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BSI Standards Publication

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

Part 2: Design guide: Method for determination of forced air-cooling structure

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National foreword

This Draft for Development is the UK implementation of IEC/TS 62610-2:2010.

The UK participation in its preparation was entrusted to Technical Committee EPL/48, Electromechanical components and mechanical structures for electronic equipment.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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CONTENTS

FOREWORD ... 3
INTRODUCTION ... 5
1 Scope and object ... 6
2 Thermal interfaces ... 6
2.1 Baseline thermal conditions ... 6
2.2 Reference temperature ... 6
2.3 Syntax of surfaces of a generic subrack, chassis or cabinet ... 7
2.4 Preferred airflow conditions ... 8
2.5 Cabinet airflow volume and temperature rise management ... 9
3 Forced air thermal flow chart for cabinet equipment ... 10
3.1 General ... 10
3.2 Evaluation of the actual thermal performance of subrack or chassis ... 11
3.3 Cabinet airflow considerations ... 11
3.4 Arrangement of subracks and/or chassis equipment within the cabinet ... 11
3.5 Selection of cabinet mounted forced air device(s) ... 12
3.6 Thermal operating environment ... 12
Annex A (informative) Limitation of application and background information ... 14
Bibliography ... 16

Figure 1 – Syntax of surfaces of a forced air cooled generic subrack or chassis to be mounted into a cabinet ... 7
Figure 2 – Syntax of surfaces of a forced air cooled generic cabinet ... 7
Figure 3 – Preferred air flow patterns ... 9
Figure 4 – Air flow volume management ... 10
Figure 5 – Forced air thermal flow chart for cabinet equipment ... 11
Figure 6 – Thermal operating environment (Cabinet sectional side view) ... 12
Figure 7 – Example of effect of reference temperature on cabinet operating temperature range ... 13
Figure A.1 – Thermal network model for a plug-in unit in subrack or chassis ... 15

Table 1 – Preferred airflow pattern ... 8

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 2: Design guide: Method for the determination of forced air-cooling structure

FOREWORD

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62610-2 TS Ed.1.0, which is a technical specification, has been prepared by subcommittee 48D: Mechanical structures for electronic equipment, of IEC technical committee 48: Electromechanical components and mechanical structures for electronic equipment.

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

Enquiry draft	Report on voting
48D/459/DTS	48D/470/RVC

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

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Power dissipation of high-end servers, telecommunication equipment and electronic controllers has been increasing rapidly (Moore's law). Thermal management for electronic systems has become critical to maintain performance and reliability.

For a long time convection air cooling was an adequate and reliable solution. Typically, the cooled air entered a system on the bottom and the heated air exits at the top. However, with increasing packaging density heat dissipation of components required "compartmentalizing" of functions within a cabinet. Individual subracks and chassis require their own individual cooling solutions often enhanced by forced air devices such as fans.

In the absence of any guide, subrack and chassis designers typically find their cooling solutions best suited for their specific application leaving the cabinet system integrator with a mix of incompatible subrack and/or chassis cooling concepts to deal with.

An improper arrangement of multiple subracks and/or chassis (the equipment) in a cabinet may cause a severe imbalance of airflow and/or unwanted temperature rises preventing effective cooling of the cabinet installed equipment. Two typical undesirable factors may be triggered by such an imbalanced airflow and/or unwanted temperature rise(s) within a cabinet. The required airflow volume to each individual cabinet mounted equipment may fall short. The air-intake temperature of each cabinet mounted subrack and/or chassis may increase as exhaust air of one equipment may increase the air-intake temperature of another equipment. As a result, unwanted temperature rise of components may occur.

The intention of this guide is to educate the subrack and/or chassis system designer and the cabinet integrator to provide for compatible forced air cooling solutions.

This guide is based on the mechanical structures as defined in the IEC 60297 and IEC 60917 series of standards.

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

Part 2: Design guide: Method for the determination of forced air-cooling structure

1 Scope and object

This part of IEC 62610 provides for compatible methods of forced air cooled cabinets assembled with associated subracks and/or chassis in accordance with the IEC 60297 and IEC 60917 series.

