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Thermal insulation for building equipment and industrial
installations – Calculation rules (ISO 12241:2008)

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This standard supersedes the Swedish Standard SS-EN ISO 12241, edition 1.

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EUROPEAN STANDARD
NORME EUROPÉENNE
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English Version

Thermal insulation for building equipment and industrial installations - Calculation rules (ISO 12241:2008)

Isolation thermique des équipements de bâtiments et des installations industrielles - Méthodes de calcul (ISO 12241:2008)

Wärmedämmung an haus- und betriebstechnischen Anlagen - Berechnungsregeln (ISO 12241:2008)

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Foreword

This document (EN ISO 12241:2008) has been prepared by Technical Committee ISO/TC 163 "Thermal performance and energy use in the built environment" in collaboration with Technical Committee CEN/TC 89 "Thermal performance of buildings and building components" the secretariat of which is held by SIS.

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of an identical text or by endorsement, at the latest by December 2008, and conflicting national standards shall be withdrawn at the latest by December 2008.

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The text of ISO 12241:2008 has been approved by CEN as a EN ISO 12241:2008 without any modification.

SS-EN ISO 12241:2008 (E)

Introduction

Methods relating to conduction are direct mathematical derivations from Fourier's law of heat conduction, so international consensus is purely a matter of mathematical verification. No significant difference in the equations used in the member countries exists. For convection and radiation, however, there are no methods in practical use that are mathematically traceable to Newton's law of cooling or the Stefan-Boltzman law of thermal radiation, without some empirical element. For convection in particular, many different equations have been developed, based on laboratory data. Different equations have become popular in different countries, and no exact means are available to select between these equations.

Within the limitations given, these methods can be applied to most types of industrial, thermal-insulation, heat-transfer problems.

These methods do not take into account the permeation of air or the transmittance of thermal radiation through transparent media.

The equations in these methods require for their solution that some system variables be known, given, assumed or measured. In all cases, the accuracy of the results depends on the accuracy of the input variables. This International Standard contains no guidelines for accurate measurement of any of the variables. However, it does contain guides that have proven satisfactory for estimating some of the variables for many industrial thermal systems.

It should be noted that the steady-state calculations are dependent on boundary conditions. Often a solution at one set of boundary conditions is not sufficient to characterize a thermal system that operates in a changing thermal environment (process equipment operating year-round, outdoors, for example). In such cases, it is necessary to use local weather data based on yearly averages or yearly extremes of the weather variables (depending on the nature of the particular calculation) for the calculations in this International Standard.

In particular, the user should not infer from the methods of this International Standard that either insulation quality or avoidance of dew formation can be reliably assured based on minimal, simple measurements and application of the basic calculation methods given here. For most industrial heat flow surfaces, there is no isothermal state (no one, homogeneous temperature across the surface), but rather a varying temperature profile. This condition suggests the requirement for numerous calculations to properly model thermal characteristics of any one surface. Furthermore, the heat flow through a surface at any point is a function of several variables that are not directly related to insulation quality. Among others, these variables include ambient temperature, movement of the air, roughness and emissivity of the heat flow surface, and the radiation exchange with the surroundings (which often vary widely). For calculation of dew formation, variability of the local humidity is an important factor.

Except inside buildings, the average temperature of the radiant background seldom corresponds to the air temperature, and measurement of background temperatures, emissivities and exposure areas is beyond the scope of this International Standard. For these reasons, neither the surface temperature nor the temperature difference between the surface and the air can be used as a reliable indicator of insulation performance or avoidance of dew formation.

Clauses 4 and 5 of this International Standard give the methods used for industrial thermal insulation calculations not covered by more specific standards. In applications where it is not necessary to assure precise values of heat energy conservation or (insulated) surface temperature, or where critical temperatures for dew formation are either not approached or not a factor, these methods can be used to calculate heat flow rates.

Clauses 6 and 7 of this International Standard are adaptations of the general equation for specific applications of calculating heat flow temperature drop and freezing times in pipes and other vessels.

Annexes B and C of this International Standard are for information only.

