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Gas-fired endothermic engine driven heat pumps - Part 5: Calculation of seasonal performances in heating and cooling mode

Gasbefeuerte endothermische Motor-Wärmepumpen - Teil 5: Berechnung der saisonalen Effizienzkennzahlen im Heiz- und Kühlmodus

Pompes à chaleur à moteur endothermique alimenté au gaz -Partie 5 : Calcul des performances saisonnières en modes chauffage et refroidissement

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Pompes à chaleur à moteur endothermique alimenté au gaz -Partie 5 : Calcul des performances saisonnières en modes chauffage et refroidissement

Gasbefeuerte endothermische Motor-Wärmepumpen - Teil 5: Berechnung der saisonalen Effizienzkennzahlen im Heiz- und Kühlmodus

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 299.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 16905-5:2021) has been prepared by Technical Committee CEN/TC 299 “Gas-fired sorption appliances, indirect fired sorption appliances, gas-fired endothermic engine heat pumps and domestic gas-fired washing and drying appliances”, the secretariat of which is held by UNI.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 16905-5:2017.

In comparison with the previous edition, the following technical modifications have been made:

Editorial and technical changes throughout the draft and in Annex ZA, ZB and ZC in order to align the text to the Ecodesign Requirements stated in Commission Regulation (EU) No 2016/426.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, Annex ZB and Annex ZC which are integral parts of this document.

Introduction

The GEHP appliances having their condenser cooled by air and by the evaporation of external additional water are not covered by this European Standard.

Single split and multisplit systems are covered by this document.

The GEHP appliances can have one or more primary or secondary functions.

This document specifies the calculation of seasonal performances in heating and cooling mode of air conditioners and heat pumps using either air, water or brine as heat transfer media, with gas-fired endothermic engine driven compressors when used for space heating, cooling and refrigeration, hereafter referred to as “GEHP appliance”

EN 16905 comprises the following parts under the general title, Gas-fired endothermic

engine driven heat pumps:

— Part 1: Terms and definitions;

— Part 2: Safety;

— Part 3: Tests conditions;

— Part 4: Tests methods;

— Part 5: Calculation of seasonal performances in heating and cooling mode.

prEN 16905-5:2021 has been prepared to address the essential requirements of the European Regulation (EU) 2016/426 relating to appliances burning gaseous fuels and repealing Directive 2009/142/EC (see EN 16905-4:2020, Annex ZA).

EN 16905-1:2017, EN 16905-2:2020, EN 16905-3:2017, EN 16905-4:2017 and EN 16905-5:2017 are linked to the Energy Related Products Directive (2009/125/EC) in terms of tests conditions, tests methods and seasonal performances calculation methods under Mandate M/535; (see EN 16905-3:2017, Annex ZA, EN 16905-4:2017, Annex ZA, EN 16905-5:2017, Annex ZA and EN 16905-2:2020, Annexes ZB and ZC).

These documents will be reviewed whenever new mandates could apply.

1 Scope

This part of EN 16905 specifies the calculation of the seasonal performance factor for gas-fired endothermic engine driven heat pumps for heating and/or cooling mode including the engine heat recovery, to be used outdoor.

This document is used in conjunction with:

a) the terms and conditions, EN 16905-1:2017

b) the safety, EN 16905-2:2021

c) the test conditions, EN 16905-3:2017

d) the test methods, EN 16905-4:2021

e) the heat pump standards, EN 14511-2:2018, EN 14511-3:2018 and EN 14825:2018.

This document only applies to appliances with a maximum heat input (based on net calorific value) not exceeding 70 kW at standard rating conditions.

This document only applies to appliances under categories I_{2H}, I_{2E}, I_{2Er}, I_{2R}, $I_{2E(S)B}$, I_{2L}, I_{2LL}, I_{2ELL}, $I_{2E(R)B}$, I_{2ESi}, $I_{2E(R)}$, I_{3P}, I_{3B}, $I_{3B/P}$, II_{2H3+}, II_{2Er3+}, $II_{2H3B/P}$, $II_{2L3B/P}$, $II_{2E3B/P}$, $II_{2ELL3B/P}$, II_{2L3P}, II_{2H3P}, II_{2E3P} and II_{2Er3P} according to EN 437:2003 + A1:2009.