This design guide contains the following:

a) Thermal interfaces of subrack and/or chassis based equipment in a cabinet
   - Reference temperature
   - Preferred airflow conditions
   - Airflow volume conditions
   - Standard air

b) Procedures for determining compatible forced airflow conditions in a cabinet by applying typical thermal interface conditions

The drawings used are not intended to indicate product design. They are only explanatory indications for determining forced air-cooling structure.

The terminology used complies with IEC 60917-1.

2 Thermal interfaces

2.1 Baseline thermal conditions

In order to enable reproducible and comparable values, standard air is defined at the air inlet to be used for the determination of the thermal capability and requirement parameters of products.

NOTE Standard air as defined for this purpose has a density of 1,2 kg/m^3, a relative humidity of 50 %, a temperature of 20 °C, a pressure of $1,013 \times 10^5$ Pa. A specified heat capacity is 1 005 J/kgK at these conditions. These values are aligned with the fan industry specifications, common test practices and electronic industry expectations.

2.2 Reference temperature

The thermal operating temperature of subrack and chassis in the cabinet should be defined at the air inlet, and this temperature is called reference temperature in this technical specification.

Reference temperature is defined as the temperature of an objective ambient air of the equipment in the cabinet which is a starting point for a rise in internal temperatures of the equipment, and, at the same time, influences internal temperatures of it.

At one typical equipment which consists of a subrack and a forced air-cooling device, temperatures of internal air and inside components of the subrack are determined as certain values from “reference temperature”. And, “reference temperature” of the equipment cabinet can be considered as equivalent with its intake air temperature, because the heat dissipating path of the forced air-cooling is dependent on ventilation characteristics of the equipment. (see Clause A.2)

The air intake is the initial point of an upstream airflow where air flows into the equipment to cool its inside. The intake air temperature of the equipment (T3-nr) as supplied by the ambient temperature (T4) could be identical (see Figure 6).

NOTE Generally, the intake air temperature is measured at the positions from 30 mm to 50 mm away from the outline of the equipment to avoid the influence of heat radiation. At the air intake opening, if the temperature is not considered as homogeneous because the opening is so wide, several positions (3 to 5) should be defined as reference temperature positions, and the average temperature should be taken as the intake air temperature.

2.3 Syntax of surfaces of a generic subrack, chassis or cabinet

In order to define airflow patterns of subrack and/or chassis based equipment mounted within a cabinet the syntax of the outer surfaces is defined as in Figure 1.

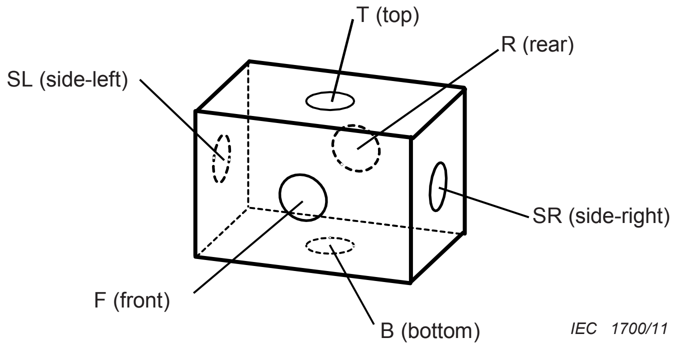


Figure 1 – Syntax of surfaces of a forced air cooled generic subrack or chassis to be mounted into a cabinet

