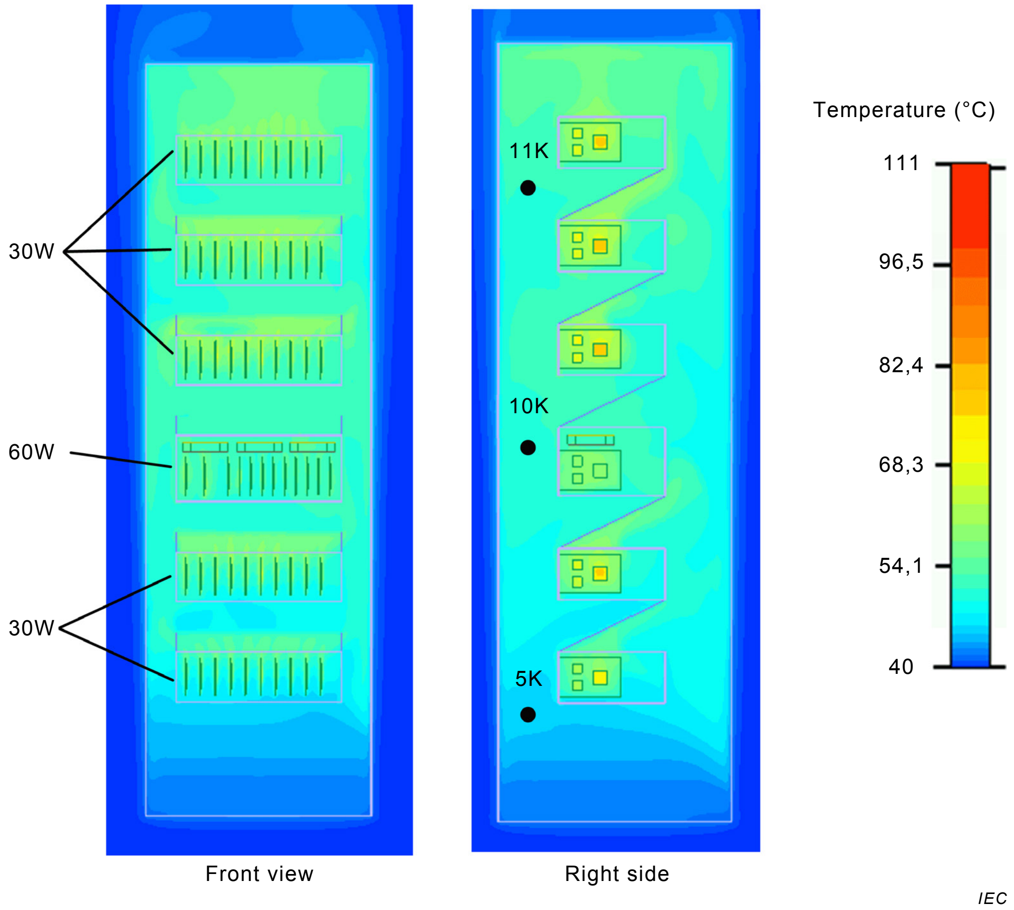


Figure A.3 – Thermal simulation example – Type B

c) Non-sealed cabinet, without air moving devices, natural ventilation – type C

size:	600 mm × 600 mm × 2 000 mm
equipment:	10 subracks, 11 W card × 10, total 110 W / subrack
thermal:	total heat dissipation 1 100 W
level:	typical temperature rise (ΔT = 10 K)

