# INTERNATIONAL STANDARD

# ISO
# 13790

First edition
2004-06-15

# Thermal performance of buildings — Calculation of energy use for space heating

*Performance thermique des bâtiments — Calcul des besoins d'énergie pour le chauffage des locaux*

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# Foreword

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ISO 13790 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

For the purposes of this International Standard, the CEN annex giving a list of EN documents corresponding to the ISO documents mentioned as normative references has been removed.

# Contents

Page

## Foreword

This document EN ISO 13790:2004 has been prepared by Technical Committee CEN/TC 89 "Thermal performance of buildings and building components", the secretariat of which is held by SIS, in collaboration with Technical Committee ISO/TC 163, "Thermal performance and energy use in the built environment", sub-committee 2, "Calculation methods".

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of an identical text or by endorsement, at the latest by December 2004, and conflicting national standards shall be withdrawn at the latest by December 2004.

Annexes A to F are normative. Annexes G to K are informative.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard : : Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom

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31db6968ea5f/iso-13790-2004

## Introduction

This standard is one of a series of calculation methods for the design and evaluation of thermal performance of buildings and building components.

The calculation method presented in this standard is based on an energy balance taking account of internal and external temperature variations and, through a utilisation factor, of the dynamic effect of internal and solar gains.

This method can be used for the following applications:

1) judging compliance with regulations expressed in terms of energy targets;

2) comparing the energy performance of various design alternatives for a planned building;

3) displaying a conventional level of energy performance of existing buildings;

4) assessing the effect of possible energy conservation measures on an existing building, by calculation of the energy use with and without the energy conservation measure;

5) predicting future energy resource needs on a national or international scale, by calculating the energy uses of several buildings representative of the building stock.

Reference can be made to other International Standards or to national documents for input data and detailed calculation procedures not provided by this standard. In particular, this applies to the calculation of the efficiency or the heat loss of the heating systems.

Unlike EN 832, whose scope is restricted to residential buildings, this standard can be applied to both residential and non-residential buildings. The most important changes in EN ISO 13790 compared to EN 832:1998, "*Thermal performance of buildings - Calculation of energy use for heating - Residential buildings*", are:

1. Ventilation rates are calculated according to standards prepared by CEN/TC 156;

2. Clause 11 has been made simpler, and energy use is calculated from heat use according to existing International Standards or, by default, to national documents;

3. A normative method has been included to calculate the effect of intermittence.

4. New input data have been included for non-residential buildings, in particular for utilisation factors.

For all these reasons, calculation using EN ISO 13790 gives results that may slightly differ from those obtained with EN 832.

# 1 Scope

This standard gives a simplified calculation method for assessment of the annual energy use for space heating of a residential or a non-residential building, or a part of it, which will be referred to as "the building".

It does not apply to buildings with air conditioning systems likely to provide space cooling during the heating season.

This method includes the calculation of:

1. the heat losses of the building when heated to constant internal temperature;

2. the annual heat required to maintain the specified set-point temperatures in the building;

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3. the annual energy required by the heating system of the building for space heating, using heating system characteristics which are to be found in specific European or International Standards, or, by default, in national documents.

ISO 13790:2004

The building can have several zones with different set-point temperatures, and can have intermittent heating.

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The calculation period is the month. For residential buildings the calculation can also be performed for the heating season. Monthly calculation gives correct results on an annual basis, but the results for individual months close to the beginning and the end of the heating season can have large relative errors. Annex J provides some information on the accuracy of the method.

# 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN ISO 7345:1995, *Thermal insulation – Physical quantities and definitions (ISO 7345:1987).*

EN ISO 13370:1998, *Thermal performance of buildings – Heat transfer via the ground – Calculation methods (*ISO 13370:1998*).*

EN ISO 13789, *Thermal performance of buildings – Transmission heat loss coefficient – Calculation method (ISO 13789:1999).*

**1**

# 3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN ISO 7345:1995 and the following apply.

**3.1**
**calculation period**

time period for the calculation of heat losses and gains

NOTE    The calculation period is the month. For residential buildings the calculation can also be performed for the heating season.

**3.2**
**external temperature**

temperature of external air

NOTE    For transmission heat loss calculations, the radiant temperature of the external environment is supposed equal to the external air temperature; long-wave transmission to the sky is considered in F.5.

