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Grelni sistemi v stavbah - Metoda za preraļ un energijskih zahtev in uļ inkovitosti sistema - 2-3. del: Sistemi za ogrevanje prostora

Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-3: Space heating distribution systems

Heizsysteme in Gebäuden - Verfahren zur Berechnung der Energieanforderungen und Nutzungsgrade der Anlagen - Teil 2-3: Wärmeverteilsysteme

Systemes de chauffage dans les bâtiments - Méthode de calcul des besoins énergétiques et d'efficacité des systemes - Partie 2-3: Systemes de distribution de chauffage des locaux

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Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-3: Space heating distribution systems

Systèmes de chauffage dans les bâtiments - Méthode de calcul des besoins énergétiques et des rendements des systèmes - Partie 2-3: Systèmes de distribution de chauffage des locaux

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This European Standard was approved by CEN on 21 June 2007.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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Foreword

This document (EN 15316-2-3:2007) has been prepared by Technical Committee CEN/TC 228 "Heating systems in buildings", the secretariat of which is held by DS.

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of an identical text or by endorsement, at the latest by January 2008, and conflicting national standards shall be withdrawn at the latest by January 2008.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/343), and supports essential requirements of EU Directive 2002/91/EC on the energy performance of buildings (EPBD). It forms part of a series of standards aimed at European harmonisation of the methodology for calculation of the energy performance of buildings. An overview of the whole set of standards is given in prCEN/TR 15615,.

The subjects covered by CEN/TC 228 are the following:

— design of heating systems (water based, electrical etc.);

— installation of heating systems;

— commissioning of heating systems;

— instructions for operation, maintenance and use of heating systems;

— methods for calculation of the design heat loss and heat loads;

— methods for calculation of the energy performance of heating systems.

Heating systems also include the effect of attached systems such as hot water production systems.

All these standards are systems standards, i.e. they are based on requirements addressed to the system as a whole and not dealing with requirements to the products within the system.

Where possible, reference is made to other European or International Standards, a.o. product standards. However, use of products complying with relevant product standards is no guarantee of compliance with the system requirements.

The requirements are mainly expressed as functional requirements, i.e. requirements dealing with the function of the system and not specifying shape, material, dimensions or the like.

The guidelines describe ways to meet the requirements, but other ways to fulfil the functional requirements might be used if fulfilment can be proved.

Heating systems differ among the member countries due to climate, traditions and national regulations. In some cases requirements are given as classes so national or individual needs may be accommodated.

In cases where the standards contradict with national regulations, the latter should be followed.

EN 15316 *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies* consists of the following parts:

Part 1: General

Part 2-1: Space heating emission systems

Part 2-3: Space heating distribution systems

Part 3-1: Domestic hot water systems, characterisation of needs (tapping requirements)

Part 3-2: Domestic hot water systems, distribution

Part 3-3: Domestic hot water systems, generation

Part 4-1: Space heating generation systems, combustion systems (boilers)

Part 4-2: Space heating generation systems, heat pump systems

Part 4-3: Heat generation systems, thermal solar systems

Part 4-4: Heat generation systems, building-integrated cogeneration systems

Part 4-5: Space heating generation systems, the performance and quality of district heating and large volume systems

Part 4-6: Heat generation systems, photovoltaic systems

Part 4-7: Space heating generation systems, biomass combustion systems

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

Introduction

In a distribution system, energy is transported by a fluid from the heat generation to the heat emission. As the distribution system is not adiabatic, part of the energy carried is emitted to the surrounding environment. Energy is also required to distribute the heat carrier fluid within the distribution system. In most cases this is electrical energy required by the circulation pumps. This leads to additional thermal and electrical energy demand.

The thermal energy emitted by the distribution system and the electrical energy required for the distribution, may partially be recovered as heat, if the distribution system is placed inside the heated envelope of the building.

This European Standard provides three methods of calculation.

The detailed calculation method describes the basics and the physical background of the general calculation method. The required input data are part of the detailed project data assumed to be available (such as length of pipes, type of insulation, manufacturer's data for the pumps etc.). The detailed calculation method provides the most accurate energy demand and heat emission.

For the simplified calculation method, some assumptions are made for the most relevant cases, reducing the required input data (e.g. the lengths of pipes are calculated by approximations depending on the outer dimensions of the building and efficiency of pumps is approximated). This method may be applied if only few data are available (in general at an early stage of design). With the simplified calculation method, the calculated energy demand is generally higher than the calculated energy demand by the detailed calculation method. The assumptions made for the simplified method depend on national design, and therefore this method is part of informative Annex A.