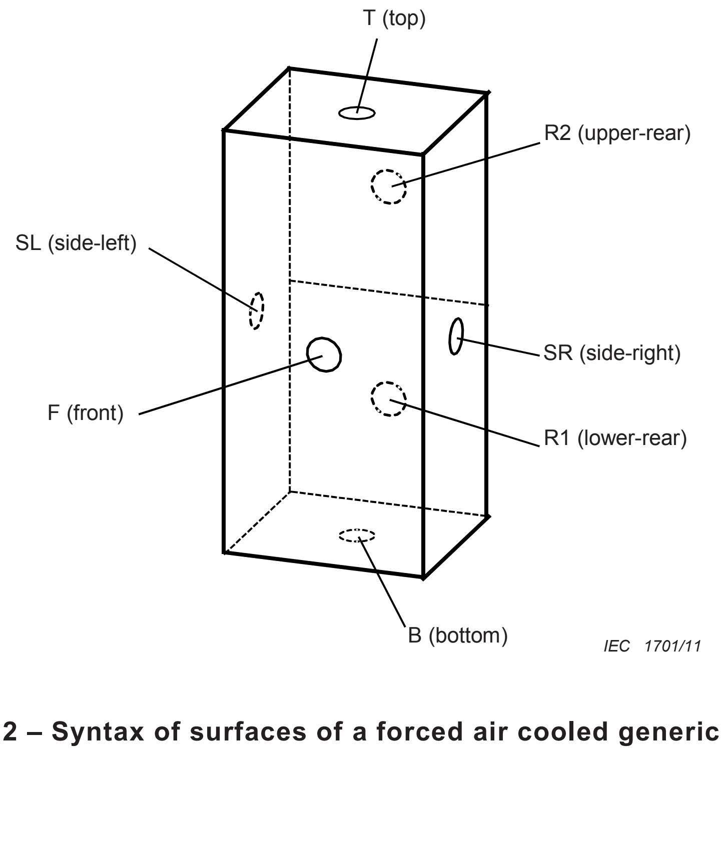


Figure 2 – Syntax of surfaces of a forced air cooled generic cabinet

2.4 Preferred airflow conditions

In order to facilitate an efficient cabinet airflow design, it is necessary to define the preferred airflow pattern of the cabinet mounted equipment. It is important that the cold air entry is not contaminated by the hot air exit (separation of the air entry path and the air exit path). The essential principles of cooling airflow direction are "FRONT to REAR" and "BOTTOM to TOP".

The complete syntax of airflow pattern in Table 1 is as follows :

Intake definition [+ additional intake definition] → exhaust definition [+ additional exhaust definition]

The intake and exhaust definition corresponds to the syntax of the surfaces as shown in Figure 1 and Figure 2.

Table 1 – Preferred airflow pattern

Airflow pattern within subrack or chassis-based equipment [a]	Airflow pattern within cabinet [b]
F → R F+B →R	F → T, F→ R2 F+B → T, F+B → T+R1 F+B → T+R2, F+B → R1+R2

[a] Subracks or chassis with forced air-cooling devices.

[b] Cabinets with forced air-cooling devices.

Subracks and chassis which do not comply to the preferred airflow pattern as described in this technical specification should provide for additional airflow management devices such as deflectors. These additional deflectors should bring the equipment in line with a preferred airflow pattern.

The following figures illustrate preferred airflow patterns in a cabinet as per Table 1.

The arrangements shown in this figure are typical only.

