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

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 European Standard was approved by CEN on 28 November 2022.

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Contents

Page

European foreword ... 4

Introduction ... 5

1 Scope ... 6

2 Normative references ... 6

3 Terms and definitions ... 6

4 Part load conditions for space cooling ... 7
4.1 General ... 7
4.2 Air-to-air units ... 7
4.3 Water-to-air and brine-to-air units ... 8
4.4 Air-to-water and air-to-brine units ... 8
4.5 Water-to-water and brine-to-water units ... 9

5 Part load conditions for space heating ... 11
5.1 General ... 11
5.2 Air-to-air units ... 11
5.3 Water(brine)-to-air units ... 12
5.4 Air-to-water(brine) units ... 12
5.4.1 General ... 13
5.4.2 Low temperature application ... 13
5.4.3 Intermediate temperature application ... 14
5.4.4 Medium temperature application ... 15
5.5 DX-to-water(brine), water-to-water(brine), brine-to-water(brine) units ... 15
5.5.1 General ... 15
5.5.2 Low temperature application ... 16
5.5.3 Intermediate temperature application ... 17
5.5.4 Medium temperature application ... 18

6 Calculation methods for reference $SPER_c$ ... 19
6.1 General ... 19
6.2 General formula for calculation of GUE_c and AEF_c ... 19
6.3 General formula for calculation of $EHRE_c$ and $AEHRF_c$ ... 19
6.4 General formula for calculation of reference $SGUE_c$ ... 19
6.5 Calculation of reference $SEHRE_c$ ... 20
6.6 Calculation of reference $SGUE_{Tc}$ ... 21
6.7 Calculation of reference $SAEF_c$ ... 21
6.8 Calculation of reference annual cooling demand ($Q_{ref,c}$) ... 21
6.9 Calculation of reference $SAEF_{cON}$ ... 22
6.10 Calculation of reference $SAEHRF_c$ ... 22
6.11 Calculation of reference total $SAEF_{Tc}$ ... 23
6.12 Procedures for the determination of GUE_{cPL} / AEF_{cPL} values ... 23
6.13 Procedures for the determination of $EHRE_{cPL}$ / $AEHRF_{cPL}$ values ... 23
6.14 Calculation of reference $SPER_c$ ... 23
6.15 Calculation of the annual primary energy consumption cooling Q_{CP} ... 24
6.16 Calculation of the seasonal space cooling efficiency $\eta_{s,c}$ ... 24

7 Calculation methods for reference $SPER_h$ ... 24
7.1 General ... 24

7.2 General formula for calculation of GUE_h and AEF_h ... 25
7.3 General formula for calculation of $EHRE_h$ ... 25
7.4 General formula for calculation of reference $SGUE_h$ ... 25
7.5 Calculation of reference $SEHRE_h$ ... 28
7.6 Calculation of reference $SGUE_{Th}$ ... 28
7.7 Calculation of reference $SAEF_h$ ... 28
7.8 Calculation of reference annual heating demand ($Q_{ref,h}$) ... 29
7.9 Calculation of reference $SAEF_{hON}$ ... 29
7.10 Calculation of reference $SAEHRF_h$ ... 30
7.11 Calculation of reference total $SAEF_{Th}$ ... 30
7.12 Procedures for the determination of GUE_{hPL} / AEF_{hPL} values ... 30
7.13 Procedures for the determination of $EHRE_{hPL}$ / $AEHRF_{hPL}$ values ... 30
7.14 Calculation of reference $SPER_h$ ... 31
7.15 Calculation of the annual primary energy consumption heating Q_{HP} ... 31
7.16 Calculation of the seasonal space heating efficiency $\eta_{s,h}$ ... 31

8 Technical documentation ... 32

Annex A (normative) **Determination of reference annual cooling/heating demands and determination of hours for active mode, thermostat off, standby, off mode and crankcase heater mode for reference $SAEF_c$ and $SAEF_h$ calculation ... 33**

Annex B (informative) **Calculation example for reference $SGUE_c$, $SAEF_c$, $SEHRE_c$, $SAEHRF_c$, $SGUE_{Tc}$, $SAEF_{Tc}$ and $SPER_c$ ... 35**

Annex C (informative) **Calculation example for reference $SGUE_h$, $SAEF_h$, $SEHRE_h$, $SAEHRF_h$, $SGUE_{Tc}$, $SAEF_{Th}$ and $SPER_h$ ... 38**

