DRAFT INTERNATIONAL STANDARD ISO/DIS 13612-1

ISO/TC **205** Secretariat: **ANSI**

Voting begins on **2012-05-07** Voting terminates on **2012-10-07**

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems —

Part 1: **Design and dimensioning**

Systèmes de chauffage et de refroissement dans les bâtiments — Méthode pour le calcul de la performance du système et la conception du système pour les systèmes utilisant les pompes à chaleur —

Partie 1: Conception et dimensionnement

ICS 27.080; 91.040.01

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 16812-1 was prepared by Technical Committee 205, *Building environment design*.

ISO 16812 consists of the following parts, under the general title Heating and cooling systems in buildings – Method for calculation of the system performance and system design for heat pump systems:

— *Part 1: Design and dimensioning*

— *Part 2: Energy calculation*

Introduction

This International Standard will be part of a series of standards on the method for calculation of heating system energy requirements and heating and cooling system efficiencies.

- Part 1 of the standard deals with design and sizing of heat pump systems
- Part 2 of the standard presents the energy calculation method

Heating and cooling systems in buildings — Method for calculation of the system performance and system design for heat pump systems —

Part 1: Design and dimensioning

1 Scope

This International Standard is applicable to heat pumps for space heating and cooling, heat pump water heaters (HPWH), and heat pumps with combined space heating and cooling and domestic hot water production, in alternate or simultaneous operation, where the same heat pump is used for space heating and cooling, and domestic hot water heating.

This International Standard establishes the required inputs, calculation methods, and required outputs for heat generation for space heating and domestic hot water production and control of the following heat pump systems:

- electrically-driven vapour compression cycle (VCC) heat pumps,
- combustion engine-driven vapour compression cycle heat pumps, and
- thermally-driven vapour absorption cycle (VAC) heat pumps.

This International Standard specifies design and dimensioning criteria for heating and cooling systems in buildings using heat pumps alone or in combination with other heat generators. These include:

- Water – water
- Brine – water
- Refrigerant – water (direct expansion systems)
- Air – air
- Air – water

This International Standard takes into account the heating requirements of attached systems (e.g., domestic hot water, process heat) in the design of heat supply, but does not cover the design of these systems. This standard covers only the aspects dealing with the heat pump, the interface with the heat distribution and emission system (e.g., buffering system), the control of the whole system and the aspects dealing with energy source of the system.

Table 1 — Heat pump systems (within this scope)

<table>
<tr><th colspan="2">Source-system
(energy extraction)</th><th colspan="2">Sink-system
(energy rejection)</th></tr>
<tr><th>Energy source [a]</th><th>Medium [b]</th><th>Medium</th><th>Energy sink [c]</th></tr>
<tr><td>Exhaust air
Outdoor air</td><td>Refrigerant</td><td>Refrigerant</td><td>Air</td></tr>
<tr><td rowspan="2">Exhaust air
Outdoor air</td><td rowspan="2">Air</td><td>Air</td><td>Air</td></tr>
<tr><td>Water</td><td>Indoor air
Water</td></tr>
<tr><td rowspan="2">Surface water
Ground water</td><td rowspan="2">Water</td><td>Water</td><td>Indoor air
Water</td></tr>
<tr><td>Air</td><td>Indoor air</td></tr>
<tr><td rowspan="4">Ground</td><td rowspan="2">Brine
(water)</td><td>Air</td><td>Water</td></tr>
<tr><td>Water</td><td>Indoor air
Water</td></tr>
<tr><td rowspan="2">Refrigerant
(direct expansion)</td><td>Water</td><td>Indoor air
Water</td></tr>
<tr><td>Refrigerant</td><td>Indoor air</td></tr>
</table>

[a] Energy source is the location where the energy is extracted

[b] Medium is the fluid transported in the corresponding distribution system

[c] Energy sink is the location where the energy is used, this can be the air conditioned space or water in case of DHW production

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 16818, *Building environment design – Energy efficiency – Terminology*

ISO 23045, *Building environment design – Guidelines to assess energy efficiency of new buildings*

ISO 13790, *Energy performance of buildings – Calculation of energy use for space heating and cooling*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16818 and the following apply.