The tabulated calculation method is based on the simplified calculation method, with some further assumptions being made. Only input data for the most important influences are required with this method. The further assumptions made for this method depend on national design as well, and therefore the tabulated method is also part of informative Annex A.

Other influences, which are not reflected by the tabulated values, shall be calculated by the simplified or the detailed calculation method. The energy demand determined from the tabulated calculation method is generally higher than the calculated energy demand by the simplified calculation method. Use of this method is possible with a minimum of input data.

The general calculation method for the electrical energy demand of pumps consists of two parts. The first part is calculation of the hydraulic demand of the distribution system, and the second part is calculation of the expenditure energy factor of the pump. Here, it is possible to combine the detailed and the simplified calculation method. For example, calculation of pressure loss and flow may be done by the detailed calculation method and calculation of the expenditure energy factor may be done by the simplified calculation method (when the data of the building are available and the data of the pump are not available) or vice versa.

In national annexes, the simplified calculation method as well as the tabulated calculation method could be applied through a.o. relevant boundary conditions of each country, thus facilitating easy calculations and quick results. In national annexes, it is only allowed to change the boundary conditions and other assumptions. The calculation methods as described are to be applied.

The recoverable part of the auxiliary energy demand is given as a fixed ratio and is therefore also easy to determine.

1 Scope

This European Standard provides a methodology to calculate/estimate the system thermal loss of water based distribution systems for heating and the auxiliary energy demand, as well as the recoverable part of each. The actual recovered energy depends on the gain to loss ratio. Different levels of accuracy, corresponding to the needs of the user and the input data available at each design stage of the project, are provided in this European Standard by different calculation methods, i.e. a detailed calculation method, a simplified calculation method and a method based on tabulated values. The general method of calculation can be applied for any time-step (hour, day, month or year).

Pipework lengths for the heating of decentralised, non-domestic ventilation systems equipment are to be calculated in the same way as for water based heating systems. For centralised, non-domestic ventilation systems equipment, the length is to be specified in accordance with its location.

NOTE It is possible to calculate the system thermal loss and auxiliary energy demand for cooling systems with the same calculation methods as shown in this European Standard. Specifically, determination of auxiliary energy demand is based on the same assumptions for efficiency of pumps, because the efficiency curve applied is an approximation for inline and external motors. It needs to be decided by the standardisation group of CEN, whether or not the extension for cooling systems should be made in this European Standard. This is also valid for distribution systems in HVAC (in ducts) and also for special liquids.

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.

EN 12831, *Heating systems in buildings — Method for calculation of the design heat load*

3 Terms and definitions

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

3.1
technical building system
technical equipment for heating, cooling, ventilation, domestic hot water, lighting and electricity production composed by sub-systems

NOTE 1 A technical building system can refer to one or to several building services (e.g. heating system, heating and domestic hot water system).

NOTE 2 Electricity production can include cogeneration and photovoltaic systems.

3.2
technical building sub-system
part of a technical building system that performs a specific function (e.g. heat generation, heat distribution, heat emission)

3.3
space heating
process of heat supply for thermal comfort

3.4
auxiliary energy
electrical energy used by technical building systems for heating, cooling, ventilation and/or domestic hot water to support energy transformation to satisfy energy needs

NOTE 1 This includes energy for fans, pumps, electronics etc. Electrical energy input to a ventilation system for air transport and heat recovery is not considered as auxiliary energy, but as energy use for ventilation.

NOTE 2 In EN ISO 9488, the energy used for pumps and valves is called "parasitic energy".

3.5
heat recovery
heat generated by a technical building system or linked to a building use (e.g. domestic hot water) which is utilised directly in the related system to lower the heat input and which would otherwise be wasted (e.g. preheating of the combustion air by flue gas heat exchanger)

3.6
system thermal loss
thermal loss from a technical building system for heating, cooling, domestic hot water, humidification, dehumidification, ventilation or lighting that does not contribute to the useful output of the system

NOTE Thermal energy recovered directly in the subsystem is not considered as a system thermal loss but as heat recovery and directly treated in the related system standard.

3.7
recoverable system thermal loss
part of a system thermal loss which can be recovered to lower either the energy need for heating or cooling or the energy use of the heating or cooling system

3.8
recovered system thermal loss
part of the recoverable system thermal loss which has been recovered to lower either the energy need for heating or cooling or the energy use of the heating or cooling system

3.9
calculation step
discrete time interval for the calculation of the energy needs and uses for heating, cooling, humidification and dehumidification

NOTE Typical discrete time intervals are one hour, one month or one heating and/or cooling season, operating modes and bins.

