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Edition 1.0 2009-09

TECHNICAL SPECIFICATION

colour inside

Mechanical structures for electronic equipment – Thermal management for cabinets in accordance with IEC 60297 and IEC 60917 series –
Part 1: Design guide: Interface dimension and provision for thermoelectrical cooling systems (Peltier effect)

IEC/TS 62610-1:2009(E)

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Mechanical structures for electronic equipment – Thermal management for cabinets in accordance with IEC 60297 and IEC 60917 series – Part 1: Design guide: Interface dimension and provision for thermoelectrical cooling systems (Peltier effect)

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

Part 1: Design guide: Interface dimension and provision for thermoelectrical cooling systems (Peltier effect)

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IEC 62610-1, 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/393/DTS	48D/405/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 the IEC 62610 series can be found, under the general title *Mechanical structures for electronic equipment – Thermal management for cabinets in accordance with IEC 60297 and IEC 60917 series*, on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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- withdrawn,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.

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INTRODUCTION

According to the Kyoto Protocol and to the directives of the European Parliament and of the Council, the usage of coolants with high potential for environmental pollution and global warming (Global Warming Potential (GWP) factor) is to be avoided.

The most promising alternatives to compressor cooling with e.g. R 134a are compressor cooling with CO_2, active cooling based on the Peltier effect and absorption cooling systems. Each of these techniques has its advantages and disadvantages.

The compressor cooling with CO_2 at the current state is more or less efficient, but high installation costs due to working pressures up to 100 bars makes this technique less interesting. Another disadvantage of CO_2 cooling systems occurs out of the physical properties of this coolant and requires additional cooling power to run this process. This fact reduces the degree of efficiency enormously.

The Peltier-effect seems to be very promising as the cooling effect is highly dependent of the properties of the material. Newly tested materials based on either porous materials or nano-structures show an improvement of the degree of efficiency. Furthermore, Peltier techniques do not need any kind of coolant and the only moving parts are the fans.

The absorption technique is a very intelligent way for cooling, but it is only profitable in combination with a heat-regenerator what makes absorption cooling system only feasible in very few applications.

For more details on mentioned alternatives for cooling, please see Annex A.

With respect to the demands of industry concerning high heat density/hotspots cooling, available space for the cooling systems, adapting to existing infrastructures, noise emission and respectively to the fact that conventional coolants like R 134a need to be replaced, this technical specification was initiated for the definition of dimensional interfaces and performances guidelines for thermoelectrical cooling systems based on the Peltier effect.

Three different arrangements for thermoelectrical cooling systems within cabinets, called “mounting locations”, have been regarded where locations 1 and 2 are feasible for cooling a whole cabinet and location 3 is for hotspot cooling inside the cabinet.

Below is the definition of each mounting location for thermoelectrical cooling systems within cabinets:

– mounting location 1: cabinet with inside or outside mounted thermoelectrical cooling system for the cooling of a whole cabinet;

– mounting location 2: cabinet with top mounted thermoelectrical cooling system for the cooling of a whole cabinet;

– mounting location 3: cabinet with inbuilt thermoelectrical cooling system in form of a subrack for hot spot cooling.

For a clear definition of interface dimensions and cooling performance guidelines, only cabinets from the IEC 60297 (19 inch) and IEC 60917 (25 mm) series have been regarded.

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

Part 1: Design guide: Interface dimension and provision for thermoelectrical cooling systems (Peltier effect)

1 Scope

This Technical Specification provides guidelines for the installation of thermoelectrical cooling systems (Peltier effect) within cabinets of the IEC 60297 (19 inch) and IEC 60917 (25 mm) series.

The cooling performance is in direct relation with the mounting location within a cabinet.

Three typical mounting locations are identified:

- mounting location 1: cabinet with inside or outside mounted thermoelectrical cooling system for the cooling of a whole cabinet;
- mounting location 2: cabinet with top mounted thermoelectrical cooling system for the cooling of a whole cabinet;
- mounting location 3: cabinet with inbuilt thermoelectrical cooling system in form of a subrack for hot spot cooling.

2 Normative references

The following referenced documents are indispensable for the application 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.

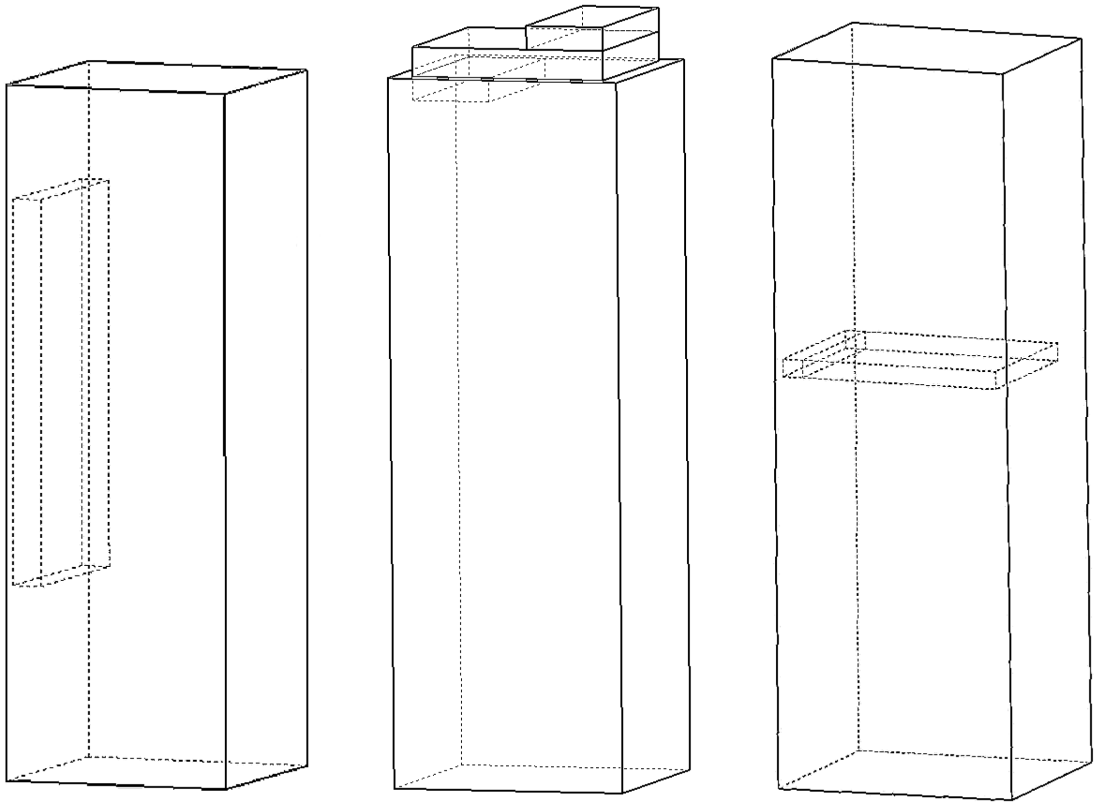
IEC 60297 (all parts), *Mechanical structures for electronic equipment – Dimensions of mechanical structures of the 482,6 mm (19 in) series*

IEC 60917 (all parts), *Modular order for the development of mechanical structures for electronic equipment practices*

3 Arrangement overview

Figure 1 illustrates the three mounting locations for thermoelectrical cooling systems.

NOTE This guideline for mounting thermoelectrical cooling systems applies to any width of cabinets. Second, the air flow management should satisfy the followings: no airflow short circuit depending on the equipment and the cable management inside the cabinet.



Mounting location 1:

cabinet with thermoelectrical cooling system inside or outside mounted for the cooling of a cabinet.