This document only applies to appliances having:

a) gas fired endothermic engines under the control of fully automatic control systems;

b) closed system refrigerant circuits in which the refrigerant does not come into direct contact with the fluid to be cooled or heated;

c) where the temperature of the heat transfer fluid of the heating system (heating water circuit) does not exceed 105 °C during normal operation;

d) where the maximum operating pressure in the:

   1) heating water circuit (if installed) does not exceed 6 bar,

   2) domestic hot water circuit (if installed) does not exceed 10 bar.

This document applies to GEHP appliances only when used for space heating or space cooling or for refrigeration, with or without heat recovery.

This document is applicable to GEHP appliances that are intended to be type tested. Requirements for GEHP appliances that are not type tested would need to be subject to further consideration.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 16905-1:2017, *Gas-fired endothermic engine driven heat pumps - Part 1: Terms and definitions*

EN 16905-4:2017, *Gas-fired endothermic engine driven heat pumps - Part 4: Test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 16905-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
equivalent active mode hours for cooling
H_{CE}
assumed annual number of hours while the unit is assumed to operate at the design load for space cooling (Pdesignc) in order to satisfy the reference annual space cooling demand

Note 1 to entry: Expressed in hours [h].

3.2
equivalent active mode hours for heating
H_{HE}
assumed annual number of hours while the unit is assumed to operate at the design load for space heating (Pdesignh) in order to satisfy the reference annual space heating demand

Note 1 to entry: Expressed in hours [h].

3.3
annual primary energy consumption cooling
Q_{CP}
reference annual cooling demand divided by the seasonal primary energy ratio cooling

3.4
annual primary energy consumption heating
Q_{HP}
reference annual heating demand divided by the seasonal primary energy ratio heating

3.5
seasonal space cooling energy efficiency
$\eta_{s,c}$
ratio between the space cooling demand for the cooling season, supplied by a space cooling unit and the annual energy consumption required to meet this demand

Note 1 to entry: Expressed in %.

3.6
seasonal space heating energy efficiency
$\eta_{s,h}$
ratio between the space heating demand for a designated heating season, supplied by a space heater and the annual energy consumption required to meet this demand

Note 1 to entry: Expressed in %.

3.7
reference seasonal gas utilization efficiency ratio in cooling mode
$SGUE_c$
seasonal gas utilization efficiency ratio, expressed in GCV, of a GEHP appliance calculated for the reference annual space cooling demand

Note 1 to entry: The reference seasonal gas utilization efficiency ratio in cooling mode is expressed in kilowatt/kilowatt (kW/kW).

3.8
reference seasonal gas utilization efficiency ratio in heating mode
$SGUE_h$
seasonal gas utilization efficiency ratio, expressed in GCV, of a GEHP appliance calculated for the reference annual space heating demand

Note 1 to entry: The reference seasonal gas utilization efficiency ratio in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.9
reference seasonal auxiliary energy factor in cooling mode
SAEF*c*

seasonal auxiliary energy factor of a GEHP appliance calculated for the reference annual space cooling demand, including the energy consumption during active mode, thermostat off mode, standby mode and off mode

Note 1 to entry: The reference seasonal auxiliary energy factor in cooling mode is expressed in kilowatt/kilowatt (kW/kW).

3.10
reference seasonal auxiliary energy factor in heating mode
SAEF*h*
seasonal auxiliary energy factor of a GEHP appliance calculated for the reference annual space heating demand, including the energy consumption during active mode, thermostat off mode, standby mode and off mode

Note 1 to entry: The reference seasonal auxiliary energy factor in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.11
reference seasonal primary energy ratio in cooling mode
$SPER_c$
seasonal primary energy ratio of a GEHP appliance calculated for the reference annual space cooling demands

Note 1 to entry: The reference seasonal primary energy ratio in cooling mode is expressed in kilowatt/kilowatt (kW/kW)

3.12
reference seasonal primary energy ratio in heating mode
$SPER_h$
seasonal primary energy ratio of a GEHP appliance calculated for the reference annual space heating demands

Note 1 to entry: The reference seasonal primary energy ratio in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.13
reference seasonal engine heat recovery efficiency in cooling mode
$SEHRE_C$
seasonal engine heat recovery efficiency expressed in GCV, of a GEHP appliance calculated for the reference annual space cooling demand

Note 1 to entry: The reference seasonal engine heat recovery efficiency in cooling mode is expressed in kilowatt/kilowatt (kW/kW).