3.10
calculation period
period of time over which the calculation is performed

NOTE The calculation period can be divided into a number of calculation steps.

3.11
heating or cooling season
period of the year during which a significant amount of energy for heating or cooling is needed

NOTE The season lengths are used to determine the operation period of technical systems.

4 Symbols, units and indices

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

Table 1 — Symbols, units and indices

$A_{h,z}$	Heated floor in the zone	[m²]
c	Specific heat capacity	[J/kg K]
e_{dis}	Expenditure energy factor for operation of circulation pump	[-]
f_S	Correction factor for supply flow temperature control	[-]
f_{NET}	Correction factor for hydraulic networks (layout)	[-]
$f_{S,des}$	Correction factor for heating surface design	[-]
f_{HB}	Correction factor for hydraulic balance	[-]
$f_{G,PM}$	Correction factor for generators with integrated pump management	[-]
f_{PL}	Correction factor for partial load characteristics	[-]
f_C	Correction factor for control of the pump	[-]
f_{PSP}	Correction factor for selection of design point	[-]
f_{ϑ}	Correction factor for differential temperature dimensioning	[-]
$f_{\dot{q}}$	Correction factor for surface related heating load	[-]
f_{η}	Correction factor for efficiency	[-]
h_{lev}	Floor height	[m]
L_L	Building length	[m]
L_{max}	Maximum length of pipe	[m]
L_W	Building width	[m]
k_{by}	Ratio of flow over the heat emitter to flow in the ring	[-]
n	Exponent of the heat emission system	[-]
N_{lev}	Number of floors	[-]
Δp_{des}	Differential pressure at design point	[kPa]
Δp_{HS}	Differential pressure of heating surfaces	[kPa]
Δp_{CV}	Differential pressure of control valves for heating surfaces	[kPa]
Δp_{ZV}	Differential pressure of zone valves	[kPa]
Δp_G	Differential pressure of heat supply	[kPa]
Δp_{FH}	Differential pressure of floor heating systems	[kPa]
Δp_{ADD}	Differential pressure of additional resistances	[kPa]
$P_{hydr,des}$	Hydraulic power at design point	[W]
$P_{el,pmp}$	Actual power input	[W]
$P_{el,pmp,ref}$	Reference power input	[W]
Φ_H	Design heating load	[kW]
$Q_{H,dis,aux,rbl}$	Recoverable auxiliary energy for space heating	[kWh/time step]
$Q_{H,dis,aux,rvd}$	Recovered auxiliary energy in the distribution system	[kWh/time step]