Mounting location 2:

cabinet with thermoelectrical cooling system top mounted for the cooling of a whole cabinet.

Mounting location 3:

cabinet with inbuilt thermoelectrical cooling system for hot spot cooling.

Figure 1 – Arrangement overview

4 Mounting location 1: cabinet with inside or outside mounted thermoelectrical cooling system in a vertical alignment

4.1 Cabinet with inside mounted thermoelectrical cooling system in a vertical alignment

4.1.1 General

Figure 2 illustrates the mounting positions of the thermoelectrical cooling system and the direction of the air circulation. For the individual application, the provided cabinet dimensions should be used as a reference.

4.1.2 Overview

Figure 2 compares inside mounted Peltier cooling systems versus external mounted Peltier systems.

The air inside the cabinet flows in vertical direction from the bottom to the top for optimal internal circulation.

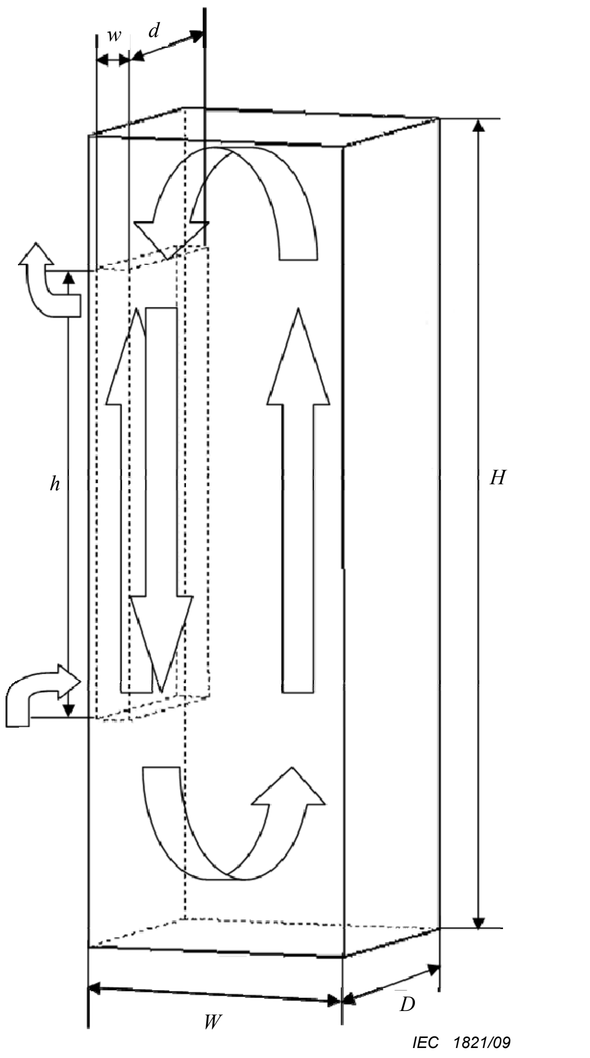


Figure 2a – Cabinet with inside mounted thermoelectrical cooling system in a vertical alignment

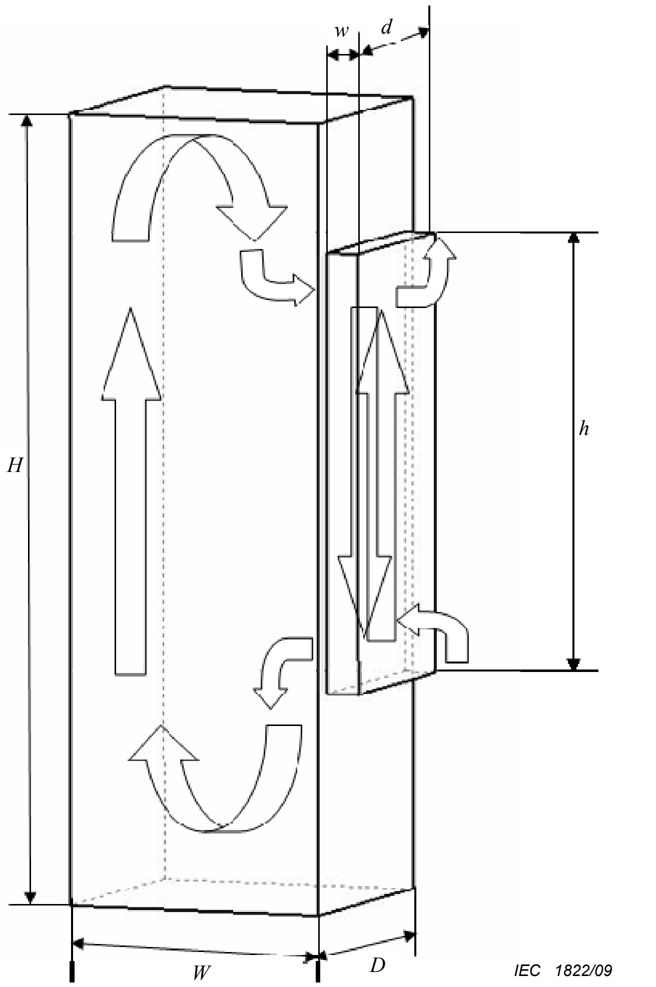


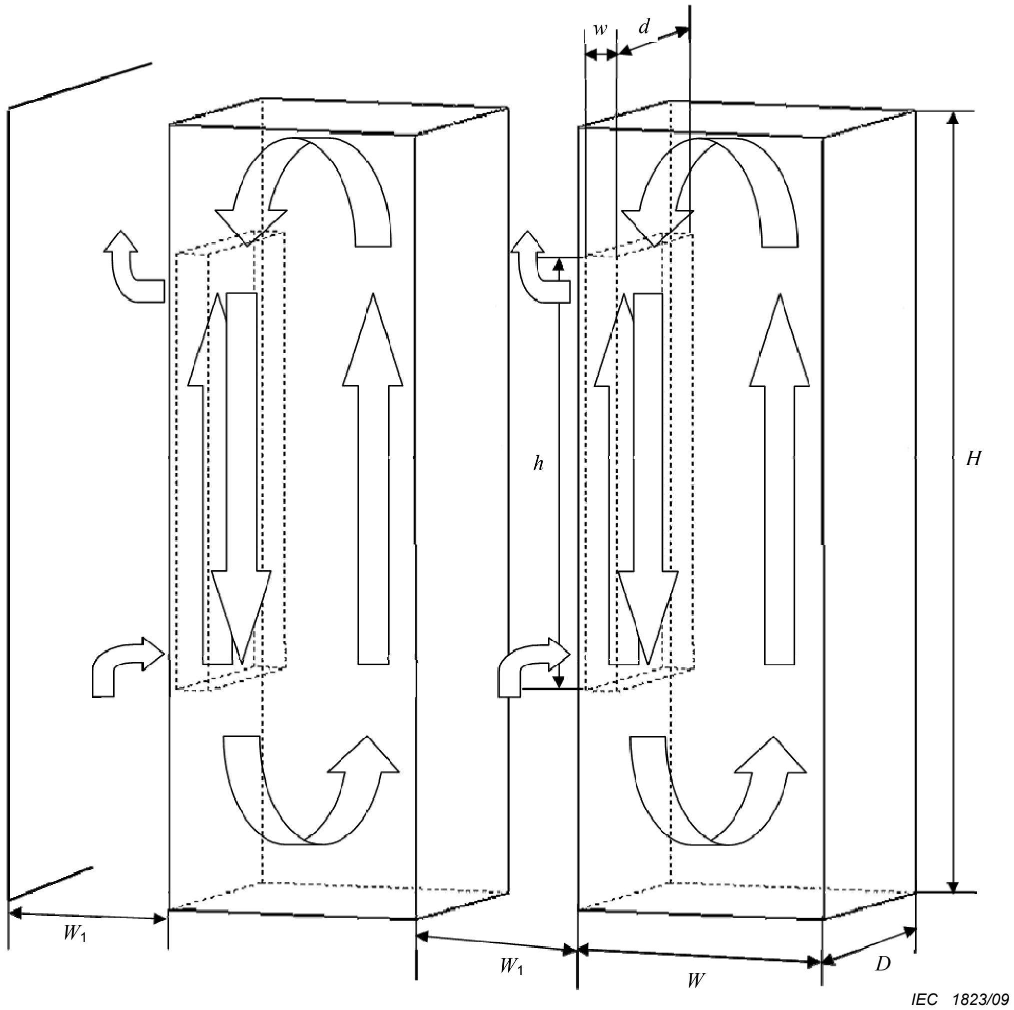
Figure 2b – Cabinet with outside mounted thermoelectrical cooling system in a vertical alignment