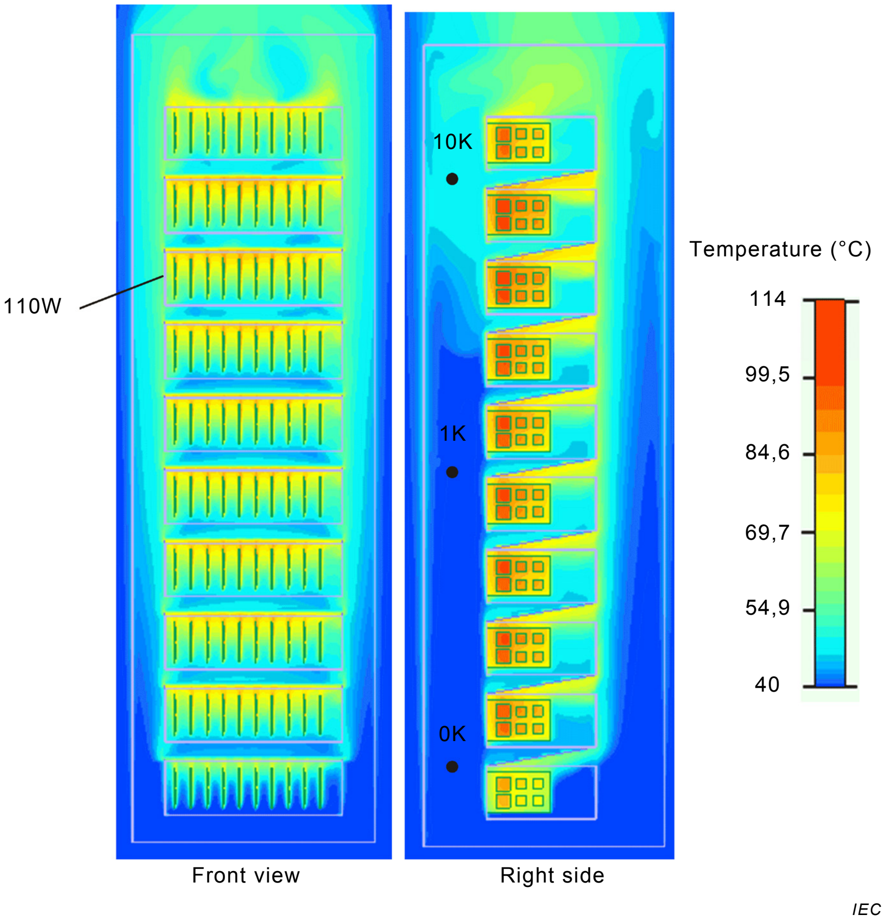


Figure A.4 – Thermal simulation example – Type C

d) Non-sealed cabinet, with air moving devices, natural ventilation – type D

size:	600 mm × 600 mm × 2 000 mm
equipment:	6 subracks, 11 W card × 10, total 110 W / subrack 2 subracks, 22 W card × 10, total 220 W / subrack, with fans
thermal:	total heat dissipation 1 100 W
level:	typical temperature rise (ΔT = 10 K)

