BS EN 62610-4:2013

BSI Standards Publication

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

Part 4: Cooling performance tests for water supplied heat exchangers in electronic cabinets

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National foreword

This British Standard is the UK implementation of EN 62610-4:2013. It is identical to IEC 62610-4:2013.

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.

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Published by BSI Standards Limited 2013

ISBN 978 0 580 72855 6
ICS 31.240

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2013.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62610-4

November 2013

ICS 31.240

English version

Mechanical structures for electronic equipment - Thermal management for cabinets in accordance with IEC 60297 and IEC 60917 series - Part 4: Cooling performance tests for water supplied heat exchangers in electronic cabinets

(IEC 62610-4:2013)

Structures mécaniques pour équipements électroniques – Gestion thermique pour les armoires conformes aux séries CEI 60297 et CEI 60917 – Partie 4: Essais de performances de refroidissement pour les échangeurs de chaleur alimentés par de l'eau dans des baies électroniques
(CEI 62610-4:2013)

Mechanische Bauweisen für elektronische Einrichtungen - Wärmemanagement für Schränke nach den Reihen IEC 60297 und IEC 60917 - Teil 4: Kühlleistungsprüfungen für Wasser-Wärmetauscher in Elektronikschränken
(IEC 62610-4:2013)

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Foreword

The text of document 48D/542/FDIS, future edition 1 of IEC 62610-4, prepared by SC 48D, "Mechanical structures for electronic equipment", of IEC TC 48, "Electromechanical components and mechanical structures for electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62610-4:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-06-19
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-09-19

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60297	Series	Mechanical structures for electronic equipment - Dimensions of mechanical structures of the 482,6 mm (19 in) series	EN 60297	Series
IEC 60917	Series	Modular order for the development of mechanical structures for electronic equipment practices	EN 60917	Series

CONTENTS

INTRODUCTION

Electronic cabinets of the IEC 60297 and IEC 60917 series are used for the housing of electronic devices in many different fields of application. A wide field of application is represented by installations of communication networks with electronic devices in information technology (IT) environments. The classic way is to install rows of cabinets into defined foot print patterns and interconnect them via cables managed from overhead cable trays or raised floor cable management. So far, cooling has been facilitated by equipping the entire IT room with air conditioning in order to provide for air flow and air temperatures required for the safe operation of the electronic devices. With the growing heat load in data centers, this form of cooling has become more and more inefficient. Thermal problems with respect to high-performance electronic devices have become more difficult to solve. The environmental aspect is gaining crucial importance forcing us to cut down on wasting resources and to reduce CO_2 emissions.

Alternatives to the air conditioning of rooms need to be looked at more closely. Under the aspect of increasing cooling efficiency, there are some major concepts, two cases serve as examples here:

Case 1. The equipped group of cabinets, with dedicated temperature control.

This method is the cold aisles / hot aisles arrangement of a smaller number of cabinets, typically four to twelve. Its advantage over the air conditioning of rooms is the smaller air volume which allows a focused heat management with optimised dimensioning of power consumption for the cooling devices and increased temperatures in the warm zones of the room. In such cases, efficiency can be increased by adopting exhaust heat recovery for room heating in cold periods. Due to the improved energy efficiency contained aisles are becoming more and more popular.

Case 2. Single cabinets with water-air heat exchangers.

This method is used for cabinets accommodating high-performance/heat dissipating electronic equipment, typically servers and mainframe computers. Its advantage over the room air conditioning or cold aisles consists in the high degree of constant air inlet temperature for sensitive electronic devices. Closed air circulation within a cabinet allows a very precise temperature control. The power consumption aspect may be similar to that of the cold aisle, but the temperature control aspect is more important and favourable to a longer life-cycle of costly equipment.

This standard has been created for case 2: Cooling performance tests for water-supplied heat exchangers in single electronic cabinet configurations. The parameters with reference to the described test sample are shown in diagrams which may be useful to provide for a standardized calculation method for specific cabinet dimensions and heat exchanger cooling requirements. The typical required cooling capacity for such cabinets is normally higher than 12 kW. The described test methods of this standard address a cooling capacity of more than 12 kW. However, since IT equipment varies the heat load to a cabinet the test also considers values below 12 kW for partial heat load.

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

Part 4: Cooling performance tests for water supplied heat exchangers in electronic cabinets

1 Scope and object

This part of IEC 62610 specifies the test setup and test parameters for water supplied heat exchangers within single electronic cabinet configurations. The tests are focused on cabinets for the installation of high power dissipation electronic equipment. The cabinets concerned are from the IEC 60297 (19 in) and IEC 60917 (25 mm) series. The purpose of this standard is to provide comparable data for the cooling performance of cabinets according to defined test setups and cooling parameters.

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 60297 (all parts), *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 Terms and definitions, symbols and units

3.1 Terms and definitions

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

3.1.1
cooling capacity
$\dot{Q}$
removed heat load given by the electronic equipment mounted inside the electronic cabinet [kW]

3.1.2
absolute humidity
mass content of water (gram of water) per defined mass of dry air (kilogram of air) [g/kg] g of water per kg dry air

3.1.3
dummy
device to generate heat load similar to most common electronic devices in information technology: horizontal air flow with air intake at the front and air outlet at the rear side of the equipment.