Key

W	width of the cabinet
D	depth of the cabinet
H	height of the cabinet
w	≤ 75 mm, width of the thermoelectrical cooling system
d	depth of the thermoelectrical cooling system
h	height of the thermoelectrical cooling system

Figure 2 – Mounting location 1

The required airflow space (W_1) between two cabinets or a cabinet and a wall (as shown in Figure 3) may be reduced by mounting the Peltier system inside the cabinet. For the given dimension of the cabinets by IEC 60297 series (19 inch) and IEC 60917 series (25 mm), the width w of the thermoelectrical cooling system must be less than 75 mm.



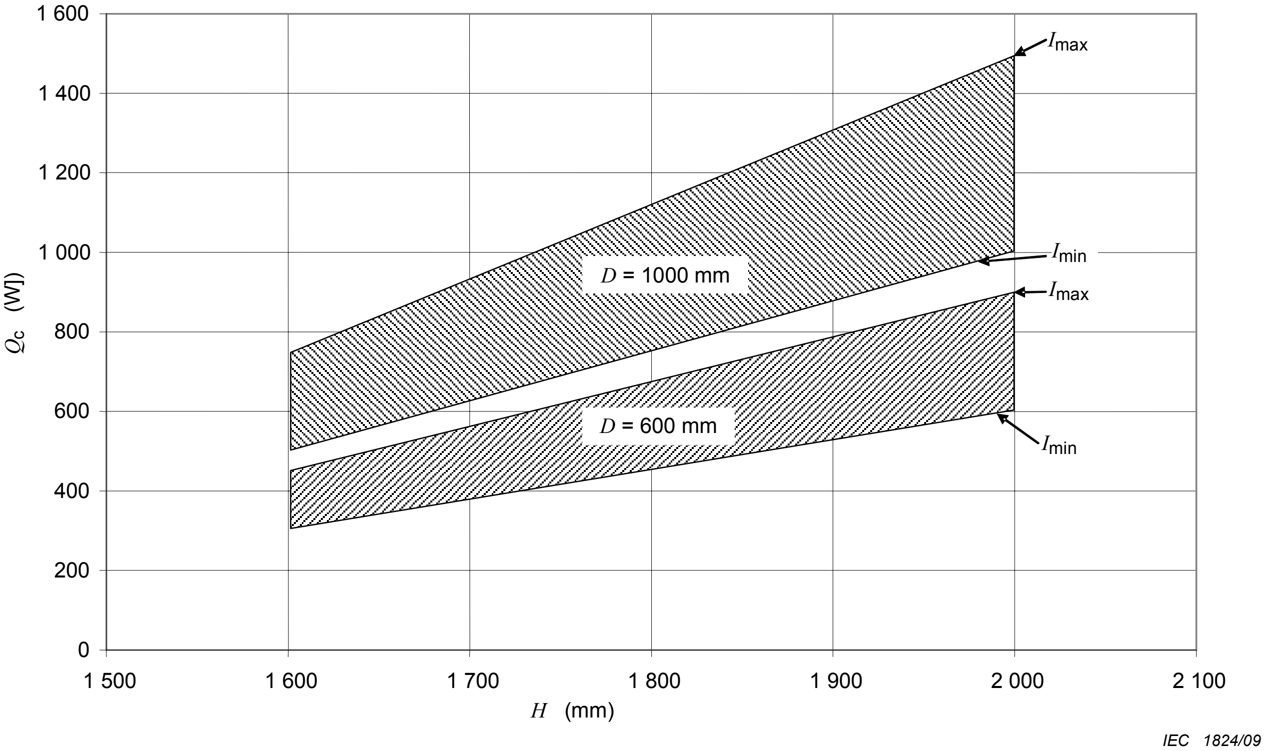
Key

W	width of the cabinet
D	depth of the cabinet
H	height of the cabinet
w	≤ 75 mm, width of the thermoelectrical cooling system
d	depth of the thermoelectrical cooling system
h	height of the thermoelectrical cooling system
W_1	distance between cabinets or distance between cabinet and wall

Figure 3 – Mounting location 1: arrangement of two cabinets with inside mounted Peltier system and minimized distance W_1

4.1.3 Performance guideline for cabinets with inside or outside mounted thermoelectrical cooling system

Figure 4 shows a cooling performance guideline of a cabinet with a vertically-aligned inside or outside mounted Peltier system. Due to the fact that the cooling power of Peltier elements is a function of the input of electrical power (current [A] and voltage [V]), the diagram illustrates two ranges of possible cooling powers in dependency of the given dimensions of a cabinet.



