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Testing methodologies of refrigerating devices for insulated means of transport

Part 1: Mechanical cooling device with forced air circulation evaporator with or without heating device

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National foreword

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Prüfung von Kühleinrichtungen für wärmegedämmte Transportmittel - Teil 1: Transportkältemaschinen mit zwangsbelüftetem Verdampfer mit oder ohne Heizeinrichtung

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 16440-1:2015) has been prepared by Technical Committee CEN/TC 413 “Insulated means of transport for temperature sensitive goods with or without cooling and/or heating device”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2015 and conflicting national standards shall be withdrawn at the latest by July 2015.

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1 Scope

This European Standard applies to mechanical cooling devices with air circulation heat exchangers with or without heating device. The mechanical cooling devices are intended to be used with insulated transport equipment. They include a drive or a means of force transmission and are provided with all the components necessary for the controlled thermal transport system. The mechanical cooling devices can be powered with independent engine and/or vehicle engine and/or any other source of energy. This standard specifies the testing methodologies.

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.

EN 228, *Automotive fuels - Unleaded petrol - Requirements and test methods*

EN 589, *Automotive fuels - LPG - Requirements and test methods*

EN 590, *Automotive fuels - Diesel - Requirements and test methods*

EN ISO 5801, *Industrial fans - Performance testing using standardized airways (ISO 5801)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025)*

ISO/IEC Guide 99:2007, *International vocabulary of metrology - Basic and general concepts and associated terms (VIM)*

3 Terms and definitions, symbols and uncertainties

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 99:2007 and the following apply.

3.1.1
air volume flow
V_A
volume flow delivered by the fans in the evaporator unit

3.1.2
calorimeter box
thermally insulated room in which the evaporator unit of the cooling device is placed

Note 1 to entry: A calorimeter box can also be substituted by a suitable thermally insulated means of transport.

3.1.3
compressor/condenser unit
part of the cooling device including compressor, condenser, fans, housing, drives (electric motor, internal combustion motor, hydraulic engine and similar) and the operating panel with the control devices

3.1.4
conditioned test room
room where the test conditions can be maintained at a constant level and in which the calorimeter box with the cooling device is mounted

3.1.5
cooling capacity
$\boldsymbol{P}_{\mathbf{C}}$
capacity available with a defined heat load P_{HL} in the insulated means of transport, determined under rated conditions

3.1.6
cooling cycle
period starting with switching *OFF* the compressor and finishing with the successive switching *OFF* of the compressor

3.1.7
cooling device
system which lowers and/or maintains temperature

Note 1 to entry: In this European Standard, the cooling device is a compression cooling device intended to be installed and/or mounted into insulated means of transport, which refrigerates the interior of the means of transport.

3.1.8
cooling energy efficiency ratio
$\boldsymbol{EER}_{C}$
ratio of the cooling capacity P_{C} to the total power P_{T} of the cooling device under rated conditions

3.1.9
cooling load
$\boldsymbol{P}_{CL}$
heat flow discharged from the calorimeter box during the determination of the heating capacity deducting the power of cooling coil fan(s)

3.1.10
dependent cooling device
refrigeration unit with compressor driven by the vehicle engine either directly or indirectly

EXAMPLE For indirectly: belt or hydraulic transmissions, alternators, etc. supplied by the refrigeration unit manufacturer or electrically driven units powered by the electrical system of the vehicle.

3.1.11
evaporator unit
part of the cooling device including evaporator, fans, housing, expansion and control valves and, if appropriate, defrosting device

3.1.12
full load
operation of the cooling device at maximum capacity under steady state conditions

3.1.13
heating capacity
$\boldsymbol{P}_{H}$
capacity available with a defined cooling load P_{CL} in the insulated means of transport, determined under rated conditions

3.1.14
heating device
system which increases and/or maintains temperature

3.1.15
heating energy efficiency ratio
$\boldsymbol{EER}_{\mathrm{H}}$
ratio of the heating capacity P_{H} to the total power P_{T} of the cooling device under rated conditions

3.1.16
heat load
$\boldsymbol{P}_{\mathrm{HL}}$
heat flow delivered into the calorimeter box by electric heating elements and their fans during the determination of the cooling capacity P_{C}

3.1.17
heat transmission
$\boldsymbol{P}_{\mathrm{TR}}$
heat flow through the insulated limiting surfaces of the calorimeter box

3.1.18
***HV* and *EV* cooling device**
refrigeration unit with compressor driven electrically in hybrid vehicles (*HV*) or electric vehicles (*EV*)

Note 1 to entry: The HV and EV refrigeration units can be driven by the electrical system of the vehicle or by a separate independent battery pack.

3.1.19
idling speed
rotational speed of engine when the vehicle stands still, the engine is uncoupled and generates less power but enough to run reasonably smoothly and operate its ancillaries

Note 1 to entry: Accessories are water pumps, alternator, and, if equipped, other accessories such as air conditioning or power steering.

Note 2 to entry: If the power of the engine in idling speed for example is not sufficient for the operation of all accessories, particularly the transport refrigeration unit, the idle speed can be raised.

3.1.20
independent cooling device
refrigeration unit with compressor driven by an independent power unit like a diesel engine or a fuel cell, etc.

3.1.21
inlet air temperature at the compressor/condenser unit
$\boldsymbol{T}_{\mathrm{IN\ CON}}$
mean temperature of different measuring points located at air inlets of the compressor/condenser unit

3.1.22
inlet air temperature at the evaporator unit
$\boldsymbol{T}_{\mathrm{IN\ VAP}}$
mean temperature of different measuring points located at air inlets of the evaporator unit

3.1.23
inside temperature of the calorimeter box
$\boldsymbol{T}_{\mathrm{i}}$
arithmetic mean temperature measured at different locations inside the calorimeter box

3.1.24
insulated transport equipment
insulated vans, bodyworks for trucks and trailers, swap bodies, any kind of mobile containers and railway wagons

3.1.25
operating time
t_o
period of time between the switching on and the switching off of the cooling device compressor

3.1.26
outlet air temperature at the evaporator unit
$T_{OUT\ VAP}$
mean temperature of different measuring points located on the air outlet of the evaporator unit

3.1.27
part load
operation of the cooling device under thermostatic control with fixed load

3.1.28
rated conditions
obligatory conditions laid down for marking, comparison and certification purposes

3.1.29
stable condition
test operation in which the test condition measured values remain within the specified ranges and without any permanent tendency during the defined time period and in which the measured system parameters remain cycling regularly both in amplitude and period

3.1.30
standby operation
refrigeration unit operating connected to a power source external to the vehicle

EXAMPLE Operation on an electrical network, etc.

3.1.31
steady state conditions
test operation in which the measured values remain within the specified ranges and without any permanent tendency during the defined time period

3.1.32
temperature of the conditioned test room
T_e
mean temperature of different measurement points located outside the calorimeter box (in the conditioned test room)

3.1.33
total energy consumption
E_T
energy consumption of all components necessary for operation of the cooling device under rated conditions

Note 1 to entry: Example of energy: fuel or electricity.

3.1.34
total power
P_T
power input of all components necessary for operation of the cooling device under rated conditions

3.1.35
wall temperature
T_W
arithmetic mean of the inside temperature of the calorimeter box T_i and the temperature of the conditioned test room T_e

$$T_w = \frac{T_e + T_i}{2} \quad \text{in °C} \tag{1}$$

3.1.36
working speed
defined value representing a commonly accepted speed related to the operational speed range of the vehicle engine

3.2 Symbols and uncertainties

For the purposes of this document, the symbols and uncertainties given in Table 1 apply.