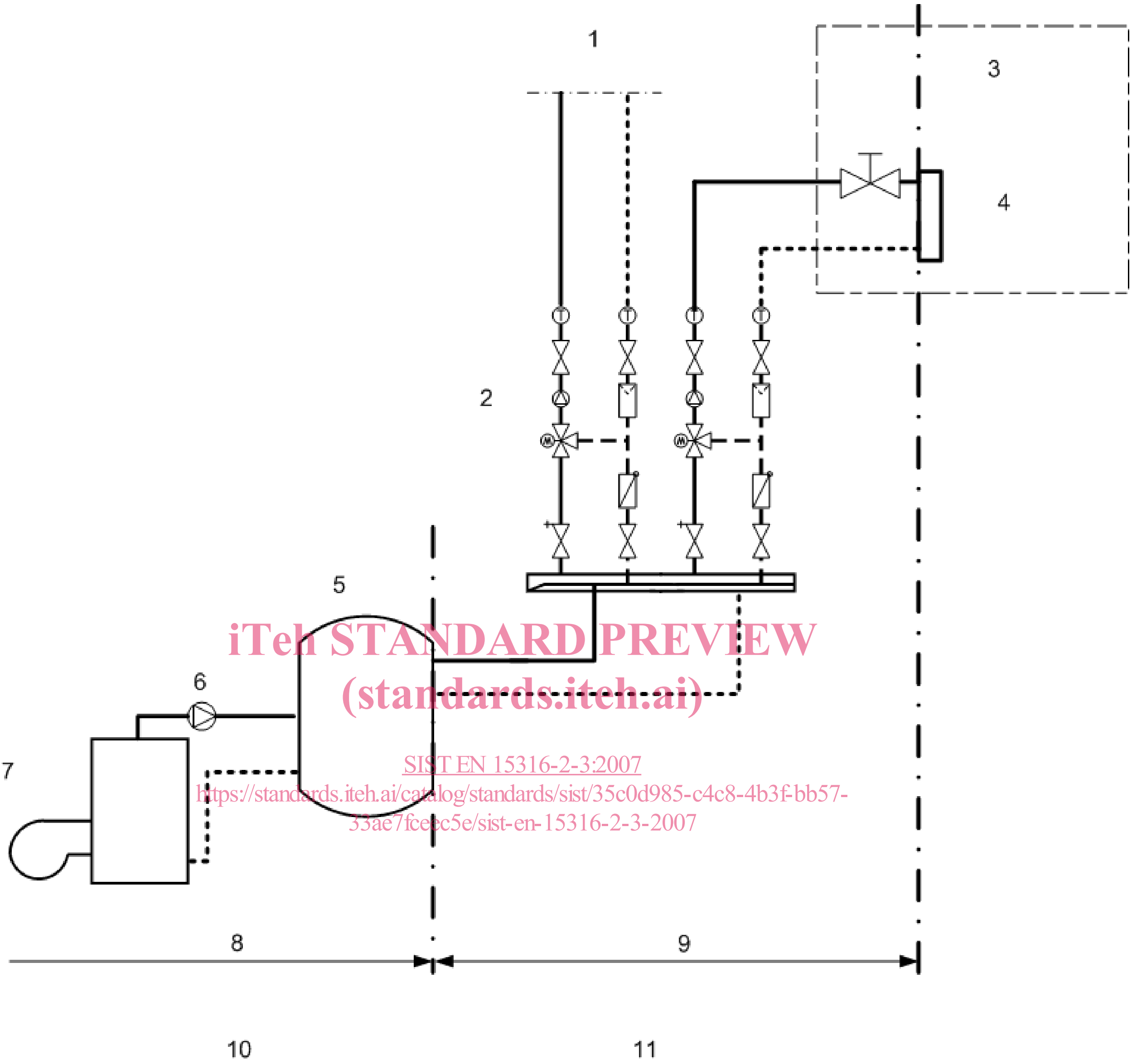
$Q_{H,dis,ls,an}$	Annual system thermal loss of the distribution system	[kWh/year]
$Q_{H,dis,ls,rbl,an}$	Recoverable system thermal losses for space heating	[kWh/year]
$Q_{H,dis,ls,nrbl,an}$	Unrecoverable system thermal losses	[kWh/year]
R	Pressure loss in pipes	[kPa/m]
$t_{op,an}$	Heating hours per year	[h/year]
Ψ	Linear thermal transmittance	[W/mK]
$\dot{V}_{des}$	Flow at design point	[m³/h]
$\dot{V}_{\min}$	Minimum volume flow	[m³/h]
$W_{H,dis,aux,an}$	Annual auxiliary energy demand	[kWh/year]
$W_{H,dis,aux,m}$	Monthly auxiliary energy demand	[kWh/month]
$W_{H,dis,hydr,an}$	Annual hydraulic energy demand	[kWh/year]
f_{comp}	Resistance ratio of components	[-]
k	Time factor	[-]
k_b	Boost mode time factor	[-]
k_r	Regular mode time factor	[-]
k_{setb}	Set back mode time factor	[-]
$\Delta\vartheta_{dis,des}$	Design heating system temperature difference	[K]
η_P	Efficiency of pump at design point	[-]
β_{dis}	Mean part load of the distribution	[-]
ρ	Specific density	[kg/m³]
θ_i	Surrounding temperature	[°C]
θ_m	Mean medium temperature	[°C]
θ_u	Temperature in unheated space	[°C]
θ_s	Supply temperature	[°C]
θ_r	Return temperature	[°C]
$\theta_{s,des}$	Design supply temperature	[°C]
$\theta_{r,des}$	Design return temperature	[°C]

5 Principle of the method and definitions

The method allows the calculation of the system thermal loss and the auxiliary energy demand of water based distribution systems for heating circuits (primary and secondary), as well as the recoverable system thermal losses and the recoverable auxiliary energy.

As shown in Figure 1, a heating system can be divided in three parts – emission and control, distribution and generation. A simple heating system has no buffer-storage, no distributor/collector, and only one pump is applied. Larger heating systems comprise more than one secondary heating circuit with different emitters. Often, such larger heating systems comprise also more than one heat generator with either one common primary heating circuit or individual primary heating circuits (in Figure 1, only one primary heating circuit is shown).