Annex D (informative) **Template for technical documentation ... 41**

Annex E (normative) Rating of outdoor units of multi-split air conditioners and heat pumps ... 46

Annex ZA (informative) **Relationship between this European Standard and the requirements of Commission Regulation (EU) No 813/2013 aimed to be covered ... 49**

Annex ZB (informative) **Relationship between this European Standard and the requirements of Commission Regulation (EU) No 2016/2281 aimed to be covered ... 50**

Annex ZC (informative) **Relationship between this European Standard and the requirements of Commission Regulation (EU) No 811/2013 aimed to be covered ... 51**

Bibliography ... 52

European foreword

This document (EN 16905-5:2022) 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 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 June 2023, and conflicting national standards shall be withdrawn at the latest by June 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16905-5:2017.

EN 16905-5:2022 includes the following significant technical changes with respect to EN 16905-5:2017:

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

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

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

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*.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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

Introduction

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”.

Single split and multisplit systems are covered by this document.

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

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

EN 16905-5:2022 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:—[1], Annex ZA). EN 16905-1:2017, EN 16905-2:—[2], EN 16905-3:2017, EN 16905-4:—[1] and EN 16905-5:2022 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:—[1], Annex ZA, EN 16905-5:2022, Annex ZA and EN 16905-2:—[2], Annexes ZB and ZC).

These documents will be reviewed whenever new mandates could apply.

[1] Under preparation. Stage at the time of publication: prEN 16905-4:2022.
[2] Under preparation. Stage at the time of publication: prEN 16905-2:2021.

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 outdoors.

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 437:2021.

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:—[1], *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 16905-1:2017 apply.

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

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

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 *T*designc 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)
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.						
[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.						

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 the determination of water (brine) temperature for fixed capacity units with variable outlet temperature refer to EN 16905-4:—[1].

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:—[1], 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 the determination of water (brine) temperature for fixed capacity units with variable outlet temperature refer to EN 16905-4:—[1].

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:—[1], 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	°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
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.									

[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.

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

For outdoor air dry bulb temperatures higher or equal to −10 °C the wet bulb temperature equals the dry bulb temperature minus 1 K. For dry bulb temperatures below −10 °C, the wet bulb temperature is not defined.

For heat pumps, the relevant T_{biv} is defined as follows:

— for the average heating season, the dry bulb temperature is +2 °C or lower;

— for the colder heating season, the dry bulb temperature is −7 °C or lower;

— for the warmer heating season, the dry bulb temperature is +7 °C or lower.

For heat pumps, the relevant *TOL* is defined as follows:

— for the average heating season, the dry bulb temperature is −7 °C or lower;

— for the colder heating season, the dry bulb temperature is −15 °C or lower;

— for the warmer heating season, the dry bulb temperature is +2 °C or lower.

If the declared *TOL* is lower than the $T_{designh}$ of the considered climate, then the outdoor dry bulb temperature is equal to $T_{designh}$ for the part load condition E in Table 5, Tables 7 to 10.

In case of colder climate and if TOL is below −20 °C, an additional part load condition G at −15 °C shall apply for air-to-air and air-to-water heat pumps.

5.2 Air-to-air units

The part load conditions for determining the reference $SGUE_h$ (Formula (16)), $SAEF_h$ (Formula (20)), $SEHRE_h$ (Formula (18)), $SAEHRF_h$ (Formula (23)) $SGUE_{Th}$ (Formula (19)), $SAEF_{Th}$ (Formula (24)), are given in Table 5.

Table 5 — Part load conditions for air-to-recycled air units for the reference heating seasons

Condition	Part load ratio in %				Outdoor heat exchanger	Indoor heat exchanger
	Formula	Average	Warmer	Colder	Air dry (wet) bulb temperature °C	Air dry bulb temperature °C
A	$(-7-16)/(T_{designh}-16)$	88,46	n/a	60,53	−7(−8)	20
B	$(+2-16)/(T_{designh}-16)$	53,85	100,00	36,84	2(1)	20
C	$(+7-16)/(T_{designh}-16)$	34,62	64,29	23,68	7(6)	20
D	$(+12-16)/(T_{designh}-16)$	15,38	28,57	10,53	12(11)	20
E	$(TOL-16)/(T_{designh}-16)$				TOL	20
F	$(T_{biv}-16)/(T_{designh}-16)$				T_{biv}	20
G	$(-15-16)/(T_{designh}-16)$	n/a	n/a	81,58	−15	20

5.3 Water(brine)-to-air units

The part load conditions for determining the reference $SGUE_h$ (Formula (16)), $SAEF_h$ (Formula (20)), $SEHRE_h$ (Formula (18)), $SAEHRF_h$ (Formula (23)) $SGUE_{Th}$ (Formula (19)), $SAEF_{Th}$ (Formula (24)), are given in Table 6.