Table 1 — Symbols and uncertainties

Symbol	Measured quantity	Unit	Uncertainties
c_p	specific heat	J/kg K	-
EER_C	cooling energy efficiency ratio	W/W or Wh/l	±7 %
EER_H	heating energy efficiency ratio	W/W or Wh/l	±7 %
E_T	total energy consumption	Wh	±5 %
h_{in}	enthalpy of the refrigerant used for the cooling load at the inlet of the calorimeter box	J/kg	-
h_{out}	enthalpy of the refrigerant used for the cooling load at the outlet of the calorimeter box	J/kg	-
P_C	cooling capacity	W	±5 %
P_H	heating capacity	W	±5 %
P_{HL}	heat load	W	±1 %
P_{CL}	cooling load	W	±3 %
P_{elec}	measured electrical power	W	±3 %
P_{fan}	power to the fans of the cooling or heat load	W	±3 %
P_{mech}	measured mechanical power	W	±3 %
P_T	total power	W	±1 %
P_{TR}	heat transmission	W	±3 %
q_m	mass flow of the refrigerant in the coil used for the cooling load	kg/s	±1 %
q_v	volume flow of the secondary refrigerant in the coil used for the cooling load	m^3/s	±3 %
T_e	temperature of the conditioned test room	°C	±0,5 K
T_i	inside temperature of the calorimeter box	°C	±0,5 K
$T_{IN\ CON}$	inlet air temperature at the compressor/condenser unit	°C	±0,5 K
$T_{IN\ VAP}$	inlet air temperature at the evaporator unit	°C	±0,5 K
$T_{OUT\ VAP}$	outlet air temperature at the evaporator unit	°C	±0,5 K
T_w	wall temperature	°C	±1 K
T_{in}	temperature of the secondary refrigerant at the inlet of the calorimeter box	°C	±0,5 K
T_{out}	temperature of the secondary refrigerant at the outlet of the calorimeter box	°C	±0,5 K
t_o	operating time	s	±0,5 %
V_A	air volume flow	m^3/h	±5 %
η_{Gen}	generator efficiency		±3 %
η_{Bat}	battery efficiency		±3 %
NOTE The uncertainties are either the maximal measurement uncertainties for the measured quantity or the uncertainties in the determination of quantities when those are calculated.			

4 Requirements

4.1 Tested appliance description

The overall height, length and width of the evaporator unit and of the compressor/condenser unit as well as the installation or mounting dimensions shall be specified by the manufacturer. Energy supply lines and removable handles are not considered. Moreover, all dimensions of the components that are required for assessing the cooling device shall be determined.

4.2 Test equipment

4.2.1 General requirements

The testing equipment shall be so equipped that all requirements of this standard for setting of reference values, stability criteria and accuracy shall be fulfilled.

The measuring uncertainty shall not exceed the values specified in Table 2.

Table 2 — Measuring uncertainty

Measuring quantity	Unit	Measuring uncertainty
Air		
— temperature	°C	±0,3 K
— air pressure	Pa	±1,0 %
— air flow rate	m^3/h	±5,0 %
Refrigerant		
— pressure	Pa	±1,0 %
— temperature	°C	±0,5 K
— mass flow rate	kg/s	±1,0 %
Electrical quantities		
— electrical performance	W	±0,5 %
— voltage	V	±0,5 %
— current	A	±0,5 %
— energy	kWh	±0,5 %
Secondary refrigerant		
— temperature	°C	±0,2 K
— volume flow	m^3/s	±0,5 %
Fuel consumption		
— volume flow	l/h	±1,0 %
— consumption (mass)	kg/h	±1,0 %
Rotational speed	min^{-1}	±0,5 %
Torque	Nm	±2,0 %
Time	s	±0,5 %

The cooling capacity P_c or heating capacity P_H under steady-state conditions shall be so determined that the maximum measuring uncertainty does not exceed 5 %, irrespective of individual uncertainties due to fluid characteristics.

Testing laboratories should be in line with EN ISO/IEC 17025.

All measuring systems used for testing shall be calibrated at regular intervals. Air temperature sensors shall be protected against radiation when necessary.

4.2.2 Requirements for the calorimeter box

The heat transmission P_{TR} of the calorimeter box shall be kept to a minimum and not exceed 35 % of the measured cooling capacity P_C or heating capacity P_H according to 5.6.6 or 5.6.8. The leak rate of the calorimeter box shall not exceed 0,25 m^3/hm^2 under an overpressure of 250 ± 10 Pa. The maximal deviation of the measured inlet air temperatures at the evaporator unit according to 5.3.3.1 of any two temperature sensors shall be lower than 3 K, at any time. The measurement of temperature shall be carried out with an uncertainty not greater than the uncertainties defined in Table 1. The electric heating system in the calorimeter box shall not exceed the specific heat load of 1 W/cm^2 in steady-state conditions. The distance between the electric heating system and the ceiling, floor and walls shall be at least 100 mm.

4.2.3 Requirements for the conditioned test room

The size of the conditioned test room and the size of the calorimeter box shall be selected so that air stream cannot be obstructed at the air inlets and outlets of the cooling device.

Therefore, when the cooling device is switched off, the room air stream velocity at a distance of 100 mm of the calorimeter box walls shall be between 1 m/s and 2 m/s in the centre of the lateral surfaces.

The calorimeter box shall be set up with a distance of at least 300 mm from the floor of the conditioned test room.

The air temperature of the conditioned test room shall be so regulated that the mean inlet air temperature at the compressor/condenser unit may be maintained to ± 0,5 K. At any given time the maximum difference between the temperatures of any two temperature sensors at the air inlet of the compressor/condenser unit shall not exceed 2 K.

The exhaust gas suction system shall not affect the gas exhaustion of the diesel engine.

4.3 Installation and connection of the cooling device

4.3.1 General

The cooling device shall be connected to the calorimeter box in compliance with the manufacturer's installation and operation instructions. Appropriate measures in the calorimeter box shall prevent any airside short circuit at the evaporator unit.

4.3.2 Installation of cooling device with locally separated components (split system)

The following installation conditions shall be observed for tests of the cooling device consisting of several parts:

— refrigerant piping between the locally separated parts shall be carried out in accordance with the manufacturer's specification;

— refrigerant piping shall be so installed that the height difference between the highest and lowest pipe does not exceed 3,5 m;

— the thermal insulation of the refrigerant piping shall be carried out according to the manufacturer's specification.

5 Test conditions and methodology

5.1 General

The cooling capacity P_C and heating capacity P_H of cooling devices are determined by measurements in a calorimeter box. To determine the cooling capacity P_C, a heat load P_{HL} shall be applied in the calorimeter box by means of electric heating elements. To determine the heating capacity P_H, a cooling load P_{CL} shall be applied in the calorimeter box by means of forced air heat exchanger.

The cooling capacity P_C shall be measured for at least one inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$. For each inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$, the cooling capacity shall be tested for at least three different inlet air temperatures at the evaporator unit according to the manufacturer's instructions. Measured values of the inlet air temperature at the evaporator unit $T_{IN\ VAP}$ may be interpolated but shall not be extrapolated.

The heating capacity P_H should be measured for at least one temperature of the conditioned test room. For each temperature of the conditioned test room the heating capacity shall be tested for at least one inlet air temperature at the evaporator unit.

5.2 Test conditions

5.2.1 Test conditions for measuring the cooling capacity P_C

The tests are carried out according to the application of the cooling device under the rated conditions given in Table 3 and 4:

Table 3 — Reference temperatures for measuring the cooling capacity P_C

Inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$ °C		**Inlet air temperature at the evaporator unit $T_{IN\ VAP}$** °C		
Normal conditions:	30	Minimum temperature of the cooling device	Intermediate chosen temperature between minimum and maximum temperature[a]	Maximum temperature of the cooling device
Elevated conditions:	38			
Tropical conditions:	43			

[a] For comparison, a temperature from Table 4 shall be chosen. For additional information, see Annex A.

Table 4 — Test temperatures for the transport of perishable foodstuff

Inlet air temperature at the evaporator unit $T_{IN\ VAP}$ °C[a]						
+ 25	+ 12	+ 7	0	- 10	−20	−30

[a] For additional information, see Annex A.

5.2.2 Test conditions for measuring the heating capacity P_H

For comparison reasons the tests are carried out according to the application of the heating device under rated conditions given in Tables 5 and 6.

Table 5 — Reference temperatures of the conditioned test room for measuring the heating capacity P_H

Temperature of the conditioned test room T_e [a] °C	Inlet air temperature at the evaporator unit $T_{IN\ VAP}$ °C
−10	Maximum temperature of the temperature class
−20	
−30	
[a] Cooling devices with reverse operating heating systems shall be maintained at the reference temperature measured at the air inlet of the compressor/condenser unit.	

Table 6 — Reference temperatures at the inlet of the evaporator for measuring the heating capacity P_H

Inlet air temperature at the evaporator unit $T_{IN\ VAP}$ °C[a]		
+ 25	+ 12	+ 7
[a] For comparison, a temperature of the conditioned test room T_e from Table 5 shall be chosen. For additional information, see Annex A.		