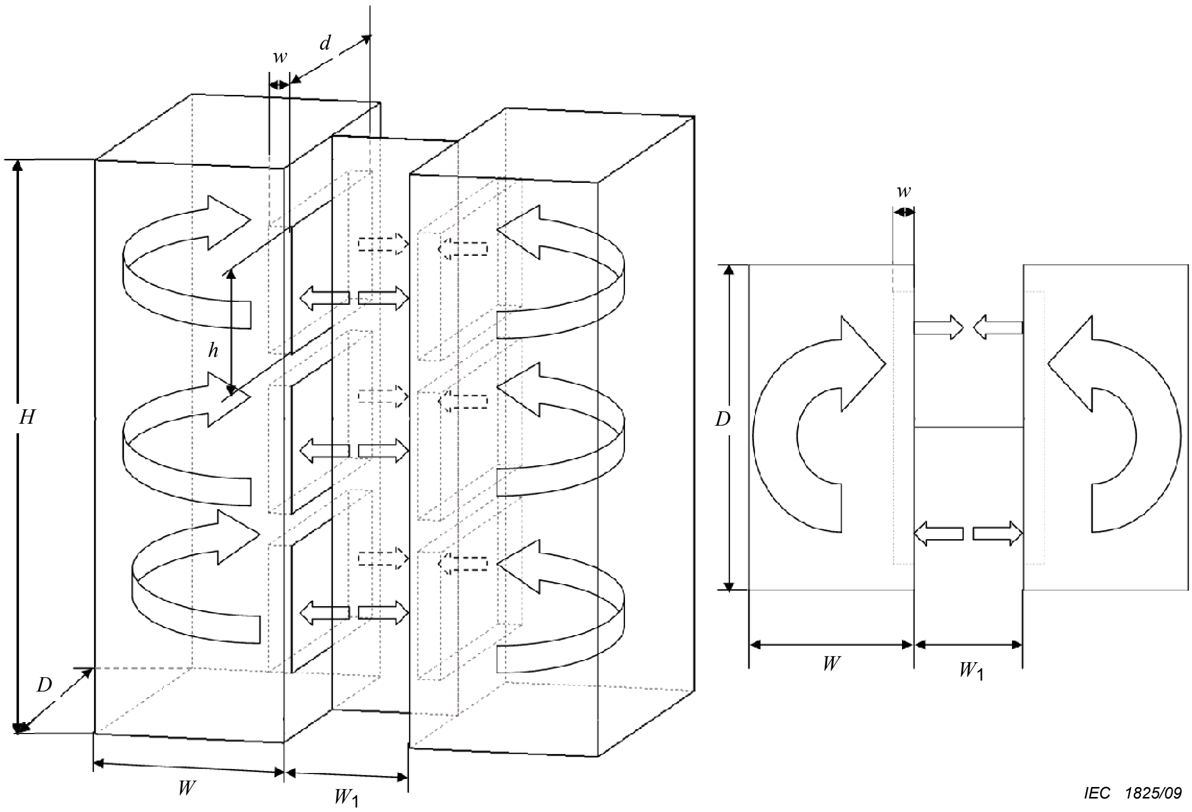
Key

I_{max}	maximum applied current to the thermoelectrical cooling unit
I_{min}	minimum applied current to the thermoelectrical cooling unit
Q_c	effective cooling power of the thermoelectrical cooling unit
H	height of the cabinet

Figure 4 – Performance guideline for cabinets with inside mounted thermoelectrical cooling system

4.2 Cabinet with inside mounted thermoelectrical cooling system in a horizontal alignment

This subclause is a guideline for mounting thermoelectrical cooling systems in a vertical alignment if the width W of the cabinets allows horizontal installation. The main advantage is an optimal air circulation inside the cabinet for best heat removal and an increase in the cooling intensity.



Key

W	width of the cabinet
D	depth of the cabinet
H	height of the cabinet
w	≤ 75 mm, width of the thermoelectrical cooling system
d	depth of the thermoelectrical cooling system
h	height of the thermoelectrical cooling system
W_1	distance between cabinets or distance between cabinet and wall

Figure 5 – Mounting location 1a: cabinet with side mounted thermoelectrical cooling system in a horizontal alignment

It is recommended to separate the outlet and the inlet of the external air circulation to prevent a short circuit of the cooling units.

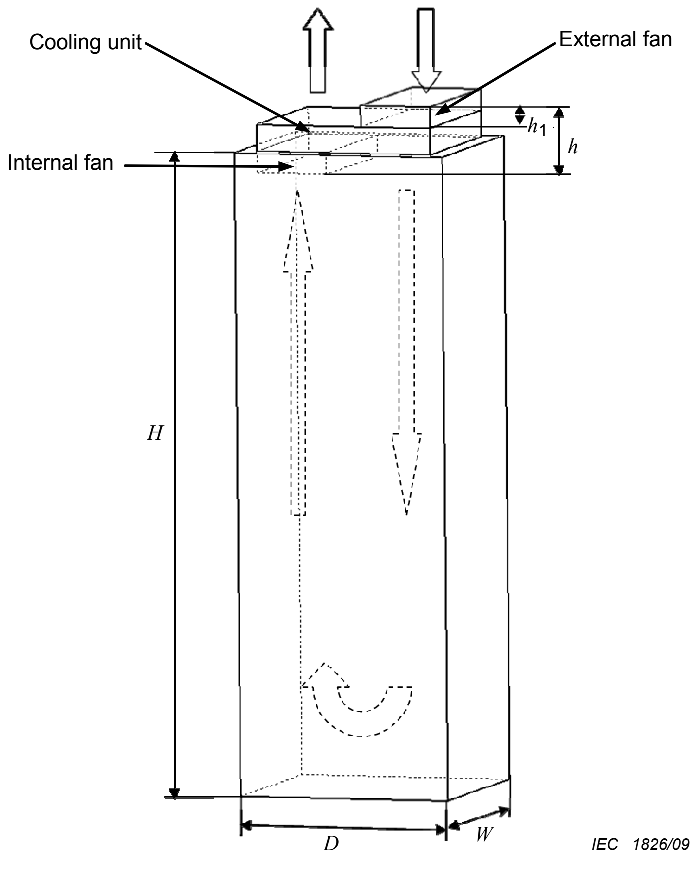
Moreover, the distance W_1 between the two cabinets or a cabinet and a wall shall be kept to a minimum. Therefore, mounting the cooling system inside the cabinet has a great advantage, but requires a depth of the cooling system less than $w \leq 75$ mm.

5 Mounting location 2: cabinet with top mounted thermoelectrical cooling system for the cooling of a whole cabinet

5.1 Overview

Figure 6 illustrates the principal application of a top mounted cooling system.

It shall be assured that the outlet of the cooled air stream allows an air circulation inside the cabinet. Nevertheless, the total height h of the thermoelectrical cooling system shall be less than 180 mm.



Key

W width of the cabinet

D depth of the cabinet

H height of the cabinet

d depth of the thermoelectrical cooling system

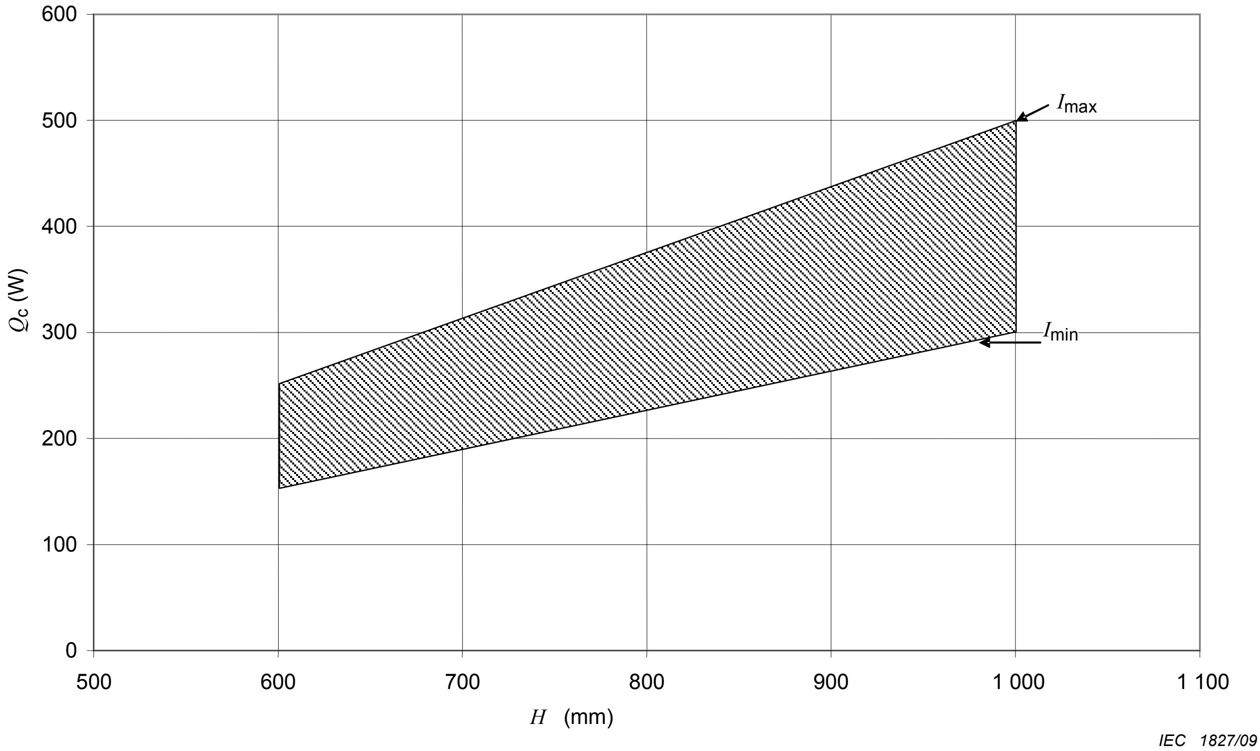
$h \leq 180$ mm, height of the thermoelectrical cooling system

h_1 height of the fan unit

Figure 6 – Mounting location 2: cabinet with top mounted thermoelectrical cooling system

5.2 Cooling performance in cabinets with top mounted thermoelectrical cooling systems

Figure 7 illustrates the performance guideline for a top mounted thermoelectrical cooling system in a cabinet with given dimensions *W* and *D*. The possible cooling power is limited to the dimension of the cooling system on the one side; on the other side the cooling power is dependent on the used electrical power for the Peltier elements. It is independent of the height *H* of the cabinet.