Note 1 to entry: The air flow orientation is defined in IEC 60297 (19 in) and IEC 60917 (25 mm) standard series cabinet design.

3.1.4
sensible cooling
cooling capacity to provide air temperature change only. The absolute humidity of air in sensible cooling process is unchanged.

3.1.5
simplified test
this test method does not consider the influence of the heat transfer through the walls of the electronic cabinet nor the heat transfer by leaking air in and out of the housing of the electronic equipment

3.1.6
extended test
this test method does not consider the heat transfer by leaking air in and out of the housing of the electronic equipment

3.2 Symbols and units

P_{el}	electrical power consumption [kW]
T	Temperature [°C]
$\dot{Q}_{air}$	heat flow of the cooling air [kW]
v_{air}	air velocity (test result) [m/s]
A_{air}	air cross-section [m^2]
ρ_{air}	air density (related to 101,325 kPa air pressure) [kg/m^3]
$c_{p,air}$	specific heat capacity of air [kJ/kgK]
δT	temperature difference [K]
δT_{CW}	temperature difference of the chilled water between supply and return [K]
δT_{air}	temperature difference of the cooling air between equipment air inlet and air outlet [K]
f	factor based on specific heat capacity of water [l/s, l/min, m^3/h]
$\dot{Q}_{CW}$	heat flow in chilled water [kW]
$\dot{V}_{CW}$	chilled-water flow [l/s, l/min, m^3/h]
$\dot{Q}$	cooling capacity [kW]
$\dot{Q}_S$	cooling capacity of the IT equipment [kW]

4 Performance test for the heat exchanger

4.1 General

For testing the heat exchanger performance, the following parameters shall be applied:

The heat load of the dummy equipment shall be unchanged during the test. The heat dissipation of the heat load dummies shall be measured during the test and be recorded in the test report as the main result of the test according to Table B.1. The determination of the heat dissipation of the heat load shall be measured in accordance to the electrical power consumption.

During all measurements all control function and algorithm of the tested unit shall be disabled.

The air temperature in front of the electronic equipment (between its front panel and door) shall be in the range defined in Annex A, with a max. tolerance of ± 1 K at the different temperature sensors. The temperature difference between air inlet and air outlet of the dummy heat loads shall be equal or less than the temperature difference defined in Annex A. The measured temperature difference during the test shall be recorded in the test report. The temperature difference of the air temperature in the test report shall be determined with an accuracy of 0,2 K.

The maximum temperature difference between the chilled water supply temperature and air inlet temperature of the equipment dummies shall be equal or less than the temperature difference defined in Annex A. This temperature difference during the test shall be measured as average after all temperatures are stabilized. The measured temperature difference as test result shall be recorded as outlined in Table B.1. During the test the chilled water supply temperature can fluctuate within the range of 1 K. The temperature difference of the air temperature in the test report shall be determined with an accuracy of 0,1 K. The temperature difference of the water temperature in the test report shall be recorded within an accuracy of 0,1 K. See Table B.1.

During the test the pressure resistance of the air water heat exchanger between chilled water supply and chilled water return of the chilled water system shall not exceed the pressure difference defined in Annex A. This pressure resistance shall include all hydraulic components for the heat exchanger operation e.g. modulating valves, balancing valves, connectors. The pressure difference and the relation to the chilled water flow rate shall be recorded in the table and the chart in according Annex B.

The water temperature increase between heat exchanger in and out is a result of the test and shall be recorded in the test report in the table according to Annex B. The chilled water flow rate shall be recorded in the test report as a test result according to the table and chart in Annex B. The flow rate shall be selected to a value such that the maximum pressure difference according to Annex A is not exceeded. The flow rate shall be measured within a tolerance of ± 2 %. The measured pressure difference shall be recorded in the test report according to the table and chart in Annex B.

The air temperature of the test chamber shall be in the same range as the temperature inside the cabinet, in front of the electronic equipment.

For the determination of the test changing humidity conditions of the test room are not recognized. The cooling capacity is considered as 100 % sensible cooling. That means according the test room conditions described in 4.2.1 and the chilled water feed temperature tolerance of ± 1 K the chilled water feed temperature shall be higher than 12 °C. See Figure 1.