3.1.1
balance point temperature
lowest design external air temperature at which the heat pump output capacity and the building heating demand (heat load) are equal

NOTE At lower external air temperatures, a second heat generator is employed to cover the entire or part of the building heating demand

3.1.2
bivalent alternative mode (low temperature cut out)
operational mode in which a second heat generator (e.g., gas boiler) completely accounts for the heat demand of the heating system if the external temperature falls below the balance point temperature

3.1.4
bivalent parallel mode
operational mode in which a second heat generator (e.g., gas boiler) accounts for the remaining heat demand of the heating system which cannot be supplied by the heat pump when the external temperature falls below the balance point temperature

3.1.4
coefficient of performance
COP
the momentary ratio of the thermal heat flux of the heat pump to the electrical power of the unit

NOTE The electrical power of the unit includes auxiliary power requirements, but not the additional power requirements for circulation pumps (heat sink and heat source)

3.1.5
minimum operating temperature
θ_{MOT}
minimum recommended value of the external temperature to operate the heat pump

3.1.6
monovalent mode
operational mode in which the heat pump is designed to cover the entire energy demand of the heating and cooling system alone (i.e., the heat pump output capacity is equal to the design heat load)

3.1.7
seasonal performance factor
the ratio of the annual heat Q_{HP} supplied by the heat pump to the total electrical energy consumed (including all auxiliary sources)

3.1.8
source (heat – cool)
source of energy extracted to the heat pump system

3.2 Symbols and abbreviations

The symbols and units used in this document are listed in table 2.

Table 2 – Symbols and units

Symbol	Description	Unit
Φ_{supply}	Heating capacity of the supply system	kW
θ_{MOT}	Minimum operating temperature (external)	°C
$\theta_{e,h}$	Design external temperature (heating)	°C
$\theta_{min,h}$	Minimal operating temperature of the heat pump (heating)	°C

Table 3 – Abbreviations and subscripts

Abbreviation	Description
H	Heating
C	Cooling
DWH	Domestic Hot Water

4 System design requirements

4.1 General

The heat pump system shall be designed to satisfy the design heating and cooling load of the building and the requirements of any attached system.

Any other recognized energy load calculation method shall only be used if accepted by the client.

The heating supply system and/or the cooling supply system shall be designed and dimensioned taking into account the type of energy source.

General consideration shall be given to energy efficiency of the heat pump system.

4.2 Heating / cooling source

4.2.1 Air as heat source

The minimum air flow declared by the manufacturer shall be taken into account when designing the system. For monovalent systems, the required capacity of the heat pump shall be determined by using the design external air temperature. For bivalent systems, a suitable balance point temperature shall be set depending on the selected operational mode (bivalent-alternative or bivalent-parallel mode) and the minimum air flow entering in the system. The air quality shall be checked and airborne salinity (a function of the distance from seawater) shall be taken into consideration.

4.2.2 Water as heat source

Water sourced from groundwater, seawater, a lake or a river may be used as a heat source.

The required water flow rate for the heat pump unit shall be made available, taking into account local regulations which may place limits on availability and flow rates.

The average groundwater temperature can be obtained from local authorities, a test borehole or (in the case of dwellings) by qualified assumption (e.g., the annual mean external temperature at the location).

The water source shall enable a continuous extraction of the design flow rate of the attached heat pumps. The possible extraction flow rate is dependent on local geological factors and can be ascertained by continuously extracting the nominal flow rate in a test run of sufficient duration to attain quasi-steady-state conditions. For larger systems, hydrogeological investigations (e.g., well test) may be necessary.

The quality of the water shall match the manufacturer's requirements. If the manufacturer's requirements cannot be achieved (e.g., in case of sea-water), a secondary circuit or a water treatment shall be considered.

Provisions for returning the water shall be provided. The direction of the ground water flow shall be taken into account when selecting the position of the injection well. The extraction well shall be situated upstream of the injection well if the heat pump is only used for heating purposes (see Figure 1).

The heat extraction system shall be designed and controlled so as to avoid the risk of freezing.

The water shall be returned to the environment as clean as possible and in accordance with local regulations.