Key

I_{max} maximum applied current to the thermoelectrical cooling unit

I_{min} minimum applied current to the thermoelectrical cooling unit

Q_c effective cooling power of the thermoelectrical cooling unit

H height of the cabinet

Figure 7 – Performance guideline for a top mounted thermoelectrical cooling system

6 Mounting location 3: cabinet with inbuilt thermoelectrical cooling system for hot spot cooling

6.1 Overview

Figure 8 demonstrates the inbuilt thermoelectrical cooling system for hot spot cooling. This allows both an active cooling and a passive heat-exchanging. In passive mode, only the hot side fan of the thermoelectrical cooling system is on and transports fresh air from the inlet at the bottom through the cabinet to the air outlet on the (back-) side. In active cooling mode, both fans of the cooling system are operating. One air fraction is cooled and the second air fraction transports the heat outside the cabinet.

This inbuilt cooling system requires an air inlet and an air outlet in the cabinet and one assembly that connects the thermoelectrical cooling system with the cabinet. The air outlet dimensions in the cabinet are similar to the dimensions of the thermoelectrical cooling system w and h. The height H_B should be adapted individually to the mounted components in the cabinet for best performance of hot spot cooling.

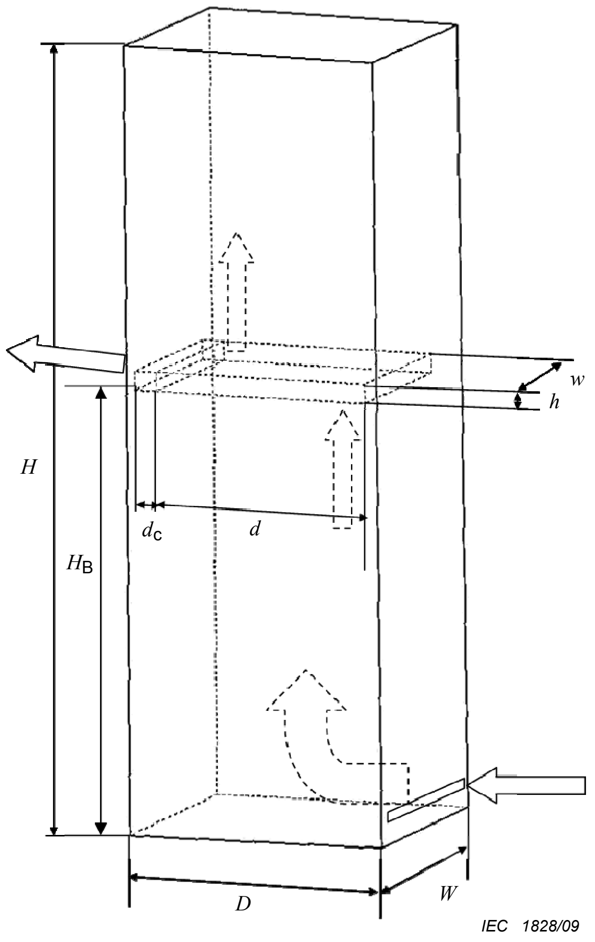


Figure 8a – Cooling operating mode

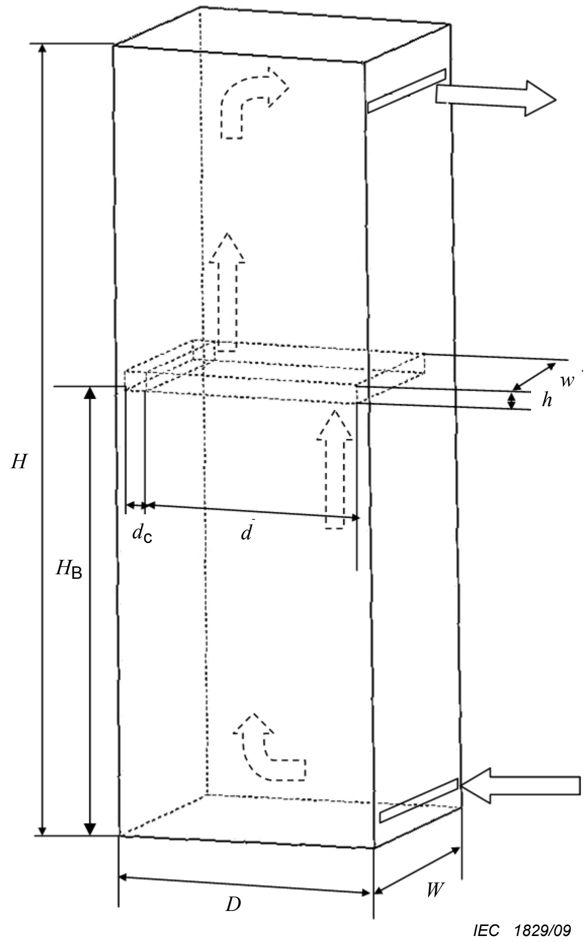


Figure 8b – Fan units operating mode

Key

W width of the cabinet

D depth of the cabinet

H height of the cabinet

d depth of the thermoelectrical cooling system

$h \leq 180$ mm, height of the thermoelectrical cooling system

$w \leq 75$ mm, width of the thermoelectrical cooling system

H_B and d_c are arbitrary (m^3/h)