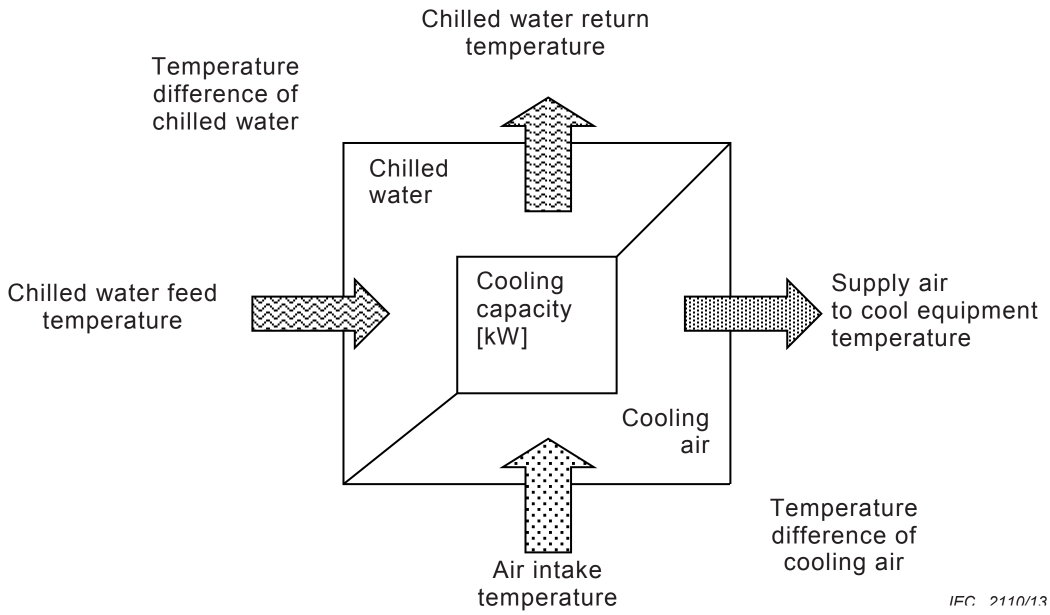


Figure 1 – Principle of the heat exchanger performance test

4.2 Test setup

4.2.1 Test room

The test sample (a closed cabinet for electronic equipment with a built-in air-water heat exchanger) is installed in an environment of precisely defined temperature and humidity, called a test room. This test room is expected to maintain the test conditions during testing within the required test conditions.

- air temperature of the test room equal to air inlet temperature of the equipment dummy [°C ± 2 K] see Annex A
- absolute humidity 8 g ± 0,5 g water per kg dry air (dew-point temperature 10,5 °C).

For the course of the test it is assumed that the absolute humidity inside the test room and inside the sample will be balanced with each other.

The test is to be performed at the standard air pressure of 101,325 kPa. Should that prove impossible, all airflows are to be recalculated in accordance with the air density altered in dependence on air pressure. Critical for the test is the air-mass flow resulting at an air pressure of 101,325 kPa. The enthalpy of the air needs to be calculated to the standard atmospheric pressure conditions.

4.2.2 Simulating the equipment heat load in the test sample

The test sample (cabinet) is to be populated with simulated electronic equipment, such as a server. The simulated electronic equipment is also referred to as “dummies”. The dummies are installed to the mounting points as provided for by the cabinets according to IEC 60297 and IEC 60917. The air-intake is at the front panel of the dummy and exits at the rear of the dummy. The dummies are designed in such a manner that a change in heat loss can be measured. The mechanical design of the heat load shall avoid any outgoing heat radiation (leaks).

The electrical power consumption by the dummies is to be recorded by measurement. The electrical power consumption shall be recorded in the test report according the table in

Annex B. It is assumed that the sample is charged by the entire electrical power in the form of heat load.

The airflow generated by the dummies shall be adjustable. During the test, the airflow is to be selected in such a way that the air pressure rise between the front and the rear of the dummies is less than the limit defined at Annex A. The dummy installation shall provide separation of the cold air zone and the warm air zone. The pressure difference between the front and the rear of the heat exchanger shall be recorded in the test report according to the table in Annex B.

4.2.3 Chilled-water flow rate and temperatures

During the test, the temperatures and the temperature difference between the chilled water supply temperature and chilled water return of the system shall be measured within a tolerance of 0,1 K.

The sample is to be supplied with water that is free from glycol and other chemical additives which would affect the specific cooling capacity of the chilled water.

The temperature increase between chilled-water supply and chilled-water return and the chilled water supply and return temperatures shall be recorded in the test report according the table in Annex B. The chilled water supply temperature shall be in a temperature range as defined in Annex A.

During the test the pressure resistance of the air water heat exchanger between chilled water supply and chilled water return of the chilled water system shall not exceed the pressure difference defined in Annex A. This pressure resistance shall include all hydraulic components for the heat exchanger operation e.g. modulating valves, balancing valves, connectors.

The water temperature increase between heat exchanger inlet and outlet is a result of the test and shall be recorded in the test report. The chilled water flow rate shall be recorded in the test report as a test result. The flow rate shall be selected to a value such that the maximum pressure difference according to Annex A is not exceeded. The pressure difference during the test shall be recorded in the test report as a result of the test according to the table in Annex B.

4.2.4 Measurement of the air temperature

The air temperature is to be measured at both the supply air inlet and exhaust air outlet of the dummies and the heat exchanger. A sufficient number of sensors shall be positioned in order to guarantee precision measurement. Initially, five air temperature sensors at the four sections (see Figures 2, 3 and 4) shall be provided. The four sections are:

1st the area in front of the dummies simulating the heat load of the electronic equipment at the air inlet side.

2nd the area at the air outlet side of the dummies.