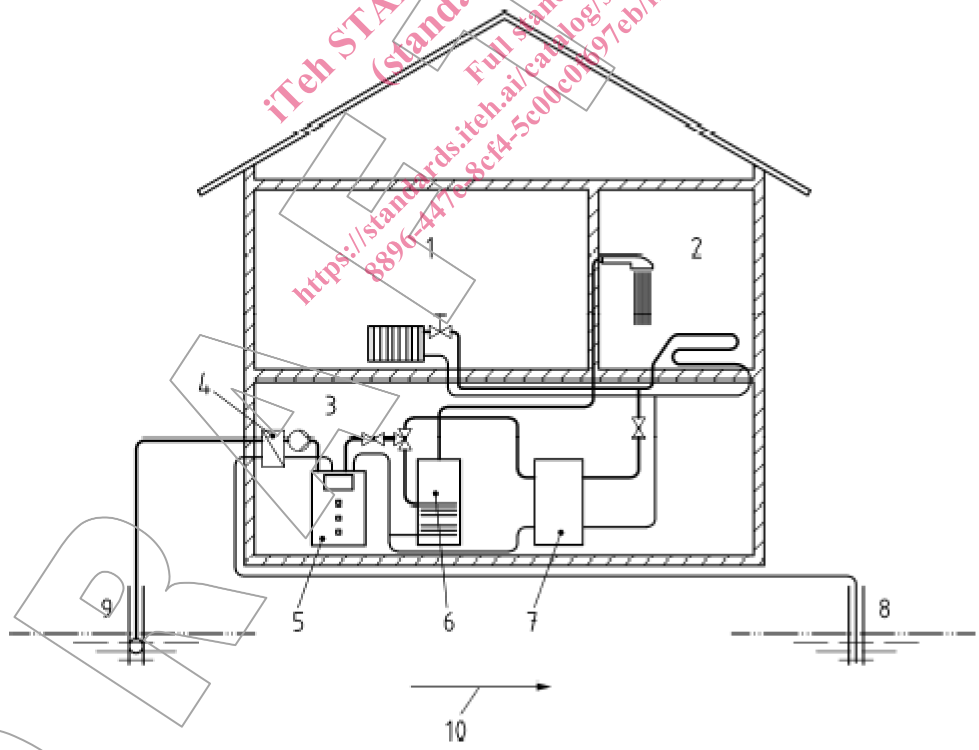

Figure 1 Arrangement of a heat pump heating system with ground water flow

Key

1 living room
2 bathroom
3 cellar
4 heat exchanger
5 heat pump
6 storage water heater
7 buffer storage
8 injection well
9 extraction well (including pump)
10 ground water flow direction

4.2.3 Ground as heat source

The minimum temperature of the ground at the appropriate depth shall be taken into account when designing the heat pump system. Information on typical temperature profiles is given in Annex A.

The temperature reduction of the ground, as a result of heat extraction over the heating period, as well as the long term temperature drop, due to consecutive years of heat pump operation, shall be taken into account so as never to jeopardize the operation of the heat pump and also to ensure economical as well as reasonable environmental operating conditions.

4.3 Electrical supply

Availability of a suitable electrical supply (both power and amperage) shall be ensured.

The operation time, the tariff and the cut-out time shall be taken into account.

The maximum current withdrawn during start-up phase shall be considered, especially for single-phase electrically-driven heat pumps.

4.4 Heat pump system design

The design of a heat pump system shall consider the following aspects:

– The heat pump system shall be designed to achieve the highest seasonal performance factor with respect to the selected heat source. The seasonal energy efficiency ratio (or seasonal energy performance) increases with decreasing temperature difference between the source temperature and the sink temperature. High source temperatures and low sink temperatures are desirable in the heating period (reducing the sink temperature by 1 K leads to an increase in the COP of about 2%).

– The heat pump system shall be designed so that its seasonal performance factor is equal to or higher than the minimum values given in an according national annex. In case no national values have been published, default minimum values are given in Annex C.

NOTE Additionally, target-values for the seasonal performance factor are given in an according national dataset. In case no national annex has been published, default target-values are given in Annex C.

– The environmental impact due to heat pump operation shall be minimised. Care shall be taken not to emit the refrigerant into the atmosphere due to leakages during operation as well as during maintenance.

NOTE Monoblock systems are hermetically sealed and the leakage rate is under 1%

– The heat pump system shall be designed to be user-friendly and require limited maintenance.

4.5 Positioning

The positioning of a heat pump shall consider the following aspects:

– the location of the heat pump (e.g., outside the building) within the heated space or in an unheated space;

- the allowable temperature range of the environment surrounding the heat pump (given by the manufacturer),
- the possibility of damage to the unit or the components due to freezing, and
- accessibility for installation and maintenance purposes.

4.6 Noise level

Heat pumps using air as a heat source are prone to cause noise problems resulting from sound conducted through solids and transmitted through air. Noise levels and information regarding the installation shall be provided in the technical documents provided by the manufacturer.

5 Dimensioning of the heat pump system

5.1 General

The heat supply system shall be designed to satisfy the design heat load of the building and the requirements of any attached system (e.g., domestic hot water production). The design heating and cooling loads shall be calculated in accordance with rules given in accepted methodologies.

NOTE 1 ISO 15265 provides benchmark results for validation of the building simulation model used for calculation of the design heating and cooling loads.

NOTE 2 Information on the design scheme is presented in Annex A.

5.2 Methodology for sizing

The method for dimensioning the heat pump is provided in Figure 3.

The maximum power supply required for any period of activity (heating or cooling) shall be calculated and the heat pump system shall be designed to satisfy the energy demand in any case.

Designers shall take into account the energy uses required by any combination of heating, domestic hot water production and cooling.

The priority given of the energy use to satisfy demand shall also be identified.

For a heat pump system sized below this maximum value a supply system shall be attached to satisfy the energy demand. For a bivalent system the minimum operating temperature shall be identified as the thermal load is calculated for this value of minimum operating temperature. The temperature operating limit and the bivalent temperature shall be identified by the designer.