3.14
reference seasonal engine heat recovery efficiency in heating mode
$SEHRE_h$
seasonal engine heat recovery efficiency expressed in GCV, of a GEHP appliance calculated for the reference annual space heating demand

Note 1 to entry: The reference seasonal engine heat recovery efficiency in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.15
reference seasonal auxiliary engine heat recovery factor in cooling mode

$SAEHRF_C$
seasonal auxiliary engine heat recovery factor, of a GEHP appliance calculated for the reference annual space cooling demand

Note 1 to entry: The reference seasonal auxiliary engine heat recovery factor in cooling mode is expressed in kilowatt/kilowatt (kW/kW).

3.16
reference seasonal auxiliary engine heat recovery factor in heating mode
$SAEHRF_h$
seasonal auxiliary engine heat recovery factor, of a GEHP appliance calculated for the reference annual space heating demand

Note 1 to entry: The reference seasonal auxiliary engine heat recovery factor in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.17
reference total seasonal gas utilization efficiency ratio in cooling mode
$SGUE_{Tc}$
total seasonal gas utilization efficiency ratio, expressed in GCV, of a GEHP appliance calculated for the reference annual space cooling demand

Note 1 to entry: The reference total seasonal gas utilization efficiency ratio in cooling mode is expressed in kilowatt/kilowatt (kW/kW).

3.18
reference total seasonal gas utilization efficiency ratio in heating mode
$SGUE_{Th}$
total seasonal gas utilization efficiency ratio, expressed in GCV, of a GEHP appliance calculated for the reference annual space heating demand

Note 1 to entry: The reference total seasonal gas utilization efficiency ratio in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.19
reference seasonal auxiliary energy factor in cooling mode
$SAEF_{Tc}$
total seasonal auxiliary energy factor of a GEHP appliance calculated for the reference annual space cooling demand

Note 1 to entry: The reference total seasonal auxiliary energy factor in cooling mode is expressed in kilowatt/kilowatt (kW/kW).

3.20
reference seasonal auxiliary energy factor in heating mode
$SAEF_{Th}$
total seasonal auxiliary energy factor of a GEHP appliance calculated for the reference annual space heating demand

Note 1 to entry: The reference total seasonal auxiliary energy factor in heating mode is expressed in kilowatt/kilowatt (kW/kW).

3.21
variable outlet temperature
$T_{outlet,average}$

water(brine) outlet temperature that is used when the control of the unit has means to automatically vary the water(brine) outlet temperature with the outdoor temperature

4 Part load conditions for space cooling

4.1 General

For the purpose of calculation of application $SGUE_c$, $SAEF_c$, $SEHRE_c$, $SAEHRF_c$, $SGUE_{Tc}$, $SAEF_{Tc}$ and reference $SGUE_c$, $SAEF_c$, $SEHRE_c$, $SAEHRF_c$, $SGUE_{Tc}$, $SAEF_{Tc}$ as explained in Clauses 6 and 7, the part load ratios mentioned below shall be based on the part load ratio formulas with at least two decimal digits. For the purpose of $SGUE_c$, $SAEF_c$, $SEHRE_c$, $SAEHRF_c$, $SGUE_{Tc}$, $SAEF_{Tc}$ the different conditions are defined by a reference design temperature Tdesignc equal to 35 °C.

The calculation of $SGUE_c$, $SAEF_c$, $SEHRE_c$, $SAEHRF_c$, $SGUE_{Tc}$, $SAEF_{Tc}$ and reference $SGUE_c$, $SAEF_c$, $SEHRE_c$, $SAEHRF_c$, $SGUE_{Tc}$, $SAEF_{Tc}$ is determined via linear interpolation of the respective part load values at the reference part load conditions mentioned below (A, B, C, D).