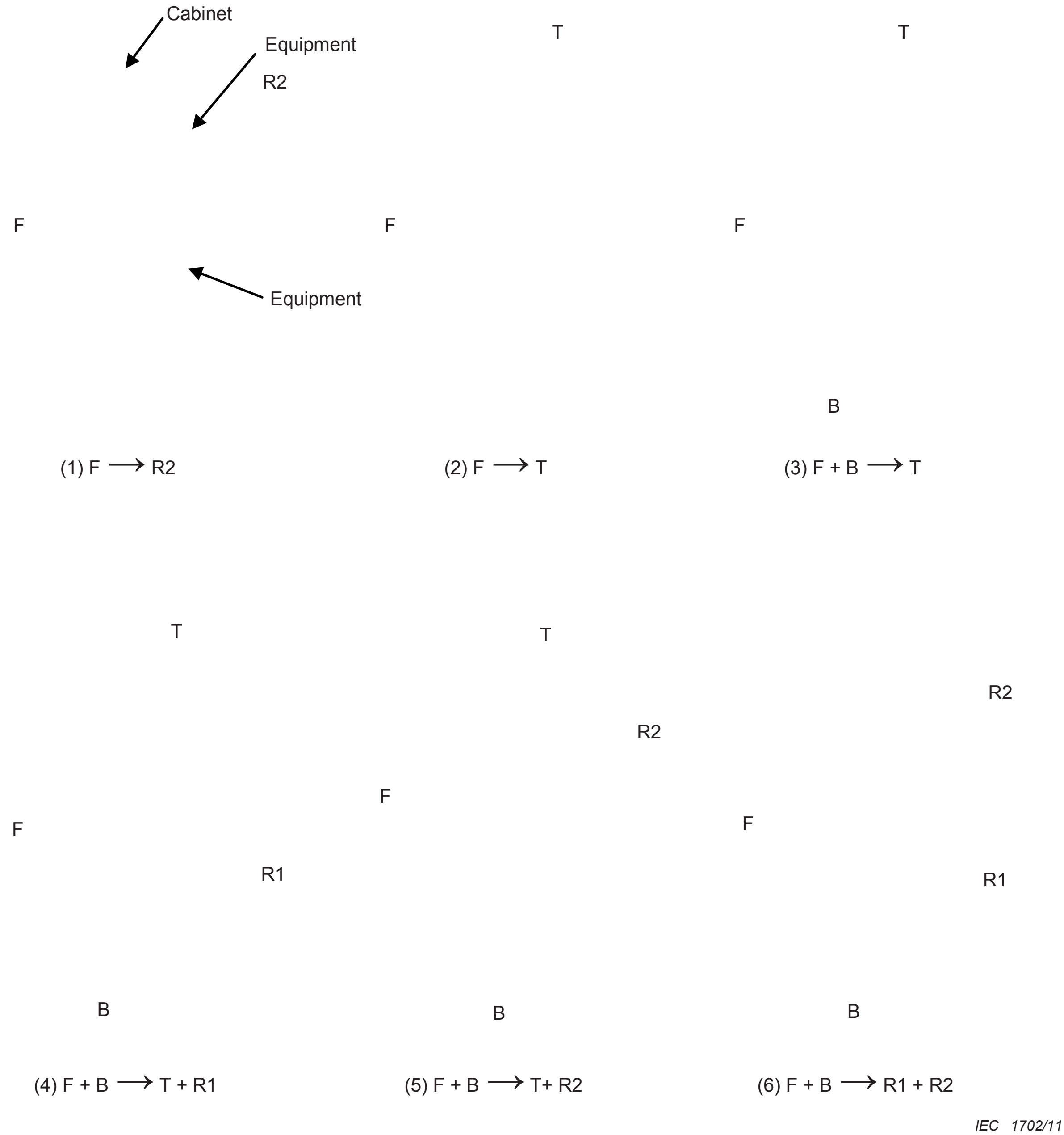


Figure 3 – Preferred air flow patterns

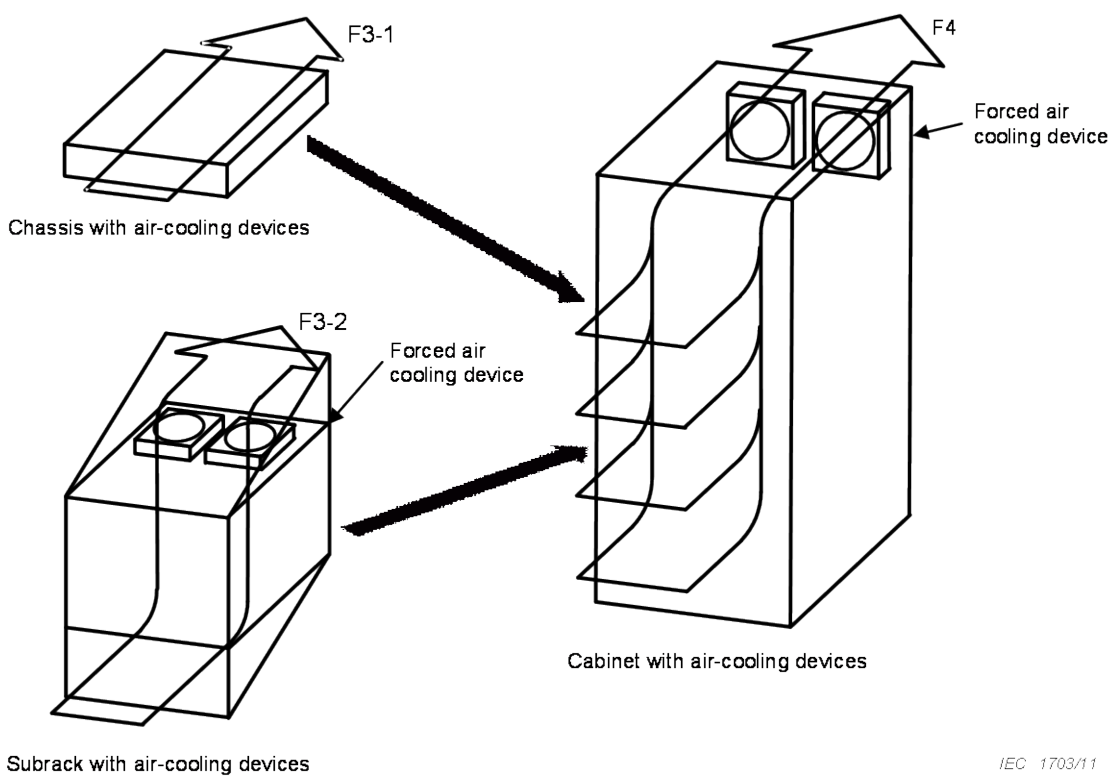
2.5 Cabinet airflow volume and temperature rise management

