Ecodesign Coordination Group
Task Force 3 "Coordination/Harmonisation of EPBD/ErP"

Position paper

Harmonisation of EPBD/ErP related Heat pump standards EN 14825 / EN 15316-4-2

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- **Context and objectives**

In Europe the characterisation of the energy performance of **products** is regulated by "**product"** Directives, as Ecodesign and Energy labelling. The energy performance of **building** is regulated by "building" Directives, as the EPBD.
The product Directive provide information to the end user on **the energy performance of the product itself,** but without any flexibility and interaction within a "system" (e.g. building installation). The main target is the rating of products to differentiate them.
The building Directive consider the building as a whole (holistic approach) and provide information to the end user on the energy performance of the building (in general expressed in kWh/m2) considering the interaction of the technical products in a "system" (e.g. heat pumps in a heating system taking into account the energy production (heat pump), the distribution and the emission).
The "product" and "building" approach are complementary and provide different information to the user. Both approaches have different methods, but both are **based on the testing of the product**.
The aim of this position paper is to show where are the differences in testing, how they could be harmonised in both standards in order to make the two approaches consistent.

- **Legal environment**

At **product level,** the Commission **Regulation (EU) No 2016/2281 of 30 November 2016** implementing **Directive 2009/125/EC** of the European Parliament and of the Council with regard to **Ecodesign** requirements for air heating products, cooling products, high temperature process chillers, fan coil units and the Commission **Delegated Regulation (EU)** with regard to **energy labelling,** are the regulatory instruments for energy performance and labelling of HVAC product.
The transposition of these regulatory instruments at national level in the EU Member States is mandatory without any changes.
The Commission's gave mandate to CEN (standardization request M/495 and Amendment N° 1) to work out related harmonised standards.
For the **heat pumps,** one of the key standards is **EN 14825** "Air conditioners, liquid chilling packages and heat pumps, with **electrically driven compressors**, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance". **EN 14825 is actually under revision**.
At **building level, Directive 2018/844** of the European Parliament and of the Council of **30 May 2018** amending Directive 2010/31/EU on the **energy performance of buildings (EPBD)** and Directive 2012/27/EU on energy efficiency are regulating the Energy performance of buildings including the technical building systems.

The EPBD is a **framework Directive,** drafting general principles, as for example the adoption of a methodology for calculating the energy performance of buildings (Article 3). But the details of the calculation method are left to the Member States when implementing the Directive at national level.
To support the Member States in the transposition, the Commission's gave mandate to CEN to work out standards dealing with the calculation for energy performance of buildings (standardization request M/480). The calculation method is used to determine the maximum energy consumption of a building. If the value is higher than the requirement, then the building permit is not delivered.
For the **heat pumps,** the key standard is **EN 15316-4-2** "Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-2: Space heating generation systems, heat pump systems, Module M3-8-2, M8-8-2". **EN 15316-4-2** is actually under revision.

- **Ecodesign: Principles of EN 14825 "Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal performance"**

According to EN 14825 heat pumps are tested at least in 7 conditions (A-G) see **figure 1** hereafter:

- conditions A, B, C, D corresponds to different outdoor conditions (-7°C, +2°C, +7°C, +12°C);
- condition E is the operation limit (below the declared capacity is equal to zero);
- condition F is the bivalent point (lowest outdoor temperature point at which the unit is declared to have a capacity able to meet 100 % of the heating load **without supplementary heater**, whether it is integrated in the unit or not);
- condition G is an additional point for colder climate when the operation limit is below -20°C.

Three climate zones are defined for Europe with different outdoor design temperature (Tdesign):

- **warmer** climate conditions (Tdesign: 2°C)
  temperature conditions characteristic for the city of Athens for the heating season;
- **average** climate conditions (Tdesign: -10°C)
  temperature conditions characteristic for the city of Strasbourg for the heating season;
- **colder** climate conditions (Tdesign: -22°C)
  temperature conditions characteristic for the city of Helsinki for the heating season.