5.2.3 Test condition for measuring the total energy consumption E_T

The tests are carried out according to the conditions given in Table 7:

Table 7 — Reference temperatures for measuring the energy consumption

Reference temperatures °C		Inlet air temperature at the evaporator unit $T_{IN\ VAP}$ °C	
cooling	Inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$ + 30	0	−20 [a]
heating	Temperature of the conditioned test room T_e [b] −20	12	
[a] If possible.			
[b] For cooling devices with reverse operating heating systems, the inlet air temperature at the compressor/condenser unit should be maintained at the reference temperature.			

For the measurement of the total energy consumption E_T for the determination of the energy efficiency, for reasons of comparison, the tests shall be carried out at 30 °C/0 °C and, if applicable, at 30 °C/- 20 °C for cooling and at – 20 °C/+ 12 °C for heating.

5.3 Temperature measurements

5.3.1 Temperature of the conditioned test room T_e

The temperature of the conditioned test room T_e shall be measured on the outside of the calorimeter box, at a distance of 100 mm from the walls, the floor and the roof, at the following 12 points:

a) at the eight external corners of the calorimeter box;

b) in the centre of the four largest external surfaces of the calorimeter box.

From the measured temperatures the arithmetic mean is calculated on the set of points of the total duration of the test. This mean value is the temperature of the conditioned test room T_e.

5.3.2 Inside temperature of the calorimeter box T_i

The inside temperature of the calorimeter box shall be measured at a distance of 100 mm from the walls, the floor and the roof, at the following 12 points:

a) in the eight corners of the calorimeter box;

b) in the centre of the four largest internal surfaces of the calorimeter box.

From the measured temperatures the arithmetic mean is calculated on the set points of the total duration of the test. This mean value is the inside temperature of the calorimeter box $T_{i.}$

5.3.3 Air temperatures of the cooling device

5.3.3.1 Inlet air temperature at the evaporator unit $T_{IN\ VAP}$

For the evaporator unit, the inlet air temperature shall be measured at a minimum of six positions equally spaced in front of the inlet. Parts of equal area shall not be greater than 0,075 m^2.

5.3.3.2 Outlet air temperature at the evaporator unit $T_{OUT\ VAP}$

For the evaporator unit, the outlet air temperature shall be measured at a minimum of six positions equally spaced behind the outlet.

5.3.3.3 Inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$

For the compressor/condenser unit, the inlet air temperature shall be measured at a minimum of six positions equally spaced in front of the inlet of the cooling device.

5.4 Cooling capacity P_C

The cooling capacity P_C shall be calculated using the following formula:

$$P_C = P_{HL} + P_{TR} \tag{2}$$

where

P_C is the cooling capacity, in W;

P_{HL} is the heat load including the fan power of the electric heating elements, in W;

P_{TR} is the heat transmission of the calorimeter box, in W.

5.5 Heating capacity P_H

5.5.1 Electric heating device

For electric heating device, the heating capacity can be determined by measuring the electrical power at the supply of the complete system, heater(s) and fan(s).

5.5.2 All heating devices

The heating capacity P_H shall be calculated using the following equation:

$$P_H = P_{CL} + P_{TR} \quad (3)$$

where

P_H is the heating capacity, in W;

P_{CL} is the cooling load deducting the fan power of the cooling coils, in W;

P_{TR} is the heat transmission of the calorimeter box, in W.

There are two different methods to determine the cooling load:

a) Direct refrigeration system:

$$P_{CL} = q_m \times (h_{out} - h_{in}) - P_{fan} \quad (4)$$

where

q_m is the mass flow of the refrigerant, in kg/s;

h_{out} is the enthalpy of the refrigerant at the outlet of the calorimeter box, in J/kg;

h_{in} is the enthalpy of the refrigerant at the inlet of the calorimeter box, in J/kg;

P_{fan} is the power to the cooler coil fans, in W.

NOTE 1 For additional information, see Annex E.2.

b) Indirect refrigeration system:

$$P_{CL} = q_v \times \rho \times c_p \times (T_{out} - T_{in}) - P_{fan} \quad (5)$$

where

q_v is the volume flow of the secondary refrigerant, in m^3/s;

ρ is the density of the secondary refrigerant, in kg/m^3;

c_p is the specific heat of the secondary refrigerant, in J/kgK;

T_{out} is the temperature of the secondary refrigerant at the outlet of the calorimeter box, in °C;

T_{in} is the temperature of the secondary refrigerant at the inlet of the calorimeter box, in °C;

P_{fan} is the power to the cooler coil fans, in W.

NOTE 2 For additional information, see Annex E.3.

5.6 Performance testing under rated conditions

5.6.1 General

The cooling device shall be continuously operated observing the manufacturer's indications (see Table 8, in case of dependent cooling devices). The evaporator unit shall be clean and free from frost before starting the test and during the complete test. After steady-state conditions have been achieved, the system shall be operated for at least 3 h without interruption. The uncertainties specified in Table 1 shall be complied during performance tests.

If the cooling device can be operated by more than one form of energy, including in standby operation, the tests shall be repeated for each mode at full and part load.

5.6.2 Provisions for cooling devices driven by vehicle engines

For cooling devices which are driven directly or indirectly (alternator, hydraulics, etc.) by the vehicle engine, the cooling capacity P_C is to be determined according to the specification of the manufacturer. Reference speeds, speed 1 (idling speed) and speed 2 (working speed), of the vehicle engine used to determine these cooling capacities are taken from Table 8. For this, the transmission ratio between the vehicle engine and the cooling device shall be specified by the manufacturer. The manufacturer shall supply an example of an installation in a vehicle showing compressor transmission ratio.

Explanations on the idling and working speeds of different vehicle categories are given in Annex B.

Usually, the cooling capacities at speed 1 and speed 2 are calculated by interpolating between measured values at minimum and maximum compressor speeds tested, examples are shown in Figure B.1 in Annex B.

Extrapolating beyond the measured values is not permitted.

Since the idling and working speeds of the compressor can vary depending on the transmission ratio and speed regime of the different vehicles, the minimum and maximum compressor speeds to be measured shall be specified by the manufacturer.

As an alternative to the measurement at minimum speed, the measured value at maximum speed and at the zero point can be interpolated to determine the cooling capacities according to specification given by the manufacturer, examples are shown in Figure B.2.

On cooling devices where the working speed of the compressor is always the same due to corresponding transmission ratio, even with different vehicles, the cooling capacity P_C can be measured directly at the corresponding idling and working speeds.

Only one measurement at idling speed is required when the compressor speed is constant and independent of the engine speed over the entire speed range (for example see cooling device type A in Figure B.3 in Annex B). The compliance of the constant compressor speed, independent from the motor speed, shall be confirmed by the manufacturer and shall be checked by a test.

For cooling devices where the cooling capacity P_C is partly independent of the engine speed only within a limited speed range, and the cooling capacity in the lower speed range drops again to idling speed (for example see cooling device type B, Figure B.3 in Annex B), a measurement at a third intermediate speed in addition to the measurements at minimum and maximum speed can be applied for (on request by the manufacturer). This additional measurement provides a better description of the dependency of cooling capacity P_C on the compressor speed. The cooling capacities can be calculated by interpolating between minimum and intermediate speeds respectively between intermediate and maximum speeds tested. The intermediate compressor speed shall also be stipulated by the manufacturer. Without this third measuring point, the cooling capacities at working and idling speeds are calculated (examples are shown in Figure B.2 in Annex B) by linear interpolation of the measured values at minimum and maximum compressor speeds.

Table 8 — Test of dependent cooling devices

	Minimum speed[a] min^{-1}	**Speed 1 - calculated** min^{-1} reference speed[b,c]	**Speed 2 - calculated -** min^{-1} reference speed[b]	**Maximum speed**[a] min^{-1}
Vehicle engine speed				
Transmission ratio between vehicle engine and cooling device				
	Measurement	**Interpolation**	**Interpolation**	**Measurement**
Inlet air temperature at evaporator $T_{\text{IN VAP}}$				
Entrance speed of cooling device				
Speed of compressor				
Cooling capacity P_{C}				
Electrical power P_{elec}				
Mechanical power P_{mech}				
Efficiencies (generator, battery etc.)				
Total power P_{T}				

[a] Minimum and maximum speeds tested given by manufacturer of the cooling device.