The cabinet with forced air-cooling devices should have enough cooling capability for power dissipation in order to maintain the cooling capacities of various types of subracks or chassis with air-cooling devices in it.

The cabinet with one or more such subracks and chassis shall have exhaust air ventilation capacity more or equal than the sum of subracks' and chassis' airflow volume. This means that the cabinet does not impede respective subracks ventilation capacities.

The airflow volume of the cabinet mounted forced air devices (F4) shall be sized to match the combined air volume as produced by the forced air devices of the subrack(s) (F3-2) and chassis (F3-1) in the cabinet.

Total airflow volume of equipments: ΣF3-n ≦ Airflow volume of the cabinet: F4



F3-n Airflow volume of equipments

F4 Airflow volume of cabinet

Figure 4 – Air flow volume management

NOTE The power dissipation of air-exit fans should be considered to evaluate the exhaust air temperature rise of the equipped cabinet.

3 Forced air thermal flow chart for cabinet equipment

3.1 General

The flow chart as shown in Figure 5 identifies the forced airflow procedure for cabinet equipment.

The details of each step in the flow chart are explained in the following subclauses.

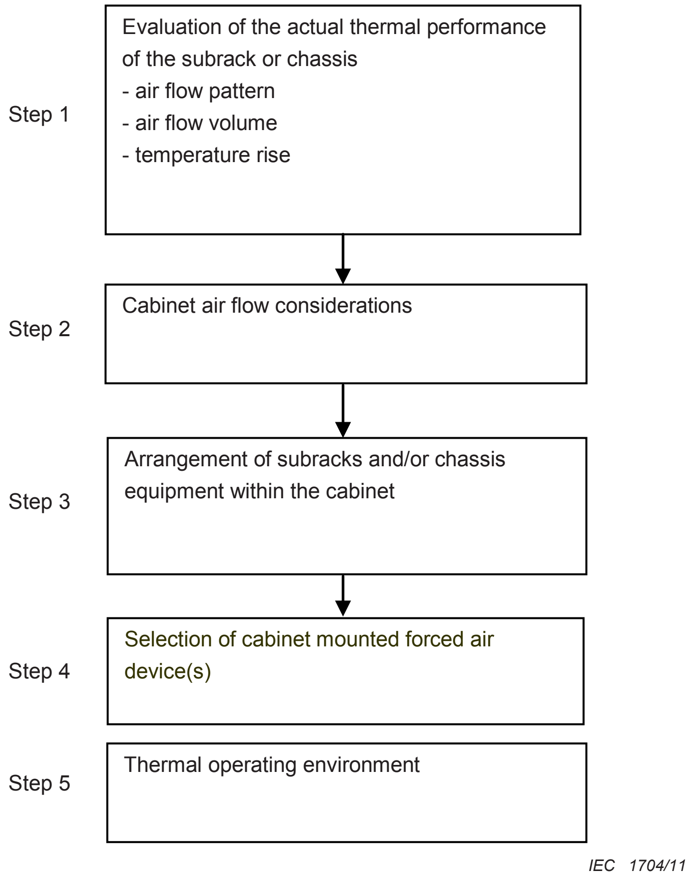


Figure 5 – Forced air thermal flow chart for cabinet equipment

3.2 Evaluation of the actual thermal performance of subrack or chassis

For the thermal management of cabinet mounted subracks and/or chassis equipment it is important to take the following into account:

a) The airflow pattern (See Table 1)
b) The airflow volume
c) The operating temperature range
d) The temperature rise limitation

3.3 Cabinet airflow considerations

The airflow in the application specific operating environment where the cabinet is installed should be investigated. The airflow pattern for the cabinet is chosen from the related Table 1.

3.4 Arrangement of subracks and/or chassis equipment within the cabinet

Ideally, all cabinet mounted subrack and/or chassis equipment have the same compatible airflow pattern chosen from Table 1. Incompatible airflow pattern of an individual subrack and/or chassis equipment may be mitigated by suitable airflow dividers or airflow deflector panels in order to prevent cabinet airflow imbalance and to control the airflow within the cabinet.

3.5 Selection of cabinet mounted forced air device(s)

The cabinet mounted forced air device(s) shall be chosen to realize that the cabinet airflow volume (F4) balances or exceeds the combined airflow volume (F3-n) provided by the subrack(s) and /or chassis.

$$\mathbf{\Sigma F3\text{-}n \leqq F4}$$

F3-n Airflow volume of subrack or chassis in the cabinet

F4 Airflow volume of the cabinet, created by the cabinet mounted forced air device(s)

3.6 Thermal operating environment

The individual subrack and/or chassis equipment operating temperature range is defined as T3-n (min) to T3-n (max) defined by the specifications for cooling of each subrack or chassis equipment.

The inlet air temperature of each subrack and/or chassis equipment mounted on a cabinet, corresponding exactly to the reference temperature of each equipment described in 2.2, "T3-nr" shall be within the operating temperature range T3-n(max/min).

$$\mathbf{T3\text{-}n\ (min) \leqq T3\text{-}nr \leqq T3\text{-}n\ (max)\ for\ each\ equipment}$$

For example, the following both conditions shall be fulfilled under the operating temperature range of the equipped cabinet T4 (max/min) in the case of Figure 6.

$$\mathbf{T3\text{-}1\ (min) \leqq T3\text{-}1r \leqq T3\text{-}1\ (max)}$$

$$\mathbf{T3\text{-}2\ (min) \leqq T3\text{-}2r \leqq T3\text{-}2\ (max)}$$

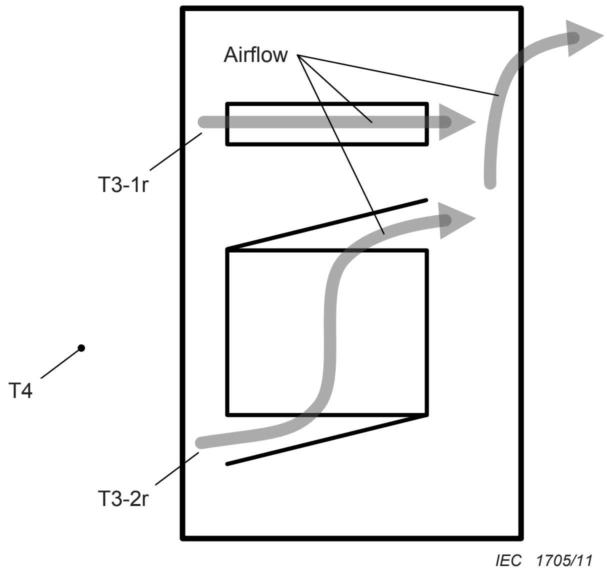


Figure 6 – Thermal operating environment (Cabinet sectional side view)

T3-nr Reference temperature of concerned subrack(s) or chassis mounted on a cabinet

T3-n (min) Minimum operating temperature for subrack(s) or chassis

T3-n (max) Maximum operating temperature for subrack(s) or chassis

T4 Ambient temperature around an equipment cabinet

NOTE 1 The operating temperature range of the equipped cabinet T4 (max/min) depends on its application.