Table 8 — 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: dry (wet) bulb temperature °C		Indoor heat exchanger: Fixed outlet °C	Indoor heat exchanger: Variable outlet[d] °C		
	Formula	Average	Warmer	Colder	Outdoor air	Exhaust air	All climates	Average	Warmer	Colder
A	$(-7 - 16) / (T_{designh} - 16)$	88,46	n/a	60,53	−7(−8)	20(12)	a / 35	a / 34	n/a	a / 30
B	$(+2 - 16) / (T_{designh} - 16)$	53,85	100,00	36,84	2(1)	20(12)	a / 35	a / 30	a / 35	a / 27
C	$(+7 - 16) / (T_{designh} - 16)$	34,62	64,29	23,68	7(6)	20(12)	a / 35	a / 27	a / 31	a / 25
D	$(+12 - 16) / (T_{designh} - 16)$	15,38	28,57	10,53	12(11)	20(12)	a / 35	a / 24	a / 26	a / 24
E	$(TOL - 16) / (T_{designh} - 16)$				TOL	20(12)	a / 35	a / b	a / b	a / b
F	$(T_{biv} - 16) / (T_{designh} - 16)$				T_{biv}	20(12)	a / 35	a / c	a / c	a / c
G	$(-15 - 16) / (T_{designh} - 16)$	n/a	n/a	81,58	−15	20(12)	a / 35	n/a	n/a	a / 32

[a] With the flow rate as determined at the standard rating conditions given in EN 14511-2 at 30/35 conditions for units with a 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.

<u>Figure 1:</u> Standardised Operating conditions to calculate the seasonal efficiency

Part load ratios are defined at the different conditions A, B, C, D. The part load ratio is the ratio depending on the outdoor temperature and the outdoor design temperature (see formula in **figure 1**) at the different conditions.

For the indoor heat exchanger (sink), the outlet temperature of the water depends on the type of **temperature application** of the unit. EN 14825 distinguish fixed outlet and variable outlet.
For the variable outlet the following 4 categories are defined (design conditions at full load):

- Units in **low** temperature application (Toutlet_max = 35°C)
- Units in **intermediate** temperature application (Toutlet_max = 45°C)
- Units in **medium** temperature application (Toutlet _max= 55°C)
- Units in **high** temperature application (Toutlet_max = 65°C)

For variable outlets the indoor heat exchanger outlet temperature at part load is function of the outdoor temperature.
Units with **fixed water flow rate are tested at 47°C/55°C** under all test points.
Variable water flow rate units are tested at fixed delta T:

- 5K for low and intermedium temperature application;
- 8K for medium to high temperature application.

It should be noticed that in EN 14825 the Heating Capacity (kW) and the coefficient of performance (COP) are declared only for continuously running.

Finally, the seasonal space heating energy efficiency classes are determined and reported in the energy label (see **figure 2**) based on the operation conditions mentioned before (Bin method).

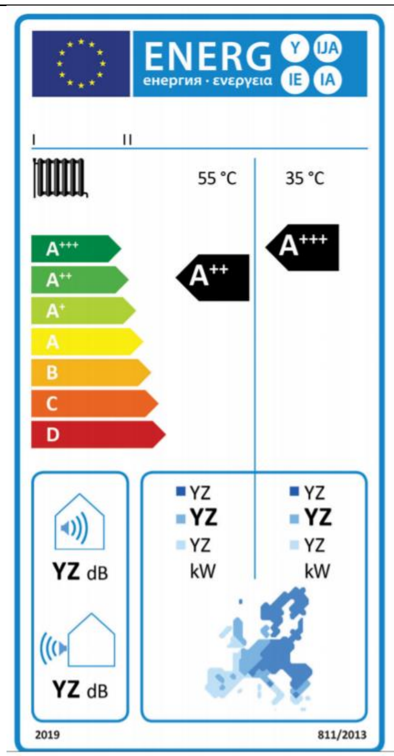

Figure 2a: Heat pump space heaters, except low-temperature heat pumps, in seasonal space heating energy efficiency classes A+++ to D