Table 6 — Part load conditions for water(brine)-to-air for the reference heating seasons

Condition	Part load ratio in %				Outdoor heat exchanger inlet/outlet temperature			Indoor heat exchanger
	Formula	Average	Warmer	Colder	Water °C	Brine °C	Water loop °C	Dry bulb °C
A	$(-7-16)/(T_{designh}-16)$	88,46	n/a	60,53	10/[a]	0/[a]	20/[a]	20
B	$(+2-16)/(T_{designh}-16)$	53,85	100,00	36,84	10/[a]	0/[a]	20/[a]	20
C	$(+7-16)/(T_{designh}-16)$	34,62	64,29	23,68	10/[a]	0/[a]	20/[a]	20
D	$(+12-16)/(T_{designh}-16)$	15,38	28,57	10,53	10/[a]	0/[a]	20/[a]	20
E	$(T_{designh}-16)/(T_{designh}-16)$	100,00	100,00	100,00	10/[a]	0/[a]	20/[a]	20
F	(Tbiv-16)/(Tdesignh-16)				10/[a]	0/[a]	20/[a]	20

[a] With the flow rate as determined at the standard rating conditions for units with a fixed flow rate or with a fixed water temperature difference of 3 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.

5.4 Air-to-water(brine) units

5.4.1 General

The part load conditions for determining the reference $SGUE_h$ (Formula (16)), $SAEF_h$ (Formula (20)), $SEHRE_h$ (Formula (18)), $SAEHRF_h$ (Formula (23)) $SGUE_{Th}$ (Formula (19)), $SAEF_{Th}$ (Formula (24)), are given in Table 7, Table 8 and Table 9.

The variable outlet temperature ($T_{outlet,\ average}$) shall only be applied when the control provides an outdoor air temperature dependant modification of the outlet temperature.

For the determination of water (brine) temperature for fixed capacity units with variable outlet temperature refer to EN 16905-4:—[1].

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:—[1].

5.4.2 Low temperature application

Table 7 — Part load conditions for air-to-water(brine) units in *low temperature application* for the reference heating seasons

Condition	Part load ratio in %				Outdoor heat exchanger	Indoor heat exchanger			
					Dry (wet) bulb temperature °C	Fixed outlet °C	Variable outlet [d] °C		
	Formula	Average	Warmer	Colder	Outdoor air	All climates	Average	Warmer	Colder
A	(−7–16)/ ($T_{designh}$-16)	88,46	n/a	60,53	−7(−8)	[a] /35	[a] /34	n/a	[a] /30
B	(+2–16)/ ($T_{designh}$-16)	53,85	100,00	36,84	2(1)	[a] /35	[a] /30	[a] /35	[a] /27
C	(+7–16)/ ($T_{designh}$-16)	34,62	64,29	23,68	7(6)	[a] /35	[a] /27	[a] /31	[a] /25
D	(+12–16)/ ($T_{designh}$-16)	15,38	28,57	10,53	12(11)	[a] /35	[a] /24	[a] /26	[a] /24
E	(TOL-16)/($T_{designh}$-16)				TOL	[a] /35	[a] / [b]	[a] / [b]	[a] / [b]
F	($T_{bivalent}$-16)/($T_{designh}$-16)				T_{biv}	[a] /35	[a] / [c]	[a] / [c]	[a] / [c]
G	(−15 - 16)/ ($T_{designh}$ −16)	n/a	n/a	81,58	−15	[a] /35	n/a	n/a	[a] /32

[a] With the flow rate as determined at the standard rating conditions at 30/35 conditions for units with fixed flow rate, and 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] Variable outlet shall be calculated by interpolation from $T_{designh}$ and the temperature which is closest to the TOL.

[c] Variable outlet shall be calculated by interpolation between the upper and lower temperatures which are closest to the bivalent temperature.

[d] If the variable outlet temperature is below the minimum of the operation range of the unit, this minimum should be considered.