Thermal insulation for building equipment and industrial installations — Calculation rules

1 Scope

This International Standard gives rules for the calculation of heat-transfer-related properties of building equipment and industrial installations, predominantly under steady-state conditions. This International Standard also gives a simplified approach for the treatment of thermal bridges.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7345, *Thermal insulation — Physical quantities and definitions*

ISO 9346, *Hygrothermal performance of buildings and building materials — Physical quantities for mass transfer — Vocabulary*

ISO 10211, *Thermal bridges in building construction — Heat flows and surface temperatures — Detailed calculations*

ISO 13787, *Thermal insulation products for building equipment and industrial installations — Determination of declared thermal conductivity*

ISO 23993, *Thermal insulation for building equipment and industrial installations — Determination of design thermal conductivity*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 9346, ISO 13787 and ISO 23993 apply.

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3.2 Definition of symbols

Symbol	Definition	Unit
A	area	m^2
a_r	temperature factor	K^3
C'	thickness parameter (see 4.2.2)	m
C_r	radiation coefficient	$W/(m^2 \cdot K^4)$
c_p	specific heat capacity at constant pressure	$kJ/(kg \cdot K)$
D	diameter	m, mm
d	thickness	m, mm
H	height	m
h	surface coefficient of heat transfer	$W/(m^2 \cdot K)$
l	length	m
m	mass	kg
\dot{m}	mass flow rate	kg/h
P	perimeter	m
q	density of heat flow rate	W/m^2
q_d	linear density of heat flow rate for ducts	W/m
q_l	linear density of heat flow rate	W/m
R	thermal resistance	$m^2 \cdot K/W$
R_d	linear thermal resistance of ducts	$m \cdot K/W$
R_l	linear thermal resistance	$m \cdot K/W$
R_{le}	linear thermal surface resistance	$m \cdot K/W$
R_s	surface resistance of heat transfer	$m^2 \cdot K/W$
R_{sph}	thermal resistance for hollow sphere	K/W
t_{fr}	freezing time	h
t_v	cooling time	h
t_{wp}	time until freezing starts	h
T	thermodynamic temperature	K
U	thermal transmittance	$W/(m^2 \cdot K)$
U_l	linear thermal transmittance	$W/(m \cdot K)$
U_{sph}	thermal transmittance for hollow sphere	W/K
U_B	thermal transmittance of thermal bridge	$W/(m^2 \cdot K)$
ΔU_B	additional term corresponding to installation-related and/or irregular insulation-related thermal bridges	$W/(m^2 \cdot K)$
U_T	total thermal transmittance for plane wall	$W/(m^2 \cdot K)$
$U_{T,l}$	total linear thermal transmittance	$W/(m \cdot K)$
$U_{T,sph}$	total thermal transmittance for hollow sphere	W/K
v	air velocity	m/s

Symbol	Definition	Unit
z, y	correction terms for irregular insulation-related thermal bridges	—
z^*, y^*	correction terms for installation-related thermal bridges	—
α	coefficient of longitudinal temperature drop	m^{-1}
α'	coefficient of cooling time	h^{-1}
Δh_{fr}	specific enthalpy; latent heat of freezing	kJ/kg
ε	emissivity	—
Φ	heat flow rate	W
λ	design thermal conductivity	$W/(m \cdot K)$
λ_d	declared thermal conductivity	$W/(m \cdot K)$
θ	Celsius temperature	$^{\circ}C$
$\Delta\theta$	temperature difference	K
ρ	density	kg/m^3
φ	relative humidity	%
σ	Stefan-Boltzmann constant (see Reference [8])	$W/(m^2 \cdot K^4)$

3.3 Subscripts

a	ambient	lab	laboratory
av	average	l	linear
B	thermal bridge	p	pipe
c	cooling	r	radiation
cv	convection	ref	reference
d	design, duct, dew point	s	surface
E	soil	sph	spherical
e	exterior, external	se	surface, exterior
ef	effective	si	surface, interior
fm	final temperature of the medium	T	total
fr	freezing	V	vertical
H	horizontal	v	vessel
i	interior, internal	W	wall
im	initial temperature of the medium	w	water

4 Calculation methods for heat transfer

4.1 Fundamental equations for heat transfer

4.1.1 General

The equations given in Clause 4 apply only to the case of heat transfer in a steady-state, i.e. to the case where temperatures remain constant in time at any point of the medium considered. Generally, the design thermal conductivity is temperature-dependent; see Figure 1, dashed line, which is derived by iterative calculations. However, in this International Standard, the design value for the mean temperature for each layer shall be used.