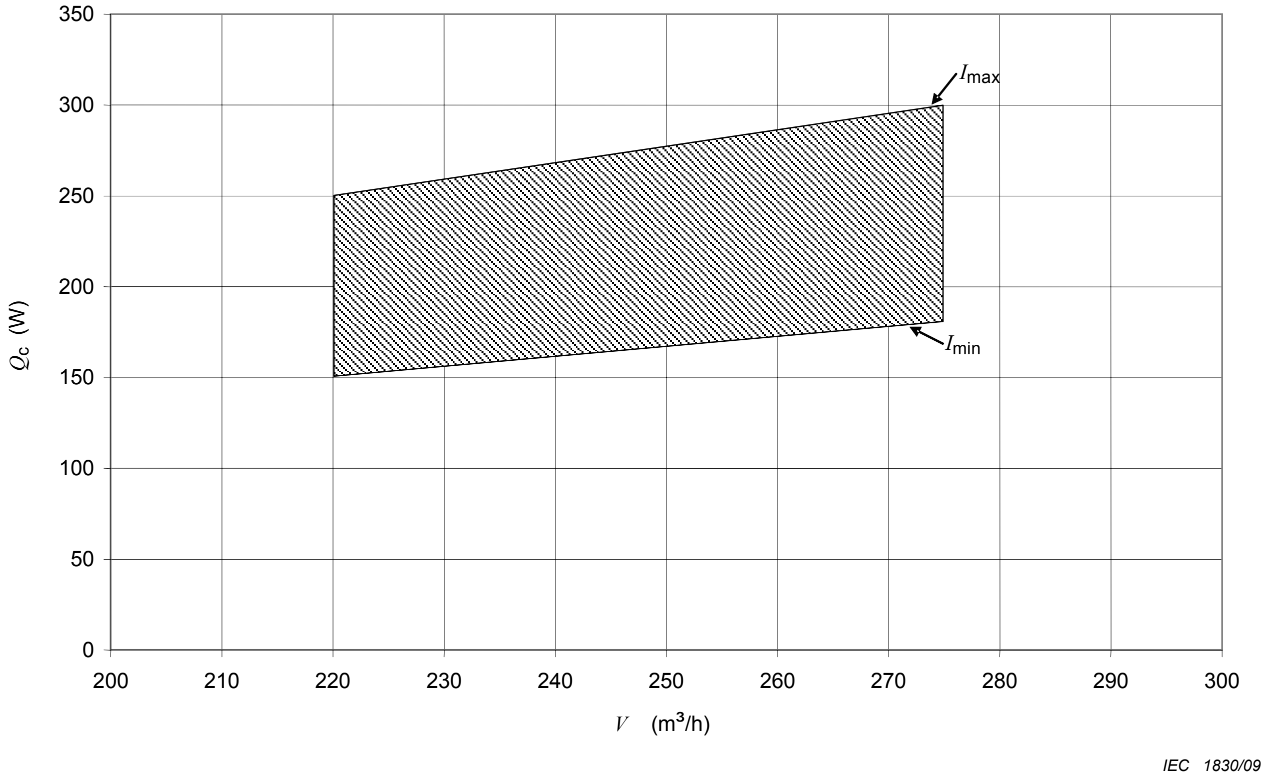
Figure 8 – Mounting location 3

According to the given dimensions of IEC 60297 series (19 inch) and IEC 60917 series (25 mm), the height h of the thermoelectrical cooling system shall be less than 1U (44,45 mm) and the width w shall be less than 19 inch (482,6 mm).

6.2 Cooling performance for an inbuilt thermoelectrical cooling system for hot spot cooling

Figure 9 illustrates the performance of an inbuilt thermoelectrical cooling system for hot spot cooling. The dimensions of the cooling system are given by IEC 60297 series (19 inch) and IEC 60917 series (25 mm) with h = 44,45 mm and w = 482,6 mm, and the depth d is limited to the depth D of the cabinet.

The following diagram shows a range of possible cooling powers for the active mode at a given cabinet depth of D = 600 mm.



Key

I_{max} maximum applied current to the thermoelectrical cooling unit

I_{min} minimum applied current to the thermoelectrical cooling unit

Q_c effective cooling power of the thermoelectrical cooling unit

V total airflow

Figure 9 – Performance guideline for inbuilt thermoelectrical cooling system for hot spot cooling

7 Remark

For the objective comparison of different cooling systems of different suppliers based on Peltier-Effect, it is necessary to develop a new technical specification for the measurement set up. The fact that this type of cooling system is dependent on several variables like airflows, voltage, materials of the Peltier elements, temperatures, and other effects such as the cooling power can vary in a huge range. With this measurement set up, it will be possible to maximize the efficiency of the cooling unit over a wide range of different operating conditions.

Annex A
(informative)

Heat management under environmental aspects

A.1 General

Both cooling and heating become more and more essential nowadays and the total amount of heat transferred increases every year. Cooling application range is very large, be it the domestic refrigerator, the water dispenser in the office, mini-bars in hotel rooms, the air conditioner in cars, trains and busses, cold stores in supermarkets, dry freezing in food industry, server rooms in information technology and many other applications.

Owing to greenhouse effect and global warming, conventional refrigerants became more and more disreputed, even some are already forbidden by law.

Since 1987, the usage of many conventional refrigerants had to be reduced and phased out according to the Montreal Protocol [1][1] on substances that deplete the ozone layer.

In the early 1990s, R 134a was introduced as a replacement for Dichlorodifluoromethane (R-12). It has insignificant ozone depletion potential (ozone layer), significant global warming potential (GWP = ±1 300) and negligible acidification potential (acid rain)[2].

Thus R 134a has been subject to use restrictions due to its contribution to climate change. In the EU, it will be banned as from 2011 in all new cars [3] for air conditioning in accordance with the Kyoto Protocol (1997) and the directives of the European Parliament and of the Council. California may prohibit the sales of canned HFC-134a to individuals to avoid non-professional recharge of air conditioners. A ban has been in place in Wisconsin since October 1994 under ATCP 136 prohibiting sales of container sizes holding less than 15 lbs of refrigerant [4]. More restrictions are to be expected in the future.

Therefore in the next years a lot of research has to been done to find cooling systems that meet all economic, ecologic and safety demands.

The main reason why Peltier technology is preferable as a thermoelectrical cooling system is given in the next clauses.

1 The figures in square brackets refer to the Bibliography.

A.2 Environmental aspects

The current CO_2 emission situation, illustrated in Figure A.1, shows the need of new "green" technology.

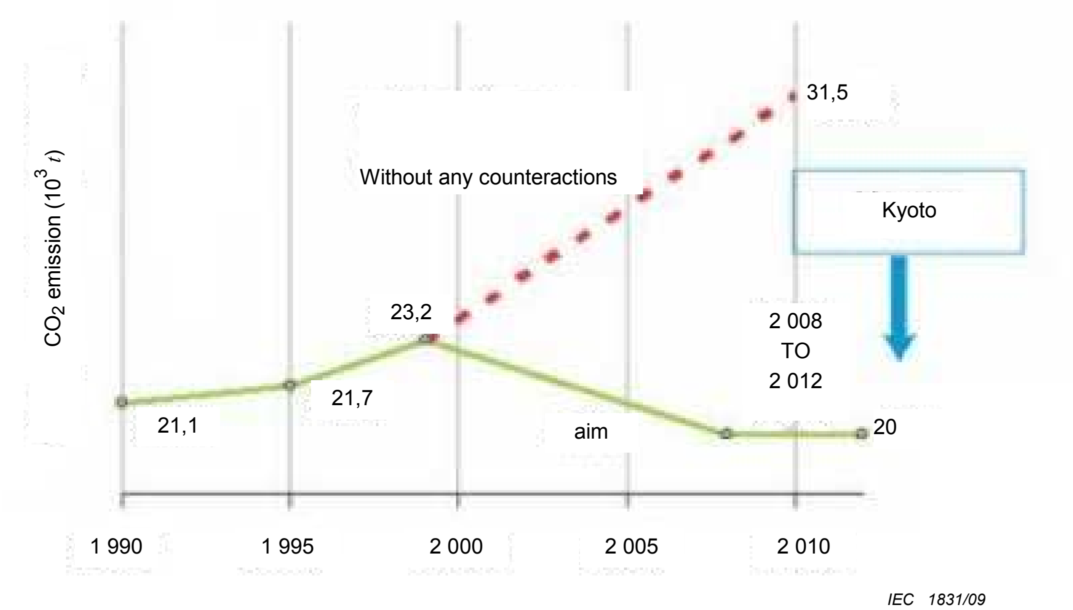


Figure A.1 – Current CO_2 emission situation

Figure A.2 illustrates the global concentration of carbon dioxide in the atmosphere. Therefore it is necessary to decrease the emission of CO_2. As thermoelectrical cooling systems based on the Peltier effect do not use any kind of refrigerant, this way of cooling reduces the emission of CO_2 and the emission of any ozone layer destroying substances. Furthermore the GWP value of Peltier cooling systems is 1 (compared to 1 340 of R 134a).