[b] Reference speeds for vehicle categories A to D as shown in Table B.1 in Annex B:

Category	speed 1	speed 2
A: diesel engine in trucks > 240 kW	800 min^{-1}	1 300 min^{-1}
B: diesel engine in trucks < 240 kW	800 min^{-1}	1 700 min^{-1}
C: diesel engine in light commercial vehicles	800 min^{-1}	2 200 min^{-1}
D: petrol engines in light commercial vehicles	800 min^{-1}	3 300 min^{-1}

[c] For trucks of categories A and B with raised idling speed higher than 800 min^{-1} the actual idling speed should be used as the reference vehicle engine speed 1.

For dimensioning the cooling capacity P_C is related to the working speed at 70 % (vehicle category A and B) or 60 % (vehicle category C and D) of the nominal engine speed of the individual vehicle.

NOTE Examples are given in Annex B.

Table 9 gives the electrical supply for testing.

Table 9 — Electrical supply for testing

Nominal voltage V	Working voltage during test V	Tolerances
12	13,5	±2 %
24	27,5	±2 %

The voltages are representing the driving mode. The voltage level in battery mode is lower. Other voltages shall be specified by the manufacturer.

5.6.3 Heat transmission P_{TR} through the calorimeter box

The value shall be determined with the cooling device fitted or mounted.

5.6.4 Steady-state conditions under rated conditions

Steady-state conditions under rated conditions are achieved if the following requirements during the measurements are fulfilled:

— the inlet air temperature at the evaporator unit $T_{IN\ VAP}$, the inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$, the inside temperature of the calorimeter box T_i and the temperature of the conditioned test room T_e have not changed by more than ± 0,5 K within the last 1 h;

— the introduced cooling load P_{CL} or heat load P_{HL} has not changed by more than 1 % within 1 h;

— for all these values also within the limits no permanent tendency is allowed.

5.6.5 Energy consumption measurements

5.6.5.1 General

The total energy consumptions E_T are measured for full and part load for dependent and independent cooling devices.

For the cooling devices able to run in standby operation, the total electrical energy consumption E_T is also measured at full load and part load.

5.6.5.2 Energy consumption measurements of dependent cooling devices

For cooling devices driven by the vehicle motor, the mechanical power shall be determined at the entrance of the unit (like the shaft of compressor, alternator, hydraulic pump) using the speed and torque for each test point.

The electrical power of auxiliaries like, e.g. evaporator or condenser fans or generator driven units powered by the electrical *DC* system of the vehicle, shall be measured separately.

The efficiency of the generator of the vehicle engine can be measured separately or an average efficiency factor as defined in Annex D can be used.

The total mechanical power P_T (in W) to the cooling device can be calculated as follows:

$$P_T = P_{mech} + P_{elec} / \eta_{Gen} \quad (6)$$

where

P_{mech} is the measured mechanical power, in W;

P_{elec} is the measured electrical power, in W;

η_{Gen} is the generator efficiency.

For electrically driven cooling devices powered by the vehicles battery in periods of standstill of the vehicle, in addition to the efficiency of the vehicle generator η_{Gen}, the efficiency factors of the battery η_{Bat} for charging and discharging shall be considered.

For alternator driven systems, the electrical power of the cooling device and the efficiency of the alternator can be measured separately to determine the total mechanical power P_T.

The fuel consumption of dependent cooling devices driven by the vehicle engine shall be determined due to the total mechanical power P_T to the cooling devices and an average specific additional fuel consumption of the vehicle engine in litre diesel per hour and per kW shaft power as defined in Annex D.

5.6.5.3 Energy consumption measurements of independent cooling devices

For cooling devices driven by combustion engines or fuel cells, the fuel consumption under rated conditions shall be measured.

5.6.5.4 Energy consumption measurements of *HV* and *EV* cooling devices

For the electric cooling devices the total electrical power P_T of the cooling device shall be measured.

In addition all efficiency coefficients of the complete power train shall be considered.

NOTE For additional information, see Annex C.

5.6.6 Measurement of the maximum cooling capacities and energy consumption at full load

The cooling capacities are measured against maximum heat load at steady-state conditions with the selection of temperature appropriate to the rated conditions. The cooling capacity and the energy consumption shall be determined as a mean value over the whole steady-state duration of at least 3 h for three inlet air temperatures at the evaporator unit which are chosen from Table 3 and Table 4 and for at least one inlet air temperature at the compressor/condenser unit, from Table 3. For the measurement of the energy consumption the tests shall be carried out at an inlet air temperature at the compressor/condenser unit at 30 °C.

All measurements shall be recorded at least every 5 min.

5.6.7 Measurement of energy consumption under rated conditions at part load

After stable conditions have been achieved the test shall be carried out under thermostatic control with a fixed heat load P_{HL}.

All measurements shall be recorded at least every 10 s.

The measurements shall be carried out at +30/–20 °C and +30/0 °C both, on the road operation and, if fitted, standby operation. For cooling devices driven by the vehicle engine the measurement is carried out at the highest engine speed tested according to 5.6.6. At –20 °C the measurements are performed in start/stop operation and at 0 °C with the evaporator fan running continuously. If no start/stop operation is possible, the measurements are performed at both temperatures with the evaporator fan running continuously.

For cooling devices which are exclusively operated at 0°C and higher only measurements at +30/0 °C are carried out.

The cooling device is operated at +30/–20°C at part load of 35 % and at +30/0°C at a part load of 20 % of the measured cooling capacity P_c at full load according to 5.6.6. The maximum switching difference of the thermal control of the cooling device is 2 K.

All temperatures shall be measured over a period of 3 h and at least 20 cooling cycles. They shall be recorded. The measuring period starts with switching *OFF* the compressor and finishes with the first switching *OFF* of the compressor after 3 h and at least 20 cooling cycles of measurement. For each test the average value shall be indicated in the test report. The minimum and maximum values during testing shall also be indicated. The maximum deviation of the average air inlet temperature of the evaporator unit shall be ± 1 K of the reference value. The operating time t_O and standstill periods shall be recorded.

Continuously regulated systems shall be measured over a period of 3 h. The maximum deviation of the average inlet air temperature at the evaporator unit may be ± 1 K of the reference value.

5.6.8 Measurement of heating capacity and energy consumption

5.6.8.1 General

For heating devices which are entirely electric heaters, the electrical power of the heaters and fans is measured.

For other heating devices the heating capacity should be measured using a cooling system to provide the cooling load in accordance with 5.5. A cooling system with forced air circulation shall be installed in the calorimeter box.

NOTE Examples for test equipment for other than electrical heating devices are shown in Annex E.

5.6.8.2 Measurement of the maximum heating capacities and energy consumption

The measurements shall be carried out for at least one inlet air temperature at the evaporator unit, which corresponds to the maximum temperature of the chosen class from Table 6 and for at least one chosen temperature of the conditioned test room of −20 °C, as defined in Table 7.

For heating devices which are entirely electric heaters, the measurement shall be carried out and recorded during 1 h period at temperatures specified by the manufacturer.

When the heating capacities are measured against maximum cooling load at steady-state conditions with the selection of temperature appropriate to the rated conditions according to Table 5 and Table 6, the heating capacity and the total energy consumption shall be determined as a mean value over the whole steady-state duration for a minimum of 3 h. All measurements shall be recorded at least every 5 min.

5.7 Air flow measurement

The air volume flow V_A of the evaporator unit is determined according to EN ISO 5801 at a temperature of 20 °C ± 5 K .

5.8 Rotation speed measurements

The speed of the compressor (except semi-hermetic and hermetic compressors) and of the fans shall be measured under rated conditions.

5.9 Time measurement

The operating times t_O and standstill periods shall be recorded.

5.10 Functional tests

5.10.1 Cooling-down test

Before starting the test, the calorimeter box and the conditioned test room are heated to the same temperature of (8 ± 1) K above the inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$ given in column 1 of Table 3 and maintained at this temperature for a period of 4 h. Afterwards the cooling device is switched on. For this test, the reference value of the cooling device controller is set to a temperature of 5 K below the lowest inlet air temperature at the evaporator unit. During testing, the cooling device shall remain fully serviceable. The test shall be carried out in all specified operating modes of the cooling device. The cooling-down time shall be recorded in the test report.

NOTE The cooling-down time is not evaluated, as it depends on the size and heat capacity of the calorimeter box.