NOTE 2 In case that the equipment cabinet has air inlet filters or air outlet filters, decreasing of the airflow volume due to pressure loss by the filters should be considered.

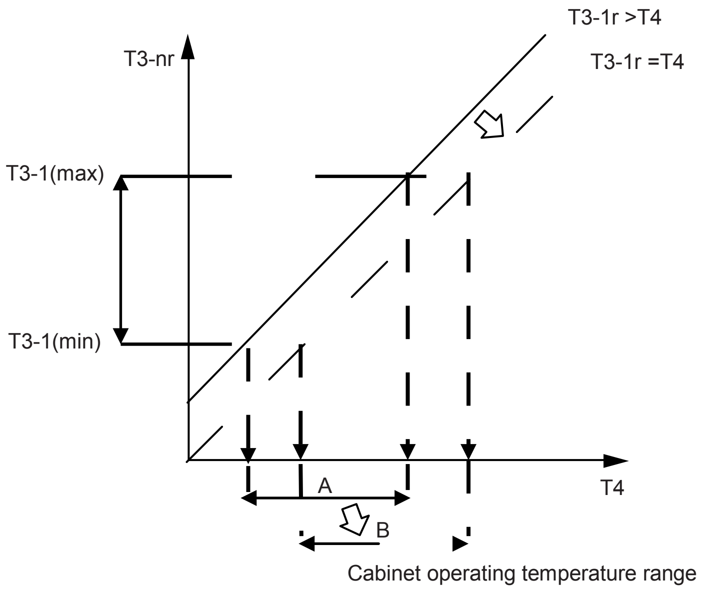
NOTE 3 Figure 7 shows the relation between reference temperature and operating temperature range of an equipment cabinet. If the reference temperature of subrack(s) and/or chassis (T3-nr) goes down form the condition of "T3-nr > T4" to "T3-nr = T4", the operating temperature range of the equipment cabinet moves to the right side as shown in Figure 7.

It means that the ambient around the equipment cabinet can be taken as higher temperature and demand for the performance of HVAC (Heating Ventilation Air Conditioning) of the cabinet can be moderated.

It also indicates that the reference temperature of subrack(s) or chassis higher than the ambient temperature around the equipment cabinet (T3-1r >T4, as the solid line) is caused mainly by imbalance of airflow.

The dotted line shows the case of a reference temperature of subrack(s) or chassis equal with the ambient temperature around the equipment cabinet (T3-1r =T4).

A and B indicate the operating temperature ranges of the cabinet for each case.



Vertical axis: reference temperature of concerned n-subrack or chassis mounted on cabinet
Horizontal axis: ambient temperature around cabinet to be installed

IEC 1706/11

Figure 7 – Example of effect of reference temperature on cabinet operating temperature range

Annex A
(informative)

Limitation of application and background information

A.1 Limitation of application of this design guide

This design guide is limited to cabinets with forced air cooling.

In case of the thermal management of the natural convection cooled cabinets, without forced air-cooling, heat dissipation from the cabinets' surface has to be considered as one of the key factors for determining their cabinet thermal management structures.

A.2 Background information on the determination of thermal management structures for the forced air–cooled cabinets by applying of their "reference temperature" and airflow volume

A.2.1 Thermal resistance

For a practical thermal design of the electronic equipment, one efficient technique is a thermal network method. It is generally used for the thermal design of various electronics equipment. The thermal network is composed of nodes and thermal resistances. A node is a point representing the temperature around the point in solid or fluid. Thermal resistance in solid or fluid along air stream is much like electrical resistance. The steady state defining equation is as follows:

$$\Delta T_{\text{across solid or liquid}} = R_T \times Q$$

Where

ΔT is a measured temperature rise across a solid or liquid,

R_T is thermal resistance of a material and Q is heat flow transferred through solid or liquid.