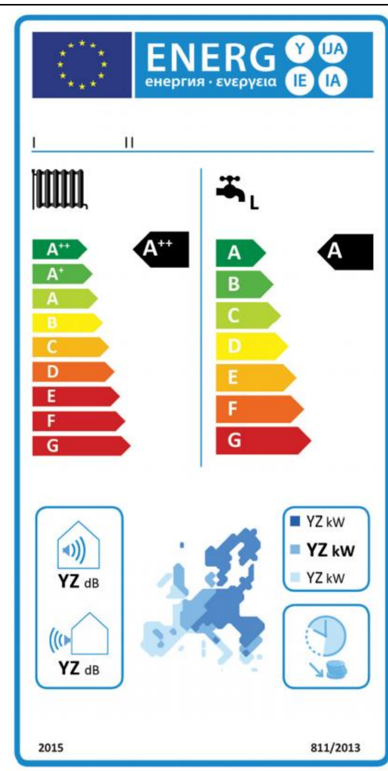

Figure 2b: Heat pump combination heaters in seasonal space heating energy efficiency classes A++ to G and in water heating energy efficiency classes A to G

Required by the COMMISSION REGULATION (EU) 2016/2281 of 30 November 2016, the **label is completed by a more detailed technical information** called "**product fiche**".
Product fiches are published by industrials on their websites. They contain for example for space heating per **climate** (e.g. average, cold,) and per **space heating temperature application** (e.g. 55°C, 35°C) the:

- declared heating capacity (kW) at design outdoor temperature;
- seasonal space heating efficiency (%);
- annual energy consumption (kWh).

For the space heating **average climate,** additional technical data are provided (see also **figure 1**):

- the **power consumption** in the different running modes (e.g. off mode, thermostat off mode);
- the **declared coefficient of performance** (**COP**) at different t load conditions (A-G);
- the **declared heating capacity** (**P**) at different load conditions (A-G);

➢ EPBD: Principles of EN 15316-4-2 Energy performance of buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-2: Space heating generation systems, heat pump systems, Module M3-8-2, M8-8-2

The standard provides a calculation method covering heat pumps for space heating, heat pump water heaters, heat pumps with combined space heating and domestic hot water production in alternate or simultaneous operation. The results of this calculation are incorporated in larger building models and take in account the influence of operational conditions (e.g. sink, source temperatures, building control).
The calculation method considers the following physical factors having an impact on the energy performance of the heat pump during the calculation period:

- effects of **variation of source and sink temperature** on thermal capacity and COP;
- effects of **compressor control in part load operation** (ON-OFF, stepwise, variable speed units);
- **auxiliary energy** input needed to operate the generation subsystem if not considered in standard testing of thermal capacity and COP.

Hereafter only the calculation of the COP is described. The calculation of the thermal capacity is comparable.

The calculation of the COP is based on a **2 steps calculation:**

- calculation of the COP **at full load**;
- calculation of the COP at **partial load**.

<u>Calculation of the COP **at full load**</u>

The key element of the calculation is the **performance map (matrix)**. A matrix presenting the **COP and thermal capacity** at **full load** is built from reference value(s) corresponding to the nominal (full load) conditions of the input and output temperatures of the heat pump, depending on the type of heat sources and sink (e.g. air, water).
For the simplest case (Path A), the calculation of the COP and thermal capacity are **derived from a unique reference value** based on results issued from the EN 14511 series.
To construct the whole matrix, the matrix contains also **default weighting factors** (corrective coefficients) of the COP for different **inlet** temperatures at **evaporato**r (source) in the last column and different **outlet** temperature at the **condenser** (sink) in the last row. The unique reference value of COP is multiplied (extrapolation) with ad'hoc weighting factor (see **figure 3**).

Once the performance map completed, the values for COP at full load for the case specific **operating conditions** are then determined by interpolation (e.g. linear, exergetic) between the matrix values.

The default weighting factors (corrective coefficients) can be replaced by specific data.
If more reference values (e.g. test results, declared values) are available, the performance map (matrix) can also be determined by interpolation (e.g. linear or exergetic) and extrapolation.