3rd the area at the air inlet side of the heat exchanger

4th the area at the air outlet side of the heat exchanger

These sensors shall be positioned in the core volume flow.

Initially a minimum number of 5 temperature sensors it required. This number of sensors can be reduced if the measuring precision continues to be sufficient. Should further sensors be required for the purpose of precision, they are to be added to the test setup. For evaluating the test, the mean value is to be generated from the measured temperatures. The variation of the temperatures of each side of the dummy equipment shall be less than $\pm$1 K.

The air temperature in front of the electronic equipment (between its front panel and door) shall be within the range defined in Annex A. The temperature difference between air inlet and air outlet of the dummy heat loads shall be equal or less than the temperature difference defined in Annex A. The measured temperature difference during the test shall be recorded in the test report. The temperature difference of the air temperature in the test report shall be recorded with an accuracy of ± 0,2 K.

4.2.5 Temperature difference between chilled water supply and equipment air inlet temperature

The cooling capacity of the dummy equipment shall be selected in such a way that the temperature difference between chilled water supply and dummy equipment air inlet temperature stays within a temperature range as defined in Annex A. The temperature difference between chilled water supply and dummy equipment air inlet temperature during the test shall be recorded in the test report according to the table in Annex B.

4.3 Assessment of the heat exchanger performance

4.3.1 Determination of the cooling capacity by means of simplified tests

A simplified test method for determining the cooling capacity of closed cabinets assembled with electronic equipment to be cooled is based on the assumption that the cooling capacity of the heat exchanger is larger than the heat absorption of the cabinet panels. The simplified test method can be applied to cooling capacities of more than 12 kW. As a condition of the test the heat absorption of the cabinet panels should be less than 600 W (<5 %). For all other test conditions (in particular heat loads less than 12 kW) applicable tests are described in 4.2.2 and 4.2.3.

The cooling capacity of the heat exchanger is based on an electronic equipment air intake temperature shown in Annex A, with ± 0,2 K as mean value. The useful cooling capacity can now be measured via the heat load dummies.

Fans used in the sample cabinet under test shall run at normal rpm as indicated by the manufacturer. Fan redundancy concepts shall not affect the test and are not covered by this standard.

The test setup conditions as described in 4.2 shall be met.

$$P_{el} = \dot{Q} \tag{1}$$

The fans in the sample shall be run at nominal speed. If the sample design provides for redundancy for the fans, the fan speed is to be selected during the test in such a way that fan redundancy is not impaired during the determination of the cooling capacity. For the purpose of checking, the fan performance is to be compensated in accordance with redundancy and can be switched off for another test. In doing so, the cooling capacity shall not be compromised.

Furthermore, the test conditions as described in 4.2 shall be met.

$\dot{Q}$ cooling capacity [kW]

P_{el} electrical power consumption [kW]