A.2.2 Thermal network model

Figure A.1 shows a simplified thermal network model for a plug-in unit in subrack or chassis. In the figure, black points indicate the nodes represented temperature. The junction temperature T_J and the surface temperature Tc are calculated by:

$$T_J = T_A + \Delta T_A + \Delta T_{CA} + \Delta T_{JC}$$

$$T_C = T_A + \Delta T_A + \Delta T_{CA}$$

where

T_A is the intake air temperature, equivalent with reference temperature.

Air intake is measured 30 mm to 50 mm from the equipments air entry.

ΔT_A is the temperature rise between intake air and the surrounding air of any component on/in the plug-in unit;

ΔT_{CA} is the temperature rise between the surrounding air of any component on/in the plug-in unit and its surface ;

ΔT_{JC} is the temperature rise between the surface of any component on/in the plug-in unit and its junction.

Each temperature rise can be described with related thermal resistance as follows

$$\Delta T_A = R_A \times Q$$

$$\Delta T_{CA} = R_{CA} \times Pd$$

where

R_A is the thermal resistance along airflow between intake air and the air nearby component concerned;

Q is the total power dissipation of upstream components;

R_{CA} is the thermal resistance between the air nearby the component concerned and its surface;

Pd is the power dissipation of component concerned.

R_A is calculated by:

$$R_A = \frac{1}{\rho_{air} \quad C_{pair} \quad F}$$

where

F is the airflow volume.

Surface temperature of components mounted in plug-in units which are installed in sub-rack or chassis can be evaluated as temperature rise value, comparing the temperature with air temperature at the air intake. The elements of temperature rise consist of air temperature rise before a component concerned, and air temperature rise caused by the heat convection on the surface of the component. Both elements are determined using airflow volume or airflow speed calculated as the value dividing airflow volume by cross-section of airflow, and power consumption.

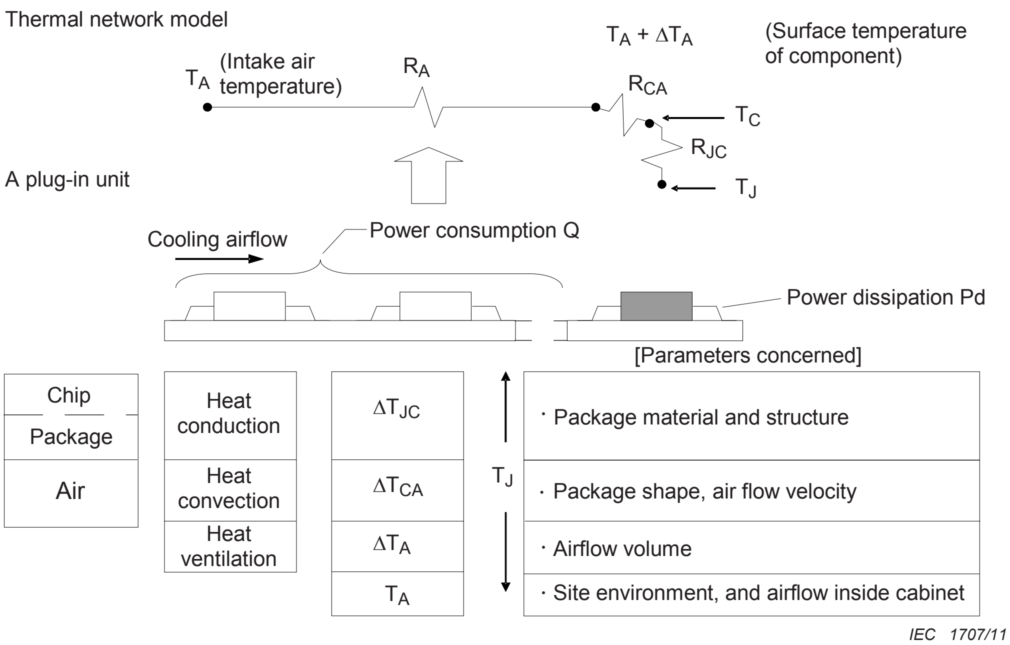


Figure A.1 – Thermal network model for a plug-in unit in subrack or chassis

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