The subdivision of the heating system into primary and secondary circuits is given by any hydraulic separator, which can be a buffer-storage with a large volume or a hydraulic separator with a small volume. Anyhow, the calculation method is valid for a closed heating circuit, and therefore the equations have to be applied for each circuit taking into account the corresponding values.



Key

1 next heating circuit
2 pump
3 room
4 emission
5 buffer-storage
6 pump
7 generator
8 generation
9 distribution
10 primary heating circuits
11 secondary heating circuits

Figure 1 — Scheme distribution and definitions of heating circuits

Controls in distribution systems are thermostatic valves at the emitter which throttles the flow or room thermostats which shut on/off the pump. Only if the flow is throttled the control of the pump (speed control) is valid.

6 Auxiliary energy demand

6.1 General

The auxiliary energy demand of hydraulic networks depends on the distributed flow, the pressure drop and the operation condition of the circulation pump. While the design flow and pressure drop is important for determining the pump size, the part load factor determines the energy demand in a time step.

The hydraulic power at the design point can be calculated from physical basics. However, for calculation of the hydraulic power during operation, this can only be achieved by a simulation. Therefore, for the detailed calculation method in this standard, correction factors are applied, which represent the most important influences on auxiliary energy demand, such as part load, controls, design criteria.

The general calculation approach is to separate the hydraulic demand, which depends on the design of the network, and the expenditure energy for operation of the circulation pump, which takes into account the efficiency of the pump in general. However, for calculation of the expenditure energy during operation, knowledge of the efficiency of the pump at each operation point is required, Therefore, for the detailed calculation method in this European Standard, correction factors are applied, which represent the most important influences on expenditure energy, such as efficiency, part load, design point selection and control.

All the calculations are made for a zone of the building with the affiliated area, length, width, floor height and number of floors.

6.2 Design hydraulic power

For all the calculations, the hydraulic power and the differential pressure of the distribution system at the design point are important. The hydraulic power is given by:

$$P_{hydr,des} = 0{,}2778 \cdot \Delta p_{des} \cdot \dot{V}_{des} \qquad \text{[W]} \qquad (1)$$

where

$\dot{V}_{des}$ is the flow at design point [m³/h];

Δp_{des} is the differential pressure at design point [kPa].

The flow is calculated from the heat load $\Phi_{H,em,out}$ of the zone (the design heat load shall be according to EN 12831) and the design temperature difference $\Delta\vartheta_{dis,des}$ of the heating system:

$$\dot{V}_{des} = \frac{3600 \cdot \Phi_{H,em.out}}{c \cdot \rho \cdot \Delta\vartheta_{dis,des}} \qquad \text{[m}^3\text{/h]} \qquad (2)$$

where

c is the specific heat capacity [kJ/kg K];

ρ is the density [kg/m³];

$\Delta\vartheta_{dis,des}$ is the design temperature difference [K].

The differential pressure for a zone at the design point is determined by the resistance in the pipes (including components) and the additional resistances (the most important are listed below):

$$\Delta p_{des} = \left(1 + f_{comp}\right) \cdot R \cdot L_{\max} + \Delta p_{HS} + \Delta p_{CV} + \Delta p_{ZV} + \Delta p_{G} + \Delta p_{ADD} \text{ [kPa]} \quad (3)$$

where

f_{comp} is the resistance ratio of components [-];

R is the pressure loss per m [kPa/m];

$L_{\max}$ is the maximum pipe length of the heating circuit [m];

Δp_{HS} is the differential pressure of heating surface [kPa];

Δp_{CV} is the differential pressure of control valve for heating surface [kPa];

Δp_{ZV} is the differential pressure of zone valves [kPa];

Δp_{G} is the differential pressure of heat supply [kPa];

Δp_{ADD} is the differential pressure of additional resistances [kPa].

6.3 Detailed calculation method

6.3.1 Input/output data

The input data for the detailed calculation method are listed below. These are all part of the detailed project data.

$P_{hydr,des}$ hydraulic power at the design point for the zone [in W]

- by calculation according to Equations (1) and (2)

$\Phi_{H,em,out}$ design heat load of the zone according to EN 12831;

$\Delta\vartheta_{dis,des}$ design temperature difference for the distribution system in the zone [K];

$L_{\max}$ maximum pipe length of the heating circuit in the zone [m];

Δp differential pressure of the circuit in the zone [kPa];

β_{dis} mean part load of the distribution [-];

$t_{op,an}$ heating hours per year [h/year];