5.10.2 Defrosting test

The function of the defrosting system shall be checked and documented. The test on the defrosting system shall be carried out following the cooling-down test in accordance with 5.10.1. The duty cycle of the defrosting system and the time elapsed until the required internal test temperature is reached again shall be determined. The volume of the calorimeter box shall be specified. After defrosting, it shall be checked if the evaporator is free from ice.

6 Test results

6.1 General

The data to be recorded for performance tests are given in Table 10. The Table includes the required general indications but it is not intended to limit the data to be recorded.

Table 10 — Data to be recorded

Measuring quantity/result	Unit	Conditioned test room	Calorimeter box	Cooling device
Thermodynamical quantities:				
— air temperature	°C	X	X	
— inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$	°C			X
— inlet air temperature at the evaporator unit $T_{IN\ VAP}$	°C			X
— outlet air temperature at the evaporator unit $T_{OUT\ VAP}$	°C			X
Electrical quantities:				
— voltage	V			X
— current	A			X
— power	W			X
Performance:				
— cooling capacity P_c	W			X
— heating capacity P_H	W			X
Performance coefficients:				
— EER_C	W/W or Wh/l_{Diesel}			X
— EER_H	W/W or Wh/l_{Diesel}			X
Refrigerants:				
— suction pressure of compressor	Pa			X
— discharge pressure of compressor	Pa			X
— evaporation pressure	Pa			X
— discharge temperature of compressor	°C			X
— evaporator superheat temperature	K			X
Part load:				
— duty cycles and standstill periods	min			X
— cooling capacity at part load	W			X
— temperature difference of the controller around the specified set points	K			X
— min. and max. values of operating cycles	°C			X
Speed:				
— speed compressor	min^{-1}			X
— speed motor	min^{-1}			X
— speed fan	min^{-1}			X
Total power	W			X

6.2 Energy efficiency ratio determination

6.2.1 General

The determination of the energy efficiency is carried out for full and part load, on the road, as well as standby operation.

6.2.2 Determination of the cooling energy efficiency ratio EER_C

EER_C is the ratio of the cooling capacity P_C to the required total power P_T. On the road operation mode for dependent and independent cooling devices EER_C is expressed as the cooling capacity P_C referred to the fuel consumption, in Wh/l.

On electric standby mode EER_C is expressed as the cooling capacity P_C referred to the required total electrical power P_T, in W/W.

6.2.3 Determination of the heating energy efficiency ratio EER_H

EER_H determination is performed by analogy with 6.2.2 In this case, the effective heating capacity P_H is referred to the required total power P_T.

7 Test report

The test report shall comply with EN ISO/IEC 17025.

The test report should contain at least the following five parts:

a) Part 1 - General information:

   1) Number, title and date of the test report;

   2) General information of the laboratory company (name, address of the company responsible for the test);

   3) General information of the laboratory facilities (name, address, location of the test facilities where the test is performed);

   4) General information about the customer requesting the test and owning the test results (name, address);

   5) General information on the manufacturer of the device (name, address);

   6) Testing methodology and standard reference and clauses applied.

b) Part 2 - Tested cooling device:

   1) Technical specification of the cooling device (date and place of manufacture, brand, make, type, serial number);

   2) Description of the cooling device (dependent/independent, single unit/assembled components, type of drives, refrigerant fluid, etc.);

   3) Description in detail of the following components and their dimensions (if applicable) of the cooling device: compressor, drive train, condenser, evaporator, fans, expansion and control valves, operating panel, software version;

4) Description of the optional components of the cooling device: defrosting device, heating system, etc.

c) Part 3 - Test conditions:

1) Description of the conditioned test room;

2) Description of the calorimeter box and of all accessories and instrumentation;

3) Reference temperatures during the cooling capacity test: $T_{IN\ CON}$ and $T_{IN\ VAP;}$

4) Reference temperatures during the heating capacity test (if applicable): T_e and $T_{IN\ VAP}$, $T_{IN\ CON}$;

5) Reference temperatures during the energy consumption test: $T_{IN\ CON}$ and $T_{IN\ VAP}$;

6) Vehicle engine speeds (idling, working);

7) Compressor and fan speeds;

8) For heating capacity, indication of the method used.

d) Part 4 - Test results:

1) Cooling capacities;

2) Heating capacities (if applicable);

3) Air volume flow;

4) Functional tests (cooling-down test, defrosting test);

5) Energy consumption at full load and at part load;

6) Uncertainties.

e) Part 5 - Summary:

1) Company requesting the test report;

2) Manufacturer;

3) Make or brand;

4) Type;

5) Serial number;

6) Brief description of equipment;

7) Main performances (reference cooling capacities at 0/-20°C and the corresponding energy consumption, in full load and part load).

Annex A
(informative)

Examples

Table A.1 — Test temperatures for the transport of perishable foodstuffs according to ATP

Inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$ °C	Inlet air temperature at the evaporator unit $T_{IN\ VAP}$ °C				
+30	+12	+7	0	−10	−20

In compliance with the ATP agreement, the cooling capacity P_c should be measured at three different inlet air temperatures at the evaporator unit $T_{IN\ VAP}$. One temperature should be the minimum temperature for the requested class. The ATP agreement specifies the inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$ of 30 °C.

Table A.2 — Test temperatures for the transport of medical products

Inlet air temperature at the compressor/condenser unit $T_{IN\ CON}$ °C	Inlet air temperature at the evaporator unit $T_{IN\ VAP}$ °C		
+30	+20	+5	−25

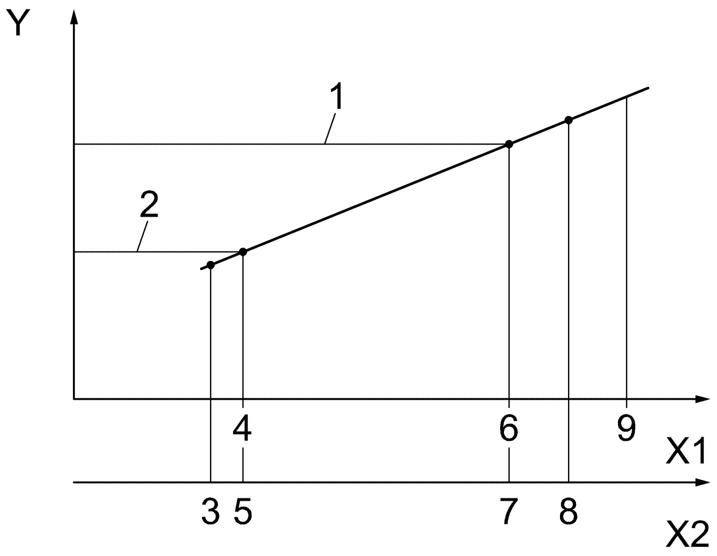
Annex B
(informative)

Explanation with regard to reference speeds for different vehicle engines

The nominal speed of the engine is defined as the speed at maximum power output as measured on the shaft. The speeds as shown in Table B.1 are taken as a reference for each vehicle category.

Table B.1 — Speed range and working speeds of different vehicle engines

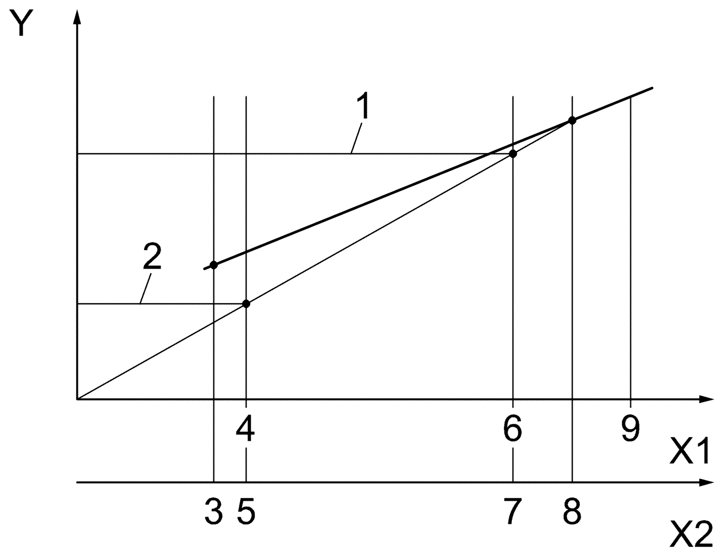
Vehicle engine category		Idling speed	Working speed		Nominal speed
		min^{-1}	min^{-1}	% of nominal speed	min^{-1}
A	Diesel engines in trucks > 240 kW	600 - 800	1 260	70 %	1 800
B	Diesel engines in trucks < 240 kW	600 - 800	1 680	70 %	2 400
C	Diesel engines in light commercial vehicles	800 - 1 000	2 280	60 %	3 800
D	Petrol engines in light commercial vehicles	800 - 1 000	3 300	60 %	5 500
NOTE Working speeds in Table 8 for A, B, and C are rounded to 1 300, 1 700, 2 200 min^{-1}.					