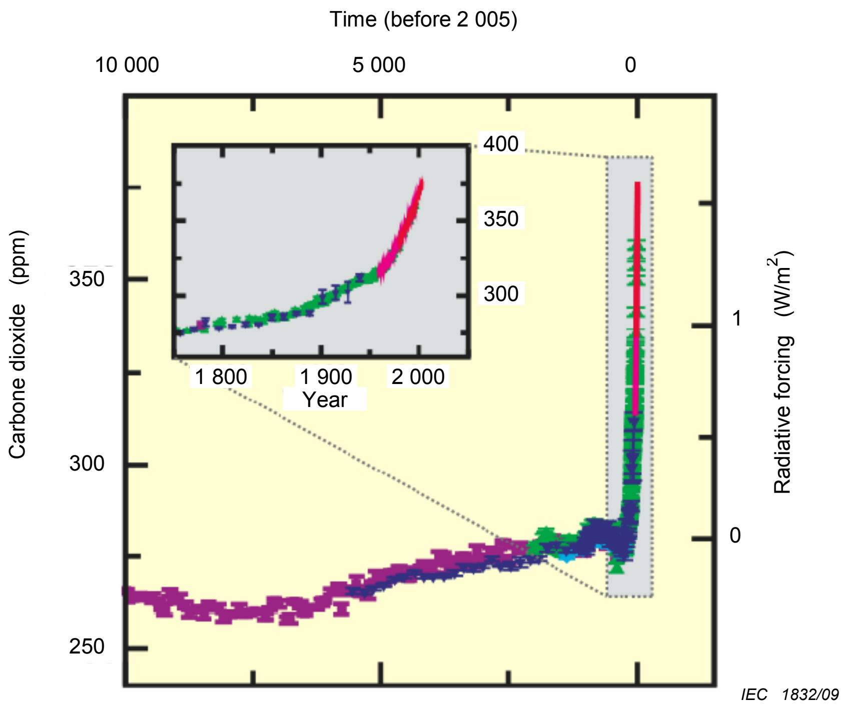


Figure A.2 – Changes in greenhouse gases from ice-core and modern data [5]

As shown in Figure A.3, the incoming and the outgoing radiation is not balanced at the moment, which leads to a positive sum of the incoming solar irradiance. This leads to the global warming.

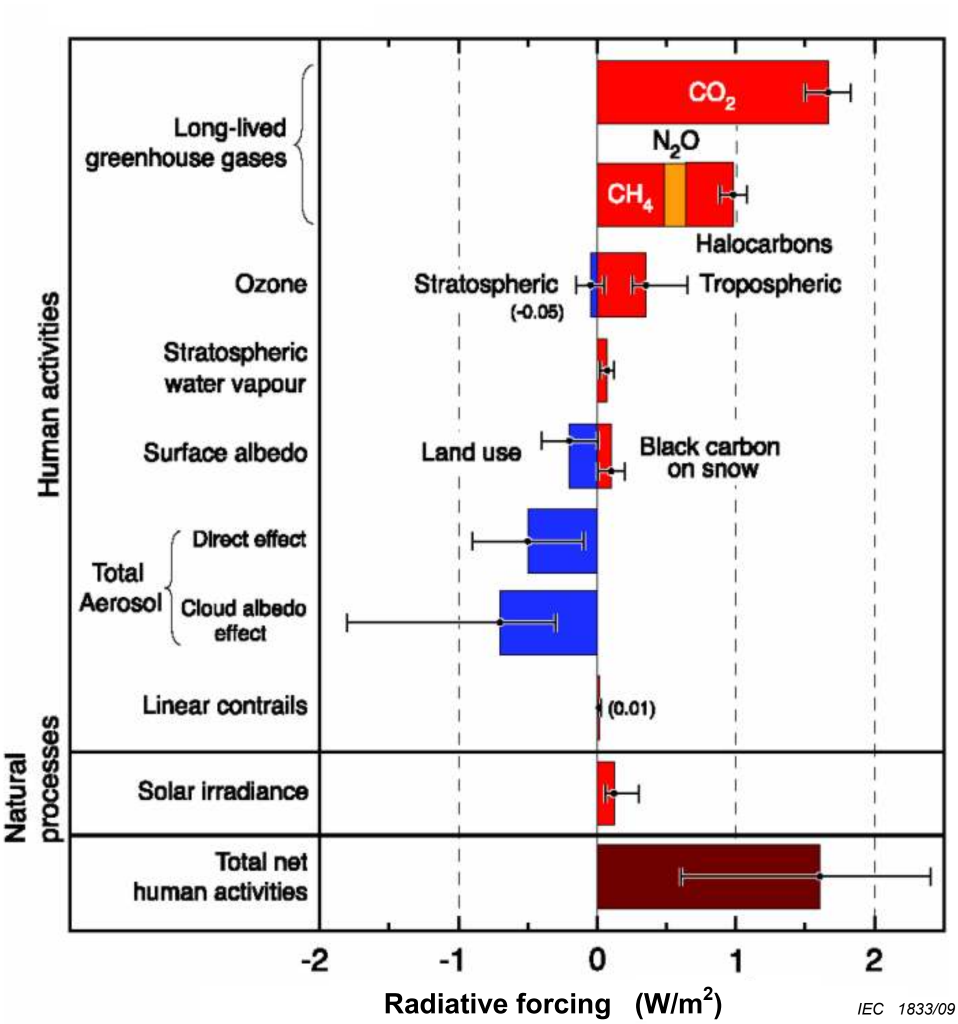


Figure A.3 – Radiative forcing of climate between 1750 and 2005 [4]

A.3 Application range

A.3.1 R 134a compressor cooling units

The range for effective cooling power is between 200 W and ±10 kW. There is a limitation by the ambient temperature. It should not be greater than 55 °C due to the thermodynamic properties of the refrigerants. The maximum working pressure is ±28 bar. The GWP is ± 1 300.

A.3.2 CO_2 compressor cooling units

The range for effective cooling power is between 200 W and ±10 kW. There is a limitation by the ambient temperature. It should not be greater than 31 °C due to the thermodynamic properties of the refrigerants. The maximum working pressure is ±100 bar. The GWP is 1.

A.3.3 Absorption cooling units

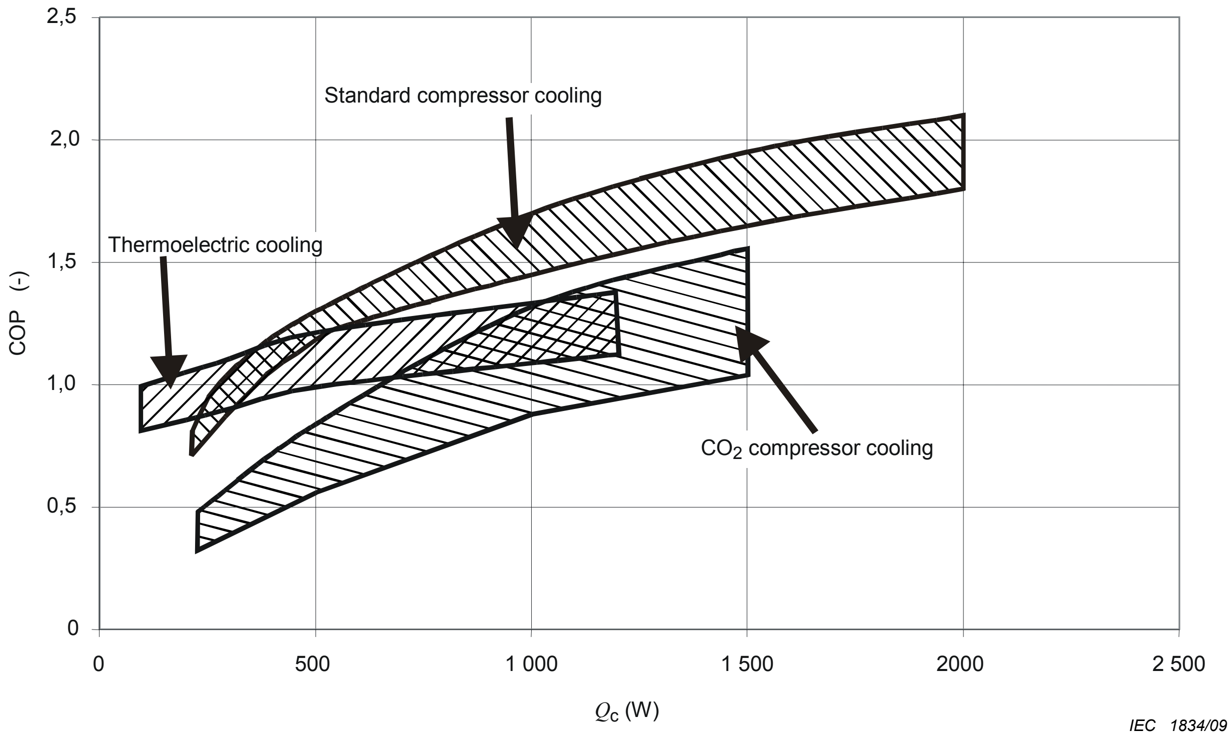
The range for effective cooling power is between 2 kW and up. There are only negligible limitations by temperature (ambient temperature of ±55 °C). The main problem is that for high COP a waste heat recovery is necessary.