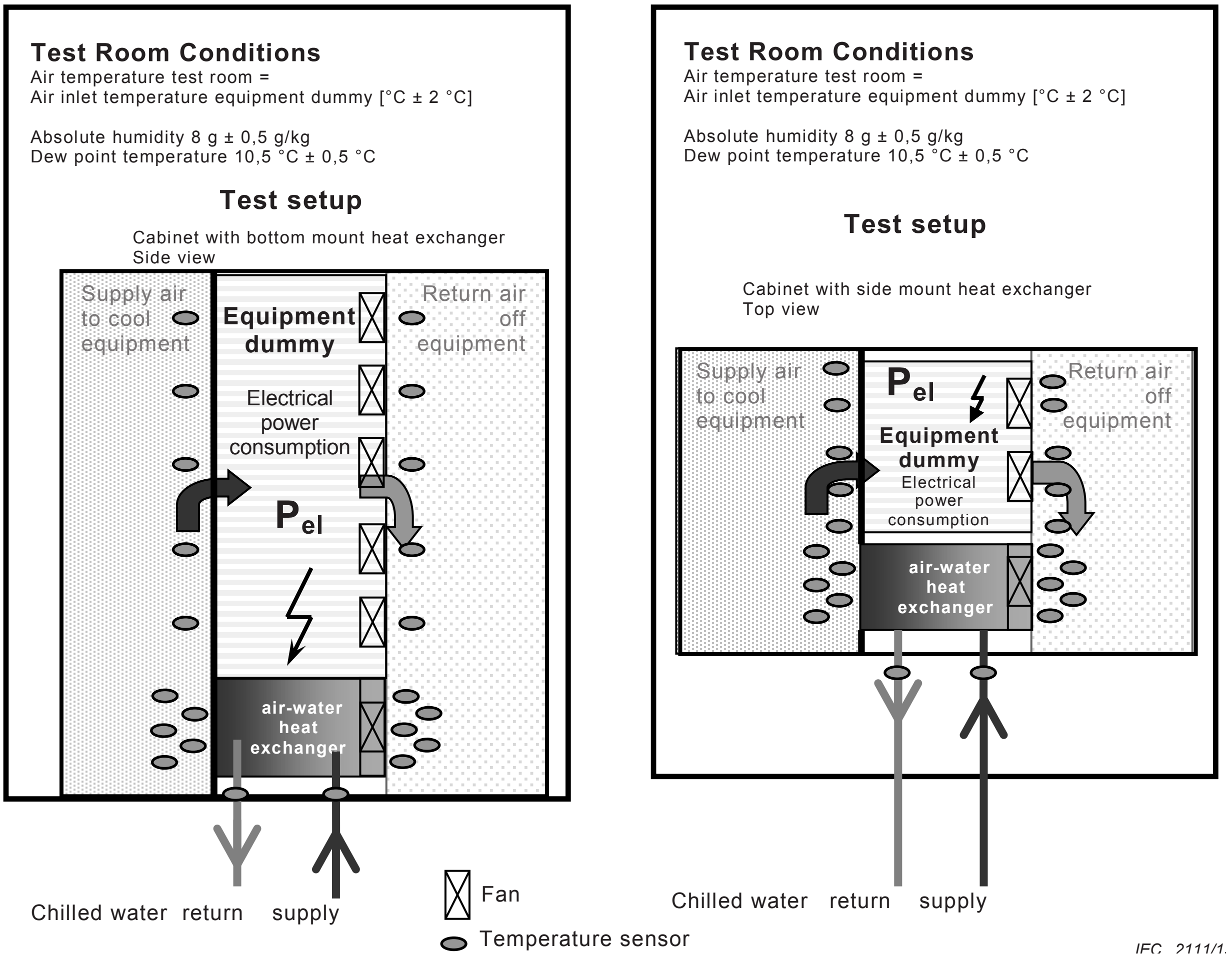


Figure 2 – Test setup of simplified tests

4.3.2 Determination of the cooling capacity by way of an extended test

According to the extended test method, the heat flow which is discharged from the sample with the help of chilled water is recorded. This allows the calculation of the difference between the heat load applied and the heat flow released by cold water to yield the heat flow discharged via the housing shell. This heat flow is usually caused by convection at the covering parts of the sample cabinet. Furthermore, air leakage flows from the sample may cause material-borne heat transfer. This test method allows test results below 12 kW as an additional informative result.

According to the extended test method, the actual temperature increase of the chilled water return of the test sample is recorded. Accordingly, the difference between the dissipated heat absorbed by the chilled water system and the heat absorbed by the cabinet covers can be calculated.

It is to be noted that unwanted air leakage of the cabinet may effect the calculation negatively.

To establish the temperature increase of the chilled water return it is necessary to measure the chilled water flow rate. The chilled water flow rate shall be measured within ± 2 %. The (heated) chilled water return shall be calculated as follows:

$$\dot{Q}_S = P_{el} - \dot{Q}_{CW} \quad (2)$$

The determination of the heat flow which is discharged from the sample by way of chilled water requires the measurement of the water flow. The water flow is to be measured at a precision of ± 2 %. The heat flow to be determined is calculated as follows:

$$\dot{Q}_{CW} = \dot{V}_{CW} * f * \delta T_{CW} \quad \text{at } \dot{Q}_{CW}\left[kW\right] \tag{3}$$

Based on the given measurement unit of the flow rate the f factor implements the specific heat capacity to formula 3 as follows.

f = 4,19 at $\dot{V}_{CW}\left[\frac{l}{s}\right]$ determining the chilled water flow rate in $\left[\frac{l}{s}\right]$

f = 0,070 at $\dot{V}_{CW}\left[\frac{l}{\min}\right]$ determining the chilled water flow rate in $\left[\frac{l}{\min}\right]$

f = 1,16 at $\dot{V}_{CW}\left[\frac{m^3}{h}\right]$ determining the chilled water flow rate in $\left[\frac{m^3}{h}\right]$

The test conditions as described in 4.1. and the method as described in 4.2.1. apply to determining the cooling capacity.

The heat flow leaving the sample by way of chilled water applies to determining the cooling capacity.