Key

X1 speed of vehicle engine
X2 speed of compressor
Y cooling capacity P_c
1 cooling capacity at speed 2 (working speed)
2 cooling capacity at speed 1 (idling speed)
3 minimum speed of compressor
4 idling speed of engine
5 speed 1 of compressor (idling speed)
6 working speed of engine
7 speed 2 of compressor (working speed)
8 maximum speed of compressor
9 nominal speed of engine

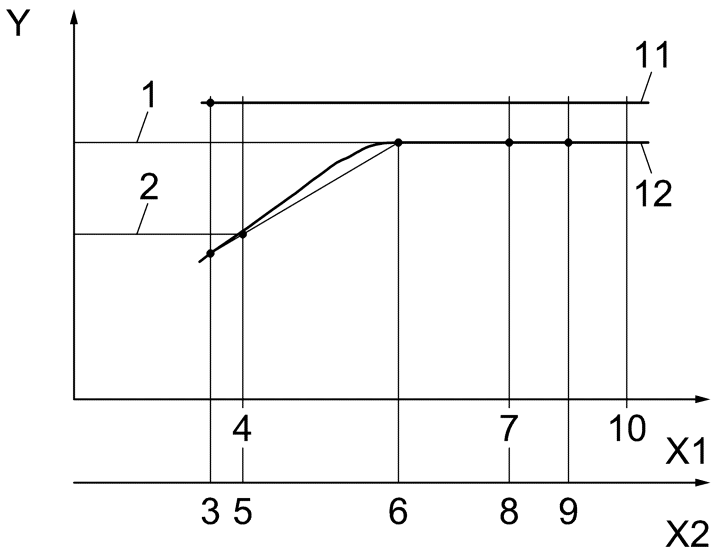
Figure B.1 — Determination of the cooling capacity P_c of dependent cooling devices based on the idling and working speed of the vehicle engine



Key

X1 speed of vehicle engine
X2 speed of compressor
Y cooling capacity P_c
1 cooling capacity at speed 2 (working speed)
2 cooling capacity at speed 1 (idling speed)
3 minimum speed of compressor
4 idling speed of engine
5 speed 1 of compressor (idling speed)
6 working speed of engine
7 speed 2 of compressor (working speed)
8 maximum speed of compressor
9 nominal speed of engine

Figure B.2 — Optional: Determination of the cooling capacity P_c of dependent cooling devices based on the zero point and the maximum speed of the vehicle engine



Key

X1 speed of vehicle engine
X2 speed of compressor
Y cooling capacity
1 cooling capacity at speed 2 (working speed)
2 cooling capacity at speed 1 (idling speed)
3 minimum speed of compressor
4 idling speed of engine
5 speed 1 of compressor (idling speed)
6 intermediate speed of compressor
7 working speed of engine
8 speed 2 of compressor (working speed)
9 maximum speed of compressor
10 nominal speed of engine
11 cooling device type A with constant cooling capacity within the whole speed range
12 cooling device type B with constant cooling capacity within a limited speed range

Figure B.3 — Determination of the cooling capacity P_c of dependent cooling devices with a constant cooling capacity either over the entire speed range (type A) or within a limited speed range (type B) of the vehicle engine

Table B.2 — Example of the determination of the cooling capacity of devices driven by vehicle engines

	Minimum speed min^{-1}	Speed 1 - calculated – min^{-1} reference speed	Speed 2 - calculated - min^{-1} reference speed	Maximum speed min^{-1}
Vehicle engine speed	550	800	2 200	3 000
Transmission ratio between vehicle engine and cooling device	1: 0,8			
	Measurement	Interpolation	Interpolation	Measurement
Inlet air temperature at evaporator unit $T_{IN\ VAP}$ (°C)	0°C			
Entrance speed of cooling device (min^{-1})	440	640	1 760	2 400
Speed of compressor (min^{-1})	440	640	1 760	2 400
Cooling capacity P_C (W)	700	889	1 946	2 550
Electrical power (W)	250	250	250	250
Mechanical power (W)	560	739	1 744	2 318
Efficiencies (generator, battery etc.)	0,6	0,6	0,6	0,6
Total mechanical power P_T (W)	977	1 156	2 161	2 735

Table B.3 — Example for the cooling capacity for devices for type B with intermediate speed driven by vehicle engines

	Minimum speed min^{-1}	Speed 1 - calculated - min^{-1} reference speed	Intermediate speed min^{-1}	Speed 2 - calculated - min^{-1} reference speed	Maximum speed min^{-1}
Vehicle engine speed	550	800	1 200	2 200	3 000
Transmission ratio between vehicle engine and cooling device		1: 1,2			
	Measurement	Interpolation	Measurement	Interpolation	Measurement
Inlet air temperature at evaporator unit $T_{IN\ VAP}$ (°C)		0°C			
Entrance speed of cooling device (min^{-1})	660	960	1 440	2 640	3 600
Speed of compressor (min^{-1})	1 100	1 520	2 580	2 640	2 650
Cooling capacity P_C (W)	1 120	1 500	2 440	2 520	2 560
Electrical power (W)	900	1 250	2 130	2 190	2 230
Mechanical power (W)	-	-	-	-	-
Efficiencies (generator, battery etc.)	0,6	0,6	0,6	0,6	0,6
Total mechanical power P_T (W)	1 500	2 083	3 550	3 650	3 717

Annex C
(informative)

Total efficiency of the power chain of electric and hybrid vehicles

The application of cooling devices in electric and hybrid vehicles is just starting. Also developments of electric and hybrid vehicles are not finished and will be on going for several years. Therefore, the definition of a procedure for the measurement of efficiencies of the power chain is postponed.

All efficiency coefficients of the complete power chain can be considered on the basis of the results of unbiased measurements supplied for example to the vehicle industry.

For cooling devices driven by the electrical power of the electric or hybrid vehicle in addition the efficiencies of the vehicle generator, the specific fuel consumption of the vehicle engine, etc. should be considered in future.

NOTE For cooling devices driven by either a separate independent battery pack dedicated to the cooling device or connected to the electrical system of the vehicle, the chain includes the efficiency coefficients for charging and discharging the battery which depend on the type of the battery system, the storage medium, the way and velocity of charging, the charging principle (by generator or recharging by mains electrical network) but also on the temperature and the cooling devices of the battery system.

Annex D
(normative)

Determination of energy and fuel consumption for cooling devices

D.1 Determination of energy and fuel consumption for dependent cooling devices

For the determination of the total energy consumption E_T of cooling devices driven by the vehicle engine the efficiencies of for example the vehicle generator or for charging and discharging the battery shall be known. Not all of these data can or have been evaluated by measurement. Therefore, the following average efficiency factors shall be used:

Efficiencies of generators η_{Gen}: For the vehicle generator (12 V / 24 V) a mean efficiency factor of 60 %.

Efficiencies of batteries η_{Bat}: For the vehicle battery (12 V / 24 V) a mean efficiency factor for charging and for discharging to be determined.

For the evaluation of the additional fuel consumption of cooling devices driven by the vehicle engine an average additional specific fuel consumption of vehicle engines in litre per hour and per kW shaft power (l/kWh) shall be used:

— For vehicles with diesel engines an average additional fuel consumption of 0,2 l/kWh;

— For vehicles with petrol engines an average additional fuel consumption to be determined.

