SLOVENSKI STANDARD
SIST EN 16440-1:2015

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Metodologije za preskušanje hladilnih naprav za toplotno izolirana transportna sredstva - 1. del: Mehanične hladilne naprave z uparjalnikom s prisilnim kroženjem zraka z grelno napravo ali brez nje

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

Leistungs- und Funktionsprüfung von Kühleinrichtungen für wärmegedämmte Beförderungsmittel - Teil 1: Transportkältemaschinen mit zwangsbelüftetem Verdampfer mit oder ohne Heizeinrichtung

Méthodes d'essai des appareils de réfrigération pour moyens de transport isothermes - Partie 1 : Systèmes de réfrigération mécanique avec évaporateur à circulation d'air forcée ou convection et dispositifs de chauffage optionnels

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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
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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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of an identical text or by endorsement, at the latest by July 2015 and conflicting national standards shall be withdrawn at the latest by July 2015.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
P_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
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
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
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
EER_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
P_{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
P_{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
$T_{IN\ CON}$
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
$T_{IN\ VAP}$
mean temperature of different measuring points located at air inlets of the evaporator unit

3.1.23
inside temperature of the calorimeter box
T_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 %