A.3.4 Peltier cooling units

The range for effective cooling power is between 25 W and 1,2 kW. There is no limitation for the ambient temperature. Only the properties of the used materials of the cooling units limit the temperature range. The maximum working pressure is ±1 bar, as there is no use of any kind of refrigerant at all. The GWP is 1.

A.4 Technical aspects

According to EN 814 the boundary conditions for cooling units is set at a maximum ambient temperature of 35 °C and 50 °C, for safety reasons up to 55 °C. The effective cooling power is between ±50 W and 1 500 W.



Key

Q_c effective cooling power of the thermoelectrical cooling unit

COP coefficient of performance

Figure A.4 – Coefficient of performance depending on the cooling power at the boundary conditions of T_a = 50 °C

The COP for the steady state of different cooling system is a function of the ambient Temperature T_a as shown in Figure A.4. For lower ambient temperatures the COP increases for the CO_2 compressor cooling, whereas it decreases for the Peltier cooling system.

Figure A.5 illustrates that it is possible to decrease the total power consumption with an intelligent control system. Compressors are mostly controlled by a on/off switch whereas Peltier devices are powered by a d.c. current. For given fixed boundary conditions, the total power consumption of both cooling systems is the hatched areas shown in Figure A.5. Peltier cooling devices are able to work more efficiently depending on boundary conditions.

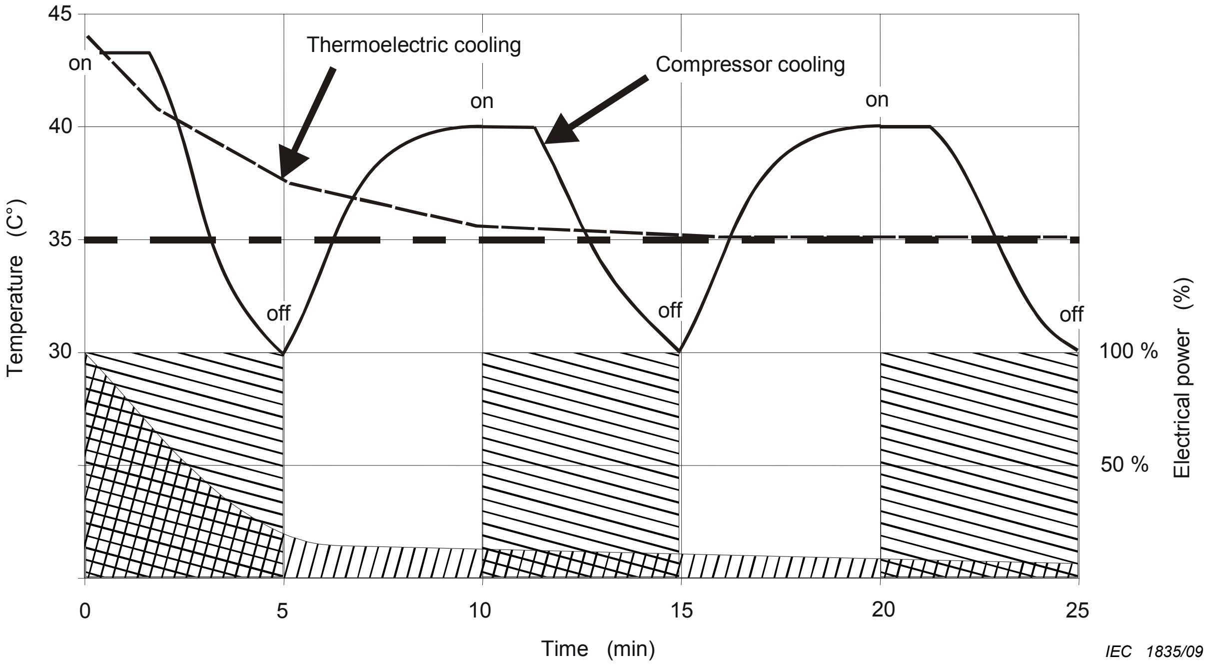


Figure A.5 – Electrical power usage of compressor cooling unit versus Peltier cooling unit at given ambient temperature and given heating dissipation to keep the internal temperature fixed

A.5 Summary

A comparison of the different cooling systems is given in the following Table A.1 by listing the advantages und disadvantages.

Table A.1 – Advantages and disadvantages of different cooling systems

Cooling process	Advantages	Disadvantages
134a compressor cooling	technically mature, high COP's, working pressure: 28 bars	GWP = 1 300, therefore forbidden in automotive industries
CO_2 compressor cooling	GWP = 1	low COP's, in developmental state, no phase change at the current state
Absorption cooling	GWP = 1	high COP only in combination with waste heat recovery.
Peltier cooling	no refrigerants at all, GWP = 1, no moving parts but fans, flat design, continuously control possible, low maintenance	COP depends on temperatures, range of cooling power is limited by 1,2 kW, at current state expensive

At the moment the disadvantages of Peltier cooling prevail because but the high investments in material research promises new Peltier devices with higher COP's. The newest results are to be presented at the 28th International Conference on Thermoelectrics and the 7th European Conference on Thermoelectrics in Freiburg, Germany on July 26 - 30, 2009 [2].

2 The official Internet website of this conference can be found under <http://ict2009.its.org>.

Bibliography

[1] United Nations Environment Programme (UNEP), <http://www.unep.org>

[2] Sydow L., Grimvall AB., Borén HB., Laniewski K., Nielsen AT., *Natural Background Levels of Trifluoroacetate in Rain and Snow*, Environmental Science & Technology, Issue 34: 3115–3118, doi:10.1021/es9913683 (2000)

[3] European Directive 2006/40/EC relating to emissions from air-conditioning systems in motor vehicles and amending Council Directive 70/156/EEC, <http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_161/l_16120060614en00120018.pdf>

[4] R744.com, *California restricts use of HFC-134a in cars*, article published on 2007-06-21 <http://www.r744.com/article.view.php?Id=494>

[5] IPCC Secretariat, *Climate Change 2007: The Physical Science Basis*, Switzerland

[6] EN 814:1997, *Air conditioners and heat pumps with electrically driven compressors – Cooling mode – Testing and requirements for marking*

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