**3.3**
**internal temperature**

arithmetic average of the air temperature and the mean radiant temperature at the centre of the occupied zone

NOTE    This is the approximate operative temperature according to ISO 7726, *Ergonomics of the thermal environment - Instruments for measuring physical quantities*.

**3.4**
**set-point temperature**

internal temperature, as fixed by the control system in normal heating mode

**3.5**
**set-back temperature**

minimum internal temperature to be maintained during reduced heating periods

**3.6**
**adjusted internal temperature**

constant virtual internal temperature leading to the same heat loss as intermittent heating

**3.7**
**heated space**

room or enclosure heated to a given set-point temperature

**3.8**
**unheated space**

room or enclosure which is not part of the heated space

**3.9**
**heat use**

heat to be delivered to the heated space by an ideal heating system to maintain the set-point temperature during a given period of time

NOTE    The heat use can include additional building heat loss resulting from non-uniform temperature distribution and non-ideal temperature control, if they are taken into account by increasing the set-point temperature and not included in the heat loss due to the heating system.

**3.10**
**energy use for space heating**

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thermal energy to be delivered to the heating system to satisfy the heat use

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**3.11**
**intermittent heating**

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31db6968ea5f/iso-13790-2004

heating pattern where normal heating periods alternate with reduced heating periods

**3.12**
**modes of intermittence**

during intermittent heating, the heating system is operated according to either of the following modes:

3.12.1    **normal mode**: the heating system functions to maintain the internal temperature at the value it would have with continuous heating;

3.12.2    **cut-off mode**: the heating system does not provide heat;

3.12.3    **reduced heating power mode**: the heating system provides a heat flow rate lower than in normal heating;

3.12.4    **set-back mode**: heat flow rate is controlled to maintain a set-back temperature;

3.12.5    **boost mode**: the heating system runs at full power in order to reach the set-point temperature at or before the end of the reduced heating period

NOTE    Depending on the control system, the boost mode can start according to two different strategies:

a) fixed time boost: the start of the boost mode is fixed by the user;

b) optimised boost: the time when the set-point internal temperature is recovered is fixed by the user, and the control system optimises the start of the boost mode, taking account of the external and internal temperatures.

### 3.13
### heated zone

part of the heated space with a given set-point temperature, throughout which the internal temperature is assumed to have negligible spatial variations

### 3.14
### heat transfer coefficient

heat flow rate between two zones divided by the temperature difference between both zones

### 3.15
### heat loss coefficient

heat transfer coefficient from the heated space to the external environment

NOTE    The heat loss coefficient of the building cannot be used when the multi-zone calculation method according to annex B is applied

### 3.16
### building heat loss

heat transferred from heated space to the external environment by transmission and by ventilation, during a given period of time

### 3.17
### ventilation heat loss

heat lost with the air leaving the heated space either by exfiltration or ventilation

### 3.18
### transmission heat loss

heat loss by transmission through the building envelope and through the ground

### 3.19
### heat gains

heat generated within or entering into the heated space from heat sources other than the space and hot water heating systems

NOTE    These include internal heat gains and solar gains.

### 3.20
### internal heat gains

heat provided within the building by occupants (sensible metabolic heat) and by appliances other than the space and hot water heating systems (lighting, domestic appliances, office equipment, etc.)

### 3.21
### solar gains

heat provided by solar radiation entering into the building through windows or passive solar devices such as sunspaces, transparent insulation and solar walls

NOTE    Active solar devices such as solar collectors are considered as part of the heating system.

### 3.22
### solar irradiation

incident solar heat per area over a given period

**3.23**
**utilisation factor**

factor reducing the total monthly or seasonal heat gains to obtain the resulting reduction of the heat use

**3.24**
**recovered heat**

heat recovered from the environment or from heating and hot water systems (including auxiliary equipment), if not directly taken into account in a reduction of the heating system losses

**3.25**
**ventilation heat recovery**

heat recovered from the exhaust air

**3.26**
**heating system losses**

total of the heat lost by the heating system, including recovered system heat loss

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## 4 Symbols and abbreviations