4.2 Air-to-air units

For outdoor air-to-recycled air units, the part load conditions for determining the declared capacity (DC) and the declared GUE_c, AEF_c, $EHRE_c$,, $AEHRF_c$, GUE_{Tc}, AEF_{Tc} are given in Table 1.

Table 1 — Part load conditions for outdoor air-to- recycled air units

	Formula	Part load ratio	Outdoor heat exchanger	Indoor heat exchanger
			Air dry bulb temperature	Air dry (wet) bulb temperatures
		%	°C	°C
A	$(35–16)/(T_{designc}-16)$	100,00	35	27(19)
B	$(30–16)/(T_{designc}-16)$	73,68	30	27(19)
C	$(25–16)/(T_{designc}-16)$	47,37	25	27(19)
D	$(20–16)/(T_{designc}-16)$	21,05	20	27(19)

4.3 Water-to-air and brine-to-air units

For water-to-air and brine-to-air units, the part load conditions for determining the declared capacity (*DC*) and the declared GUE_c, AEF_c, $EHRE_c$,, $AEHRF_c$, GUE_{Tc}, AEF_{Tc} are given in Table 2.

Table 2 — Part load conditions for water-to-air and brine-to-air units

	Formula	Part load ratio	Outdoor heat exchanger			Indoor heat exchanger
			Cooling tower or water(brine) loop application Inlet/outlet water(brine) temperatures	Ground coupled application Inlet/outlet water(brine) temperatures	Dry cooler application Inlet/outlet water temperatures	Air dry (wet) bulb temperature
		%	°C	°C	°C	°C
A	$(35–16)/(T_{designc}-16)$	100,00	30/35	10/15	50/55	27(19)
B	$(30–16)/(T_{designc}-16)$	73,68	26/[a]	10/[a]	45/[a]	27(19)
C	$(25–16)/(T_{designc}-16)$	47,37	22/[a]	10/[a]	40/[a]	27(19)
D	$(20–16)/(T_{designc}-16)$	21,05	18/[a]	10/[a]	35/[a]	27(19)

[a] With the flow rate as determined during "A" test for units with a fixed flow rate or a fixed water temperature difference of 5 °K for units with a variable flow rate. If for any of the test conditions the resulting flow rate is below the minimum flow rate then this minimum flow rate is used as a fixed flow rate with the inlet temperature for this test condition.

NOTE If a cooling tower and a water-to-air unit are sold as a matched assembly, they shall be tested as an air-to-air unit.

4.4 Air-to-water and air-to-brine units

For each application, units either allowing or not allowing a variation of the outlet water/brine temperature with the outdoor temperature are considered. The part load conditions for determining the declared capacity (*DC*) and the declared GUE_c, AEF_c, $EHRE_c$, $AEHRF_c$, GUE_{Tc}, AEF_{Tc} are given in Table 3.

The variable outlet temperature (*T*outlet,average) shall only be applied when the control provides a regulation of outlet water temperature that considers the outdoor temperature.

For units with variable outlet that have to cycle on/off to reach the required part load ratio, the inlet and outlet temperatures of the indoor heat exchanger shall be determined according to EN 16905-4:2017, Annex H.

Table 3 — Part load conditions of air-to-water and air-to-brine units

	Formula	Part load ratio	Outdoor heat exchanger	Indoor heat exchanger		
			Outdoor air dry bulb temperature	Fan coil application Inlet/outlet water(brine) temperatures		Cooling floor application Inlet/outlet water(brine) temperatures
				Fixed outlet	Variable outlet[b]	
		%	°C	°C	°C	°C
A	$(35–16)/(T_{designc}-16)$	100,00	35	12/7	12/7	23/18
B	$(30–16)/(T_{designc}-16)$	73,68	30	[a]/7	[a]/8,5	[a]/18
C	$(25–16)/(T_{designc}-16)$	47,37	25	[a]/7	[a]/10	[a]/18
D	$(20–16)/(T_{designc}-16)$	21,05	20	[a]/7	[a]/11,5	[a]/18

[a] With the flow rate as determined during "A" test for units with a fixed flow rate or with a fixed water temperature difference 5 K for units with a variable flow rate. If for any of the test conditions the resulting flow rate is below the minimum flow rate then this minimum flow rate is used as a fixed flow rate with the outlet temperature for this test condition.