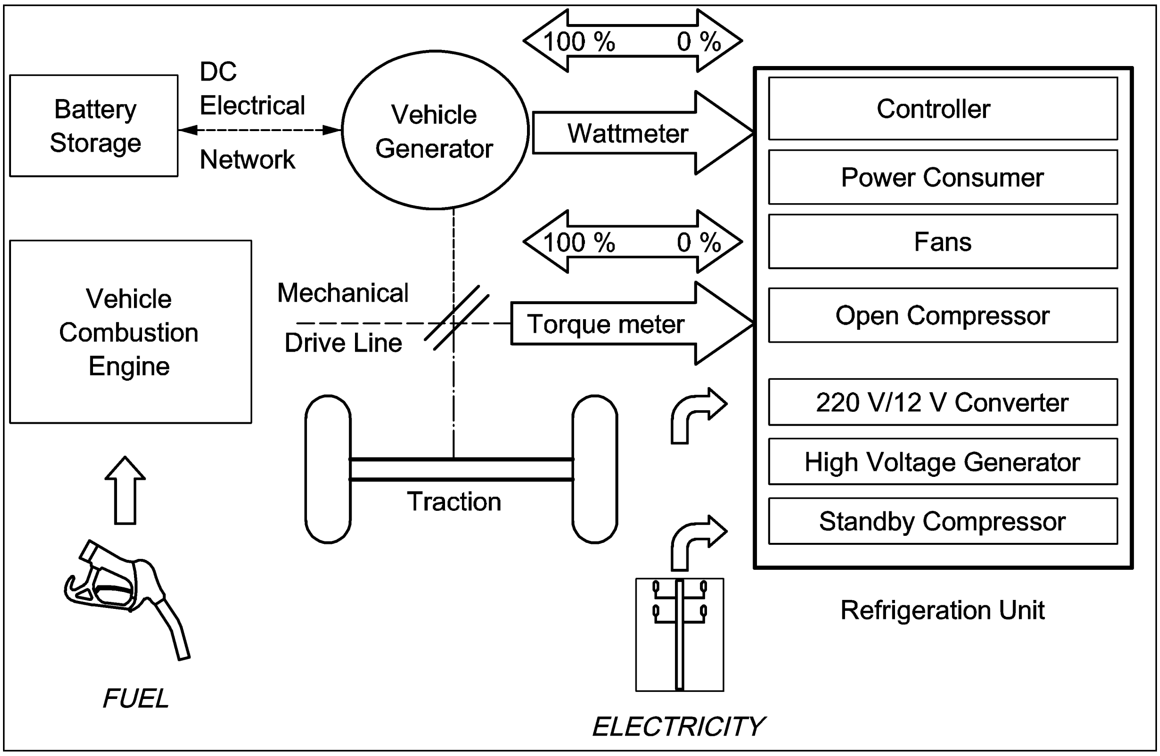


Figure D.1 — Dependent cooling devices driven by the engine of the vehicle

D.2 Determination of fuel consumption for independent cooling devices

For cooling devices driven by an integrated combustion engine the fuel consumption at rated conditions shall be measured. If it is measured by volume flow meter devices, the temperature of the fuel at the entrance of this measuring system shall be recorded to compensate for density. The quality of the fuel according to EN 590 for diesel, EN 228 for petrol and EN 589 for LPG has to be indicated.

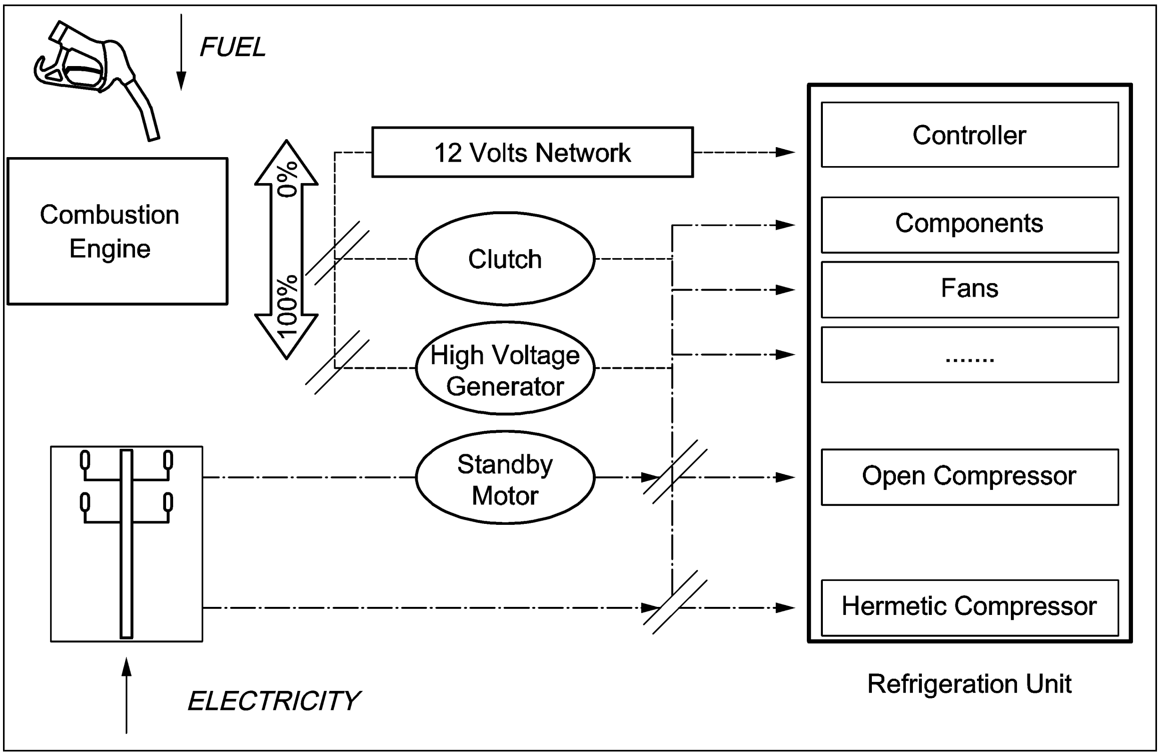


Figure D.2 — Independent cooling devices driven by a separate diesel engine

Annex E
(informative)

Heating device test methodologies

E.1 General

The refrigeration system providing the cooling load should be connected to the calorimeter box as indicated in Figures E.1 and E.2.

The refrigerant temperature at the inlet and outlet at the calorimeter box should be measured using temperature sensors either directly inserted into the pipe or inserted into pockets within the pipe or in copper sleeves clamped to the inlet and outlet pipe-lines. The sensors should be positioned no further than 150 mm from the exterior of the calorimeter box.

Where thermocouples or similar devices are utilized, the sensor cables should be arranged such that external influences on the connection cables are eliminated by the use of insulation.

A flow measuring device (flow meter) should be installed in the liquid inlet supply line of the calorimeter box in order to measure mass flow rate of the refrigerant.

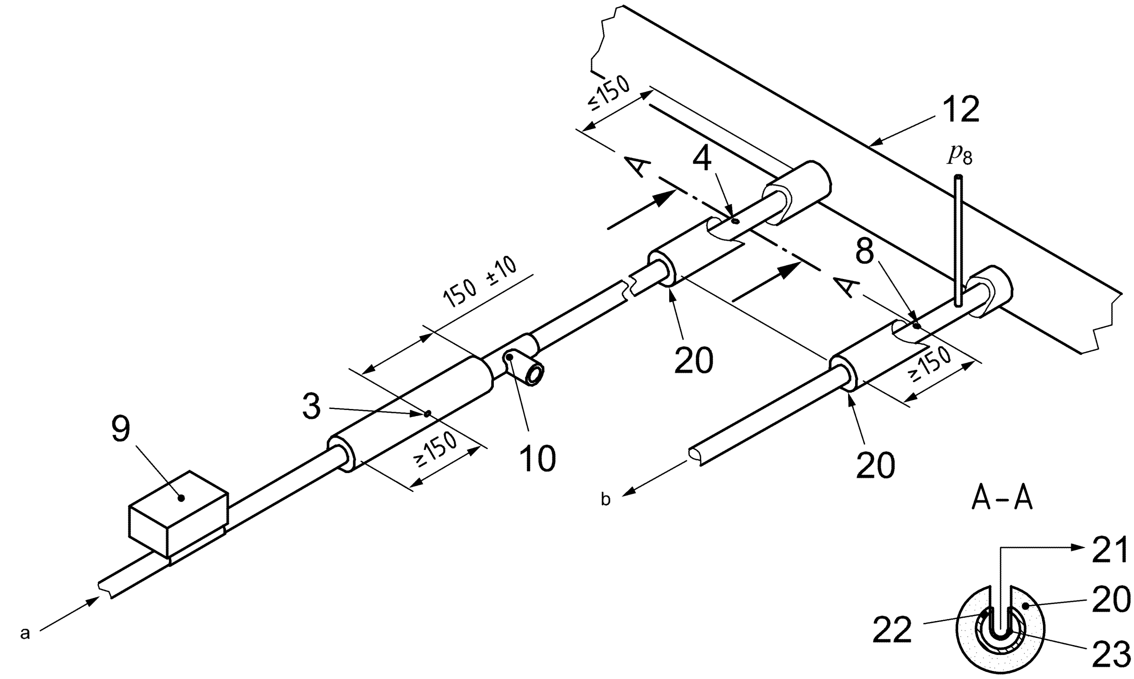
The flow meter can be located inside or outside of the calorimeter box.