**Table 1 — Symbols and units**

| Symbol | Quantity | Unit |
|---|---|---|
| $A$ | area | m² |
| $a$ | numerical parameter in utilisation factor | - |
| $b$ | correction factor for unheated zones | - |
| $C$ | effective heat capacity of a heated space | J/K |
| $c$ | specific heat capacity | J/(kg·K) |
| $d$ | layer thickness | m |
| $F$ | factor | - |
| $g$ | total solar energy transmittance of a building element | - |
| $I$ | solar irradiance | J/m² |
| $H$ | heat transfer coefficient, heat loss coefficient | W/K |
| $h$ | surface coefficient of heat transfer | W/(m²·K) |
| $L$ | length | m |
| $N$ | number | |
| $Q$ | quantity of heat or energy | J |
| $R$ | thermal resistance | m²·K/W |
| $T$ | thermodynamic temperature | K |
| $t$ | time, period of time | s |
| $U$ | thermal transmittance | W/(m²·K) |
| $V$ | volume of air in a heated zone | m³ |
| $\dot{V}$ | airflow rate | m³/s |
| $\Phi$ | heat flow rate, heating power | W |
| $Z$ | heat loss parameter for solar walls | W/(m²·K) |
| $\alpha$ | absorption coefficient of a surface for solar radiation | - |
| $\gamma$ | gain/loss ratio | - |
| $\delta$ | ratio of the accumulated internal-external temperature difference when the ventilation is on to its value over the calculation period | - |
| $\varepsilon$ | emissivity of a surface for thermal radiation | - |

| Symbol | Quantity | Unit |
|--------|----------|------|
| $\eta$ | efficiency, utilisation factor for the gains | - |
| $\kappa$ | factor related to heat losses of ventilated solar walls | - |
| $\theta$ | Celsius temperature | °C |
| $\rho$ | density | kg/m³ |
| $\sigma$ | Stefan-Boltzmann constant ($\sigma = 5{,}67 \times 10^{-8}$) | W/(m²·K⁴) |
| $\tau$ | time constant | s |
| $\chi$ | heat capacity per area | J/(m²·K) |
| $\xi$ | ratio of the effects of a change in heating flow rate on the internal temperature and on the structure temperature | - |
| $\zeta$ | effective part of the heat capacity | - |
| $\omega$ | ratio of the total solar radiation falling on the element when the air layer is open to the total solar radiation during the calculation period | - |

NOTE     Hours can be used as the unit of time instead of seconds for all quantities involving time (i.e. for time periods as well as for air change rates), but in that case the unit of energy is Watt-hours [Wh] instead of Joules.

**Table 2 — Subscripts**

| | | | | | |
|---|---|---|---|---|---|
| C | capacity, calculation, convective | f | form, final | r | radiative, recovered, reduced |
| F | frame | g | gains | s | solar, sunspace |
| G | ground | h | heating, heated, hemispherical | sb | set back |
| L | loss | hol | holidays | se | surface external |
| P | related to power | hw | hot water | si | surface internal |
| S | shading | i | internal | ss | surface-sky average |
| T | transmission | ih | intermittent heating | sw | solar wall |
| V | ventilation | $i,j,k,m,n$ | dummy integers | t | transparent insulation |
| a | air | l | layer | th | heating system |
| ad | adjusted | m | metabolic, month | u | unheated |
| ap | appliances | nh | no heating | v | ventilation |
| bh | boost heating | o | overall | w | window |
| c | structure | p | partition wall | $y, z$ | zone number |
| d | design, daily, direct | pp | peak power | $\perp$ | perpendicular |
| e | exterior, envelope | ps | permanent shading | 0 | base, reference |

## 5 Outline of the calculation procedure and required data

### 5.1 Energy balance

The energy balance includes the following terms (only sensible heat is considered):

5.  transmission and ventilation heat loss from the heated space to the external environment;

6.  transmission and ventilation heat transfer between adjacent zones;

7.  internal heat gains;

8.  solar gains;

9.  generation, distribution, emission and control losses of the space heating system;

10. energy input to the space heating system.

It may also include recovered energy from various sources.

NOTE    As heat gains may induce internal temperature to rise above the set-point, the resulting additional heat loss is taken into account through a utilisation factor reducing heat gains.