$$\dot{Q} = \dot{Q}_{CW} \tag{4}$$

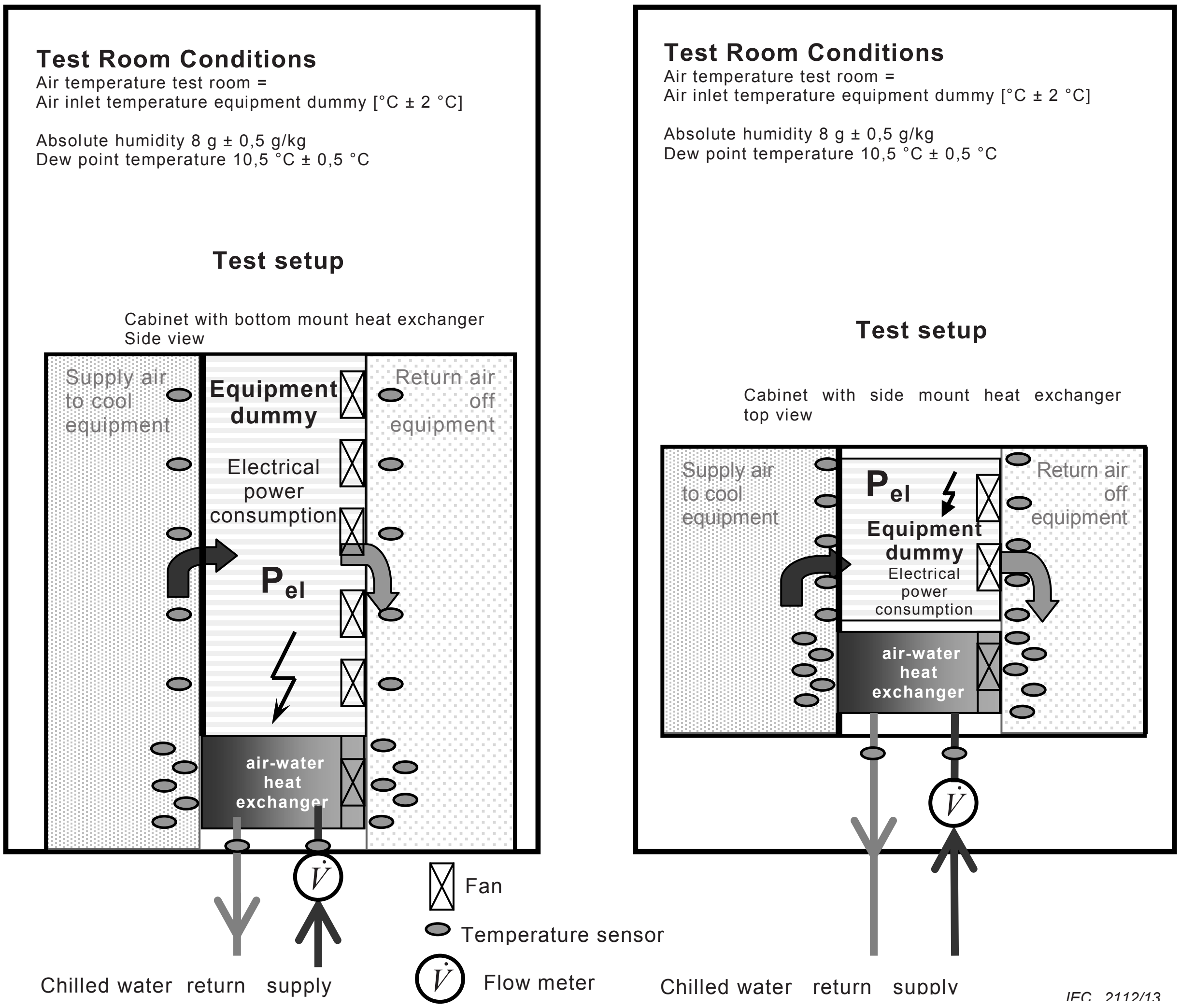


Figure 3 – Test setup of extended tests

4.3.3 Complete identification of the cooling capacity

In addition to the determination of the heat flow leaving the sample by means of cooling water, the heat flow that is passed into the heat exchanger as well as the cooling air can be determined. This heat flow should correspond with the heat flow that leaves the sample as cooling capacity by way of chilled water.

A difference detected between the two air flows taken of the same sample may be caused by air leakage. Should the difference between both heat flows be larger than 5 %, the sample needs to be checked for its setup, particularly for its internal air leakage volume. The amount of air leakage is to be reduced to be max. within 5 %.

The determination of the heat flow of the cooling air requires measuring the air flow at either the air inlet into the heat exchanger or the air outlet from the heat exchanger. By means of suitable measurement instruments, the air flow rate is measured at several measuring spots in a defined flow cross-section, and its mean value is calculated. The measuring instrument shall not affect the air flow in the sample. The result is the volume per time increment of cooling air passing the heat exchanger. Since the measurement of the air flow rate is carried out to measure the air velocity in a defined cross-section area formula 5 considers the flow rate input as a factor of cross-section and air velocity. This test method allows test results below 12 kW as an additional informative result.

$$\dot{Q}_{air} = v_{air} * A_{air} * \rho_{air} * c_{p,air} * \delta T_{air} \quad (5)$$