Regular operation of the flow measuring device should be verified.

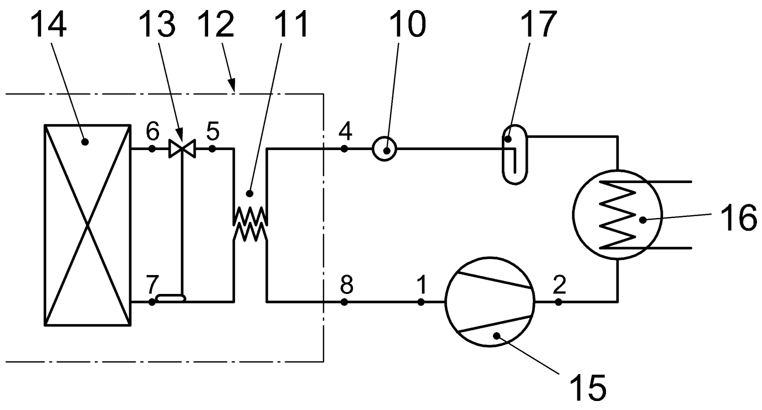
E.2 Direct refrigeration systems

The liquid should be sub-cooled at reference point 3 and at the inlet 4.

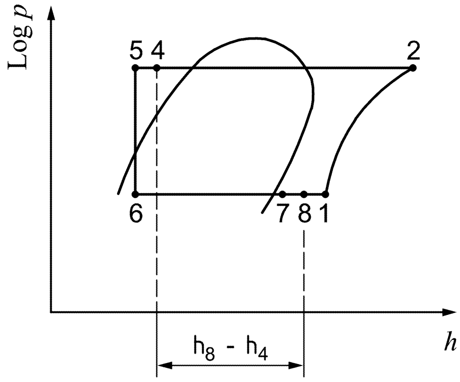
A liquid sight glass should be installed in the liquid piping downstream and, if necessary, optionally upstream of the flow meter in order to verify the vapour-free state of the refrigerant being supplied to the calorimeter box during the test period.



a) Position of the temperature sensors and flow meter



b) Scheme of the refrigeration circuit and the location of reference points



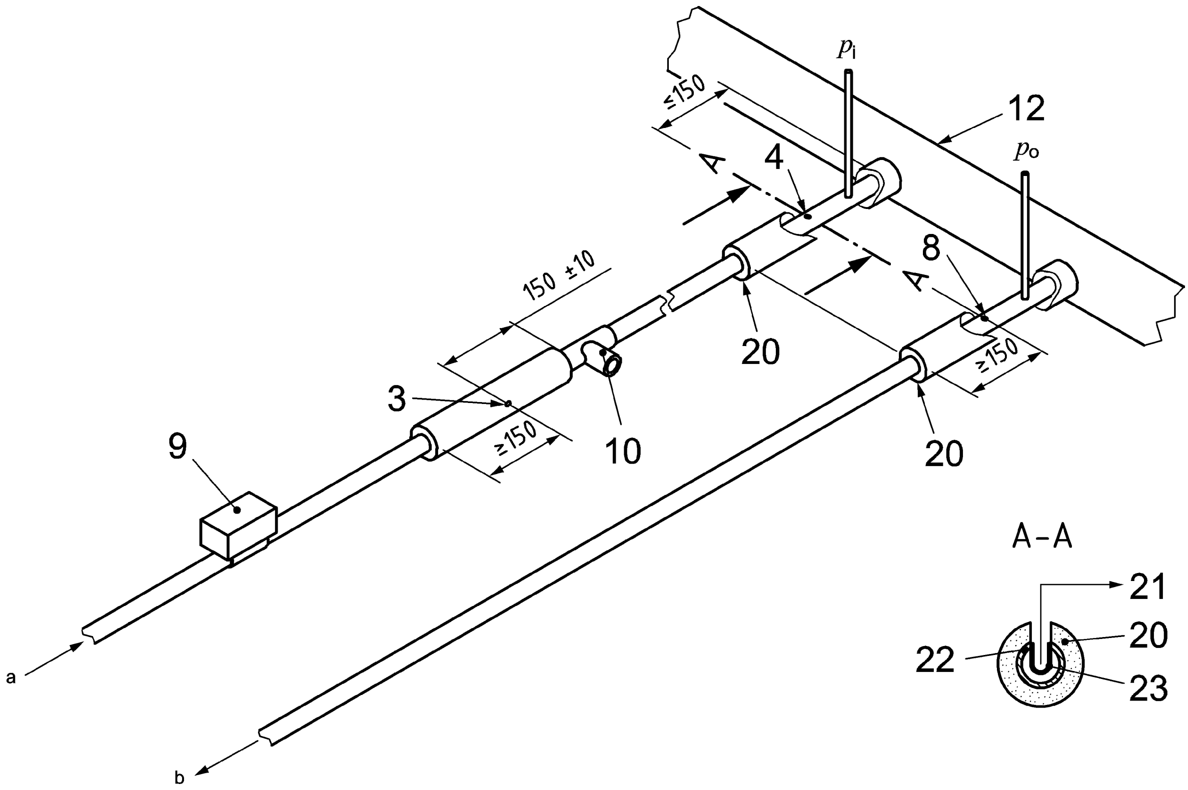
c) Log pressure/enthalpy diagram

Key

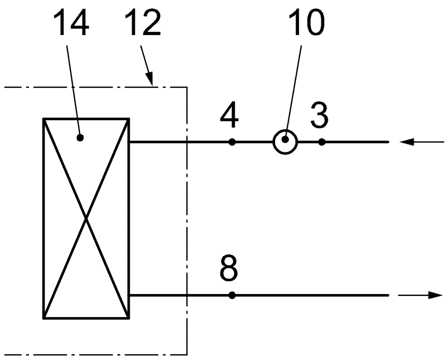
1 compressor inlet
2 compressor outlet
3 sight glass location for subcooled liquid state upstream flow meter
4 measurement point at the inlet of the calorimeter box
5 expansion device inlet
6 expansion device outlet and inlet of the evaporator (cooling coil)
7 outlet of the evaporator (cooling coil) and superheat measurement of the evaporator
8 measurement point at the outlet of the calorimeter box
9 inlet valve: open during refrigeration; closed during switch off or defrosting
10 refrigerant mass flow meter
11 internal liquid vapour heat exchange, if any
12 calorimeter box
13 expansion device
14 cooling coil
15 compressor
16 condenser
17 liquid receiver
20 insulation (to at least 150 mm from temperature sensor)
21 temperature sensor at 4 and 8
22 refrigerant circulation pipe
23 copper thermo-pocket for housing the temperature sensor (shall be filled with glycol or a similar fluid)

Figure E.1 — Description of the direct refrigeration system

E.3 Indirect refrigeration system



a) Position of the temperature sensors and of the flow meter



b) Scheme of the connection of the cooling coil and location of reference points

Key

3 sight glass location for subcooled liquid state upstream flow meter

4 measurement point at the inlet of the calorimeter box

8 measurement point at the outlet of the calorimeter box

9 inlet valve: open during refrigeration; closed during switch off or defrosting

10 secondary refrigerant mass flow meter

12 calorimeter box

14 cooling coil

20 insulation (to at least 150 mm from temperature sensor)

21 temperature sensor at 4 and 8

22 secondary refrigerant circulation pipe

23 copper thermo-pocket for housing the temperature sensor (shall be filled with glycol or a similar fluid)

Figure E.2 — Indirect refrigeration system

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[4] EN ISO 23953-2, *Refrigerated display cabinets - Part 2: Classification, requirements and test conditions (ISO 23953-2)*

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