[b] If the variable outlet temperature is above the maximum of the operating range of the unit, this maximum should be considered.

4.5 Water-to-water and brine-to-water units

For each application, units either allowing or not allowing a variation of the outlet water/brine temperature with the outdoor temperature are considered. The part load conditions for determining the declared capacity (*DC*) and the declared GUE_c, AEF_c, $EHRE_c$, $AEHRF_c$, GUE_{Tc}, AEF_{Tc} are given in Table 4.

The variable outlet temperature (*T*outlet,average) shall only be applied when the control provides a regulation of outlet water temperature that considers the outdoor temperature.

For units with variable outlet that have to cycle on/off to reach the required part load ratio, the inlet and outlet temperatures of the indoor heat exchanger shall be determined according to EN 16905-4:2017, Annex H.

Table 4 — Part load conditions of water-to-water, water-to-brine, brine-to-water, brine-to-brine and DX-to-water units

	Formula	Part load ratio	Outdoor heat exchanger				Indoor heat exchanger		
			Cooling tower or water(brine) loop application Inlet/outlet water(brine) temperatures	Ground coupled application Inlet/outlet water(brine) temperatures	Dry cooler application Inlet/outlet water(brine) temperatures	DX Bath temperature	Fan coil application Inlet/outlet water temperatures		Cooling floor application Inlet/outlet water temperatures
							Fixed outlet	Variable outlet [b]	
		%	°C	°C	°C		°C	°C	°C
A	(35–16) / ($T_{designc}$-16)	100,00	30/35	10/15	50/55	30	12/7	12/7	23/18
B	(30–16) / ($T_{designc}$-16)	73,68	26/[a]	10/[a]	45/[a]	30	[a]/7	[a]/8,5	[a]/18
C	(25–16) / ($T_{designc}$-16)	47,37	22/[a]	10/[a]	40/[a]	30	[a]/7	[a]/10	[a]/18
D	(20–16) / ($T_{designc}$-16)	21,05	18/[a]	10/[a]	35/[a]	30	[a]/7	[a]/11,5	[a]/18

[a] With the flow rate as determined during "A" test for units with a fixed flow rate or with a fixed water temperature difference of 5 K for units with a variable flow rate. If for any of the test conditions the resulting flow rate is below the minimum flow rate then this minimum flow rate is used as a fixed flow rate with the outlet temperature for this test condition.

[b] If the variable outlet temperature is above the maximum of the operating range of the unit, this maximum should be considered. Note If a cooling tower and water-to-water unit are sold as a matched assembly, they shall be tested as an air-to-water unit.

5 Part load conditions for space heating

5.1 General

For the purpose of calculation of $SGUE_h$, $SAEF_h$, $SEHRE_h$, $SAEHRF_h$ $SGUE_{Th}$, $SAEF_{Th}$, and reference $SGUE_h$, $SAEF_h$, $SEHRE_h$, $SAEHRF_h$ $SGUE_{Th}$, $SAEF_{Th}$, as explained in Clauses 6 and 7, the part load ratios mentioned below shall be based on the part load ratio formulas with at least two decimal digits.

The calculation of $SGUE_h$, $SAEF_h$, $SEHRE_h$, $SAEHRF_h$ $SGUE_{Th}$, $SAEF_{Th}$ and reference $SGUE_h$, $SAEF_h$, $SEHRE_h$, $SAEHRF_h$ $SGUE_{Th}$, $SAEF_{Th}$ is determined via linear interpolation of the respective part load values at the reference part load conditions mentioned below (A, B, C, D). For the purpose of reference $SGUE_h$, $SAEF_h$, $SEHRE_h$, $SAEHRF_h$ $SGUE_{Th}$, $SAEF_{Th}$ there are three reference conditions: average(A), warmer (W) and colder (C).

The relevant $T_{designh}$ values are defined as follows:

— Average climate: dry bulb temperature conditions at – 10 °C outdoor temperature and 20 °C indoor temperature;

— Colder climate dry bulb temperature conditions at – 22 °C outdoor temperature and 20 °C indoor temperature

— Warmer climate dry bulb temperature conditions at + 2 °C outdoor temperature and 20 °C indoor temperature