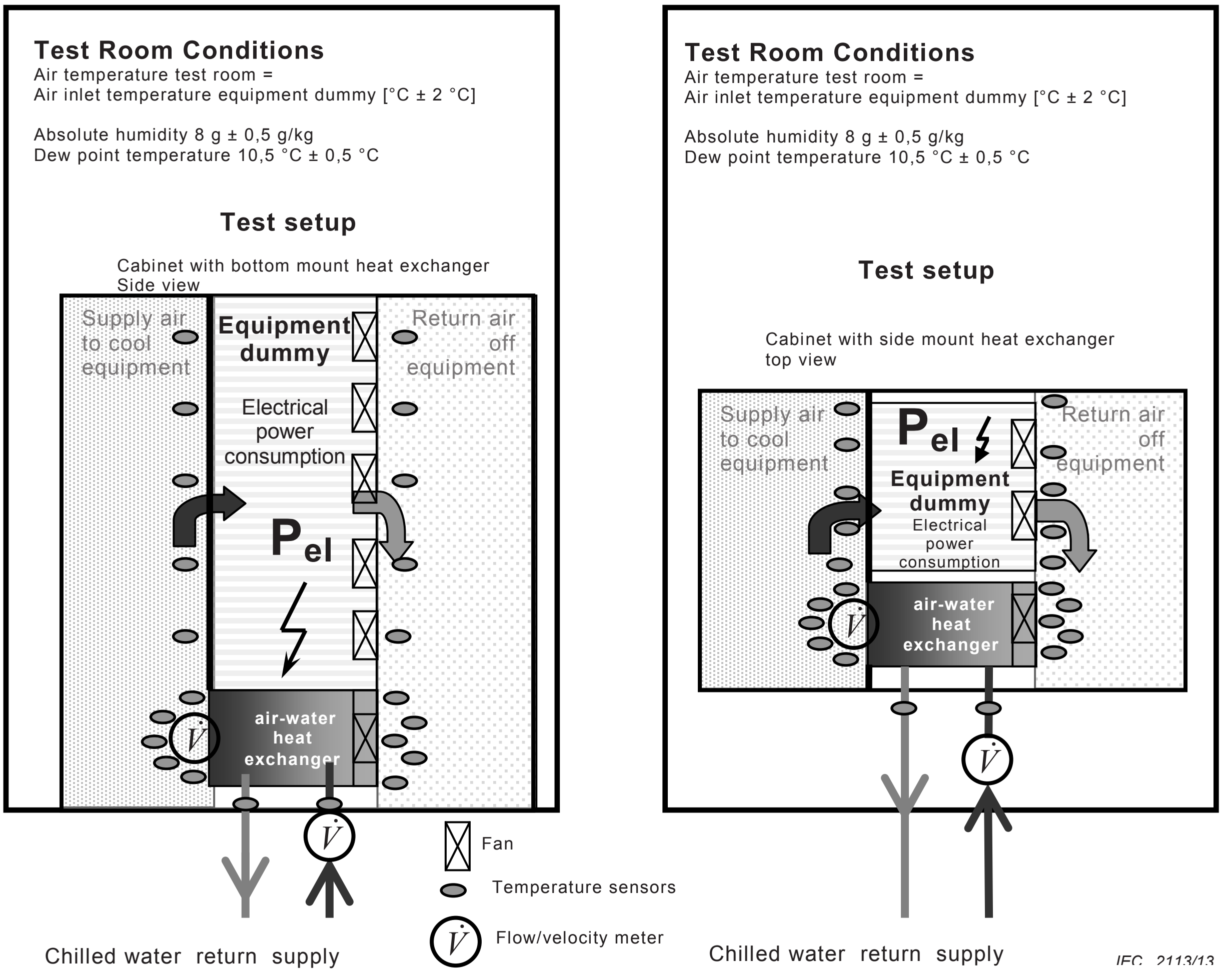


Figure 4 – Test setup, test for complete identification of the cooling capacity

4.4 Electrical power consumption

During the test of the cooling system the electrical power consumption shall be measured. As a test result, a diagram of the electrical power consumption versus cooling capacity shall be provided (see Figure 5).

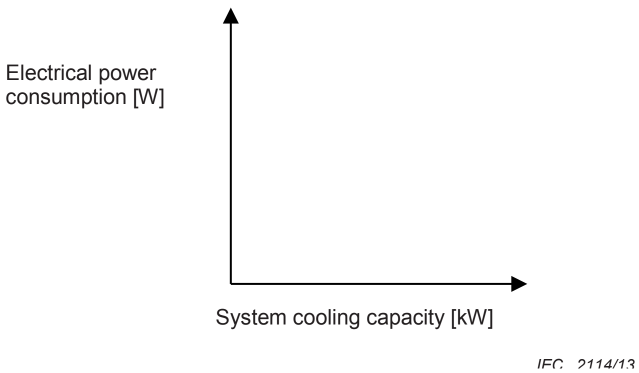


Figure 5 – Diagram of electrical power consumption versus cooling capacity

4.5 Water circuit pressure resistance

The test shall provide a diagram of the pressure resistance in the chilled water circuit (see Figure 6).

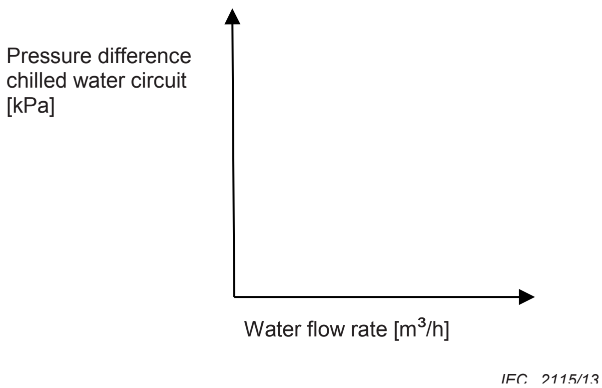


Figure 6 – Diagram of water pressure resistance versus water flow rate

Annex A
(normative)

Test conditions

A.1 Closed air loop air to water heat exchanger for high density cooling systems for IT equipment and server cooling

Air intake temperature of the dummy equipment: 18 °C to 27 °C.