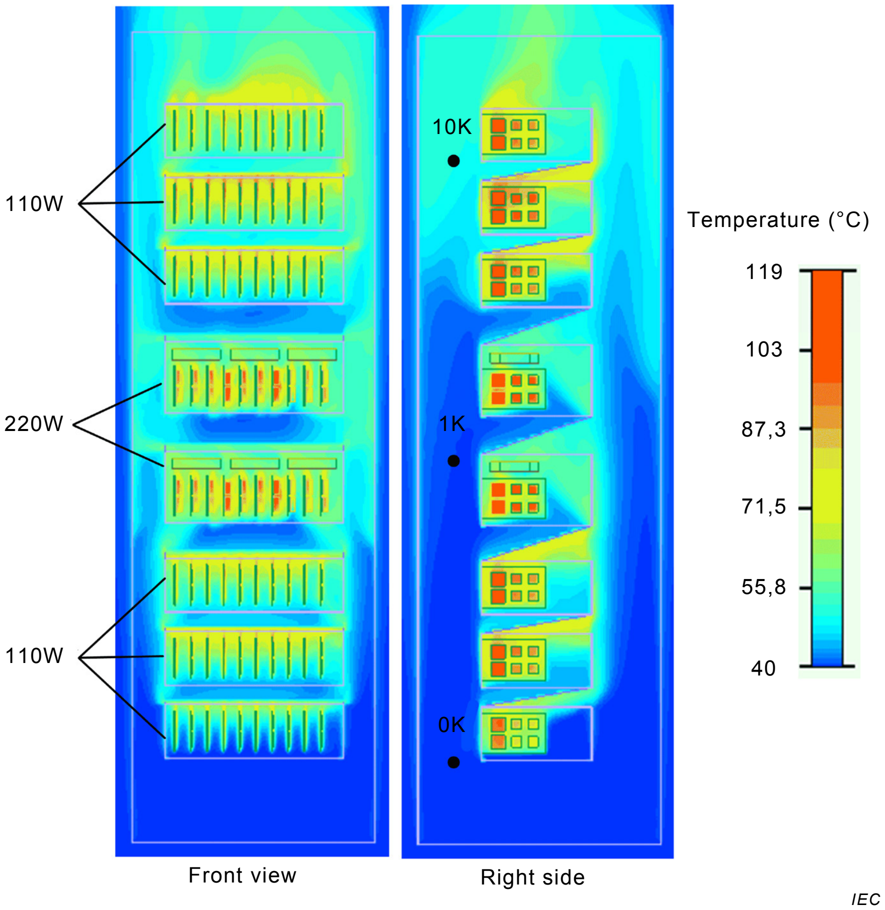


Figure A.5 – Thermal simulation example – Type D

e) Non-sealed cabinet, with air moving devices, forced air cooling – type E

size:	600 mm × 600 mm × 2 000 mm
equipment:	2 ATCA shelves, 128,6 W card × 14, total 1 800 W / subrack, with fans
thermal:	total heat dissipation 3 600 W
level:	typical temperature rise (ΔT = 10 K)

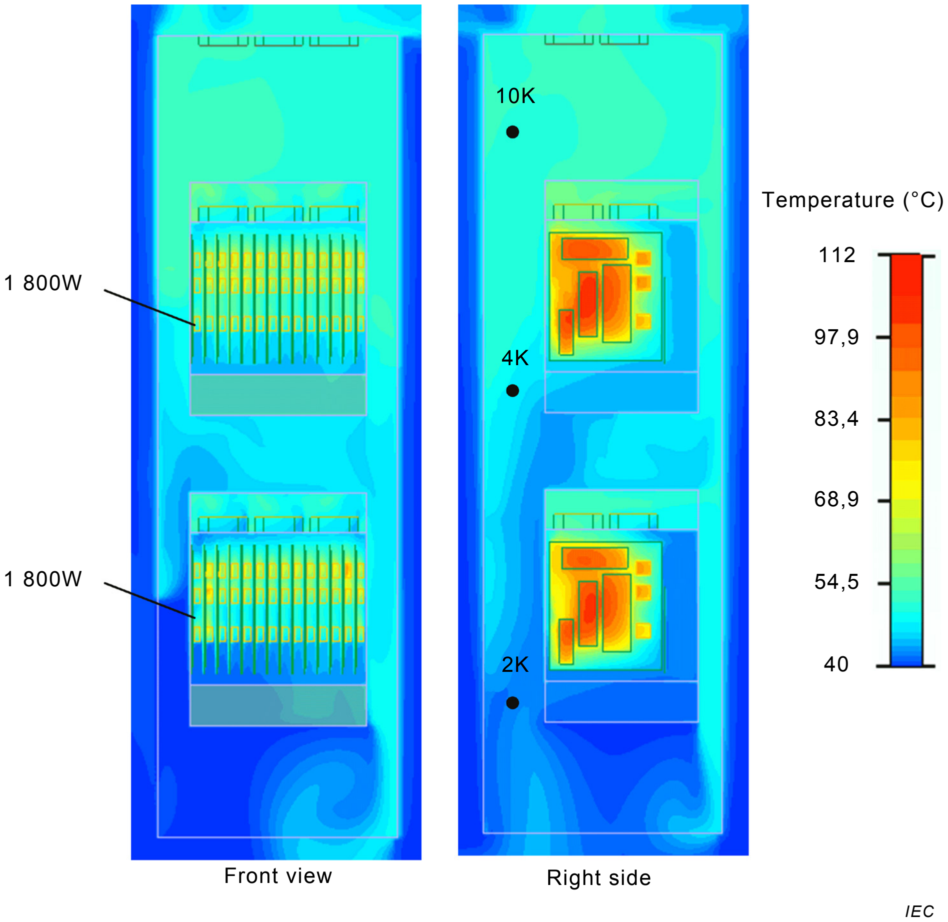


Figure A.6 – Thermal simulation example – Type E

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