The main terms of the energy balance are schematically illustrated in Figure 1.
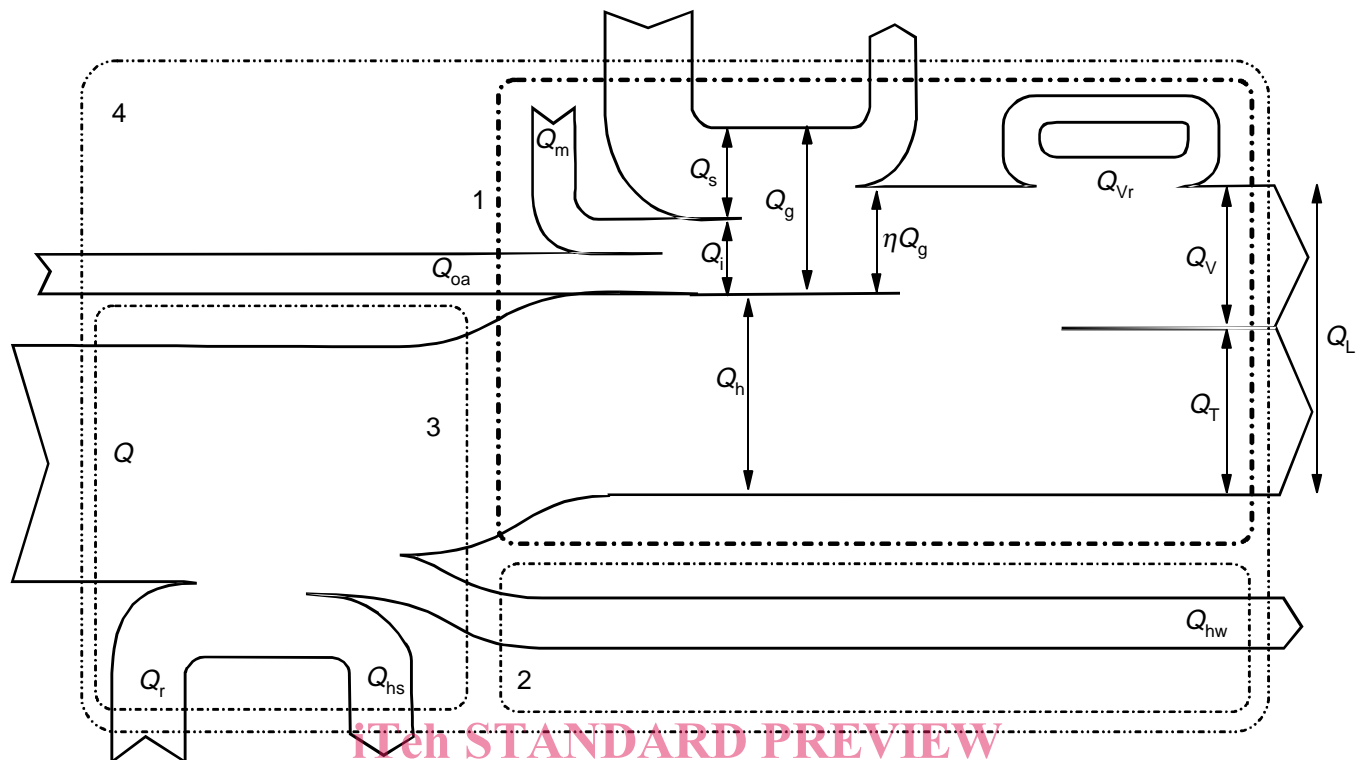
**Key**

| | | | | |
|---|---|---|---|---|
| $Q$ | Energy use for heating | | $Q_h$ | Heat use |
| $Q_{oa}$ | Heat from other appliances | | $Q_V$ | Ventilation heat loss |
| $Q_r$ | Recovered energy | | $Q_{Vr}$ | Ventilation heat recovery |
| $Q_{hs}$ | Losses from the heating system | | $Q_T$ | Transmission heat loss |
| $Q_m$ | Metabolic heat | | $Q_{hw}$ | Heat for hot water preparation |
| $Q_s$ | Passive solar gains | | $Q_L$ | Total heat loss |
| $Q_i$ | Internal gains | | 1 | Boundary of the heated zone |
| $Q_g$ | Total gains | | 2 | Boundary of the hot water system |
| $\eta\,Q_g$ | Useful gains | | 3 | Boundary of the heating plant |
| | | | 4 | Boundary of the building |

**Figure 1 – Energy balance of a building**

## 5.2 Calculation procedure

The calculation procedure is summarised below. In addition, the special approach given in annex A shall be followed when applying this standard to existing buildings.

1) Define the boundaries of the heated space and, if appropriate, of different zones and unheated spaces, according to 5.3.

2) In case of intermittent heating or intermittent ventilation define, within the calculation period, the periods having different heating and ventilation patterns (e.g. day, night, weekend) according to clause 6.