Temperature difference between air intake and air outlet of the equipment dummy: 20 K or less.

Temperature difference between air intake temperature into the equipment and chilled water supply temperature: 10 K or less.

Chilled water supply temperature shall stay between 12 °C and 25 °C.

During the test the pressure resistance of the air water heat exchanger between chilled water supply and chilled water return of the chilled water system shall not exceed 100 kPa.

This pressure resistance shall include all hydraulic components for the heat exchanger operation e.g. modulating valves, balancing valves, connectors.

The pressure difference between front sides and the rear side of the dummy equipment shall between 0 Pa and 10 Pa ± 1 Pa.

A.2 Closed air loop cooling systems for industrial/telecom air to water heat exchangers

Air intake temperature of the dummy equipment: 35 °C to 55 °C.

Temperature difference between air intake and air outlet of the dummy equipment: 25 K or less.

Temperature difference between air intake temperature and chilled water supply temperature: 10 K or less.

Chilled water supply temperature shall stay between 12 °C and 25 °C.

During the test the pressure resistance of the air water heat exchanger between chilled water supply and chilled water return of the chilled water system shall not exceed 300 kPa.

This pressure resistance shall include all hydraulic components for the heat exchanger operation e.g. modulating valves, balancing valves, connectors.

The pressure difference between front sides and the rear side of the dummy equipment shall between 0 Pa and 20 Pa ± 1 Pa.

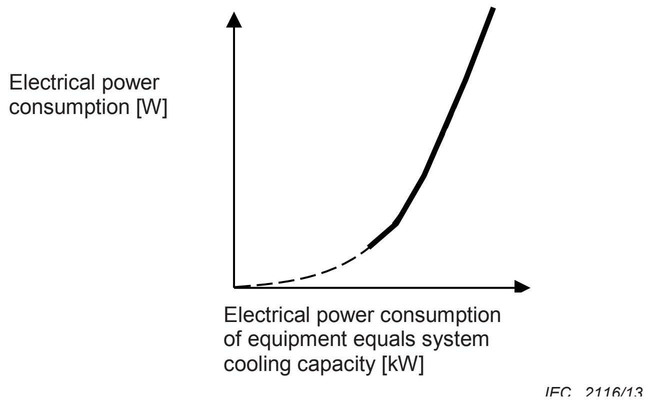
Annex B
(normative)

Test results

B.1 Test result recording template

Table B.1 – Test result recording template

Electrical power consumption of the equipment dummies:	[kW]
Total electrical power consumption of the unit:	[W]
Chilled water supply temperature:	[°C]
Chilled water return temperature:	[°C]
Temperature increase between chilled water supply and return	[K]
Chilled water flow rate	$\left[\frac{m^3}{h}\right]$, $\left[\frac{l}{\min}\right]$ or $\left[\frac{l}{s}\right]$
Chilled water system pressure difference Diagram see Figure 6	[kPa]
Air temperature at equipment dummy air inlet	[°C]
Air temperature at equipment dummy air outlet	[°C]
Temperature difference between air inlet and air outlet at the equipment dummy	[K]
Pressure difference between front sides and the rear side of the dummy	[Pa]
Cooling capacity	**[kW]**



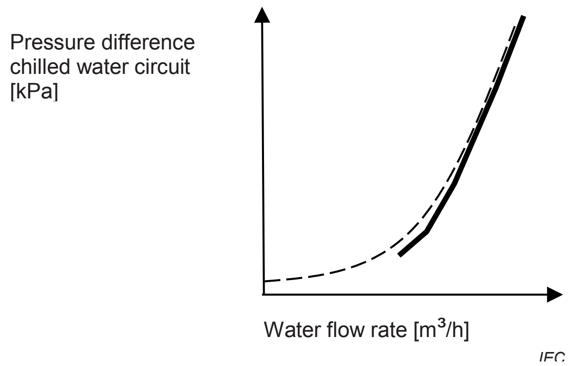


Figure B.1 – System cooling capacity and water flow rate

B.2 Test result recording template

Table B.2 – Test for closed air loop air to water heat exchanger for high density cooling systems for IT equipment and server cooling

Electrical power consumption of the equipment dummies:	35 kW
Total electrical power consumption of the unit:	1 500 W
Chilled water supply temperature:	12,2 °C
Chilled water return temperature:	18,2 °C
Temperature increase between chilled water supply and return	6,0 K
Chilled water flow rate	5,0 $\frac{m^3}{h}$
Chilled water system pressure difference Diagram see Figure 6	60 kPa
Air temperature at equipment dummy air inlet	21,0 °C
Air temperature at equipment dummy air outlet	40,3°C
Temperature difference between air inlet and air outlet at the equipment dummy	19,3 K
Pressure difference between front sides and the rear side of the dummy	5 Pa
Cooling capacity	**35 kW**

Test passed:
All conditions according Clause A.1 are in the allowed limits.

Test performed according to 4.3.1 (simplified tests).

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