K	$\vartheta_{gen;in}$			$\vartheta_{gen;in,k-1}$	$\vartheta_{gen;in,k}$		Weighting factor $\vartheta_{gen;out}$
ϑ_{out}							
							$f_{COP;k,l-1}$
$\vartheta_{gen;out;l}$		$f_{COP;k-3,1} \times f_{COP;k-2,1} \times f_{COP;k-1,l}$	$f_{COP;k-2,1} \times f_{COP;k-1,l}$	$f_{COP;k-1,l}$	$COP_{Pn;ref}$	$f_{COP;k+1,l}$	1
					$f_{COP;k,l+1}$		$f_{COP;k,l+1}$
					$f_{COP;k,l+1} \times f_{COP;k,l+2}$		$f_{COP;k,l+2}$
					$f_{COP;k,l+1} \times f_{COP;k,l+2} \times f_{COP;k,l+3}$		$f_{COP;k,l+3}$
Weighting factor $\vartheta_{gen;in}$		$f_{COP,k-3,l}$	$f_{COP,k-2,l}$	$f_{COP,k-1,l}$	1	$f_{COP;k+1,l}$	

Figure 3a: Principles for establishing a matrix calculating the value of COP correction factors

Table C.1 — Air-Water heat pumps - Weighting factors for calculation of the COP

										Air
		0 °C	0 °C	0 °C	0 °C	0 °C	0 °C	0 °C	0 °C	$\Delta\theta_{in;ref}$
Water		−15 °C	−15 °C	−7 °C	2 °C	7 °C	20 °C	20 °C	20 °C	ϑ_{in}
$\Delta\theta_{out;ref}$	ϑ_{out}									Weighting factor ϑ_{out}
3	25									1
3	25									1,1
5	35					$COP_{gen,Pn,ref}$				1
5	45									0,8
8	55									0,8
10	65									0,8
	Weighting factor ϑ_{in}	1	0,8	0,5	0,8	1	1,25	1	1,0	

Figure 3b: Example of a performance map with a unique reference value for an air-water heatpump

Calculation of the COP at **partial load**

The principles of the part load calculation are the following:

- it is distinguished between **on/off** functioning and **continuous** operation (e.g. inverter);
- the **part load COP is derived from the COP at full load capacity.**

➢ **Proposal for harmonising EN 14825 and EN 15316-4-2**

The table hereafter (**figure 4**) represent a **performance map** according **EN 15316-4-2** at full load. The sink and source temperature conditions are comparable to **EN 14825.** They correspond to an **average climate** (design temperature – 10°C) with a **medium temperature application** (sink max: 55°C).
In this table, the conditions A, B, C, B, D, E of EN 14825 have been reported **but with changed conditions:**

- all points have the **same sink temperature (55°C).** In EN 14825 all points have different sink temperatures (the values of EN14825 are reported crossed under the points);
- all points are at **full load**. In EN 14825 all points have different loads (the values of EN14825 are reported crossed under the points).

Only point E would fit to the conditions of EN 15316-4-2.

If the initial running conditions **fit perfectly to the approach of EN 14825** they **do not fit at all** for the use in **EN 15316-4-2** because the impact parameters on the COP (sink + source temperature, load) are **all varying at the same time** in EN 14825. It is **difficult to identify the influence** of each on the COP.

Full load
Therefore it is proposed to change the test conditions of EN 14825 to be easily used in EN 15316-4-2.
Heat pumps should be tested:

- with the same sink temperature (e.g. 55°C);
- with the source temperature of EN 14825;
- at full load.

In that case the weighting factors for different source temperatures can easily be identified (see **figure 4** last row).

	Source					
Sink	**- 10°C**	**−7 °C**	**2 °C**	**7 °C**	**12 °C**	$\boldsymbol{\vartheta}_{\mathbf{in}}$
$\boldsymbol{\vartheta}_{\mathbf{out}}$						Weighting factor $\boldsymbol{\vartheta}_{\mathbf{out}}$
25°C						1,1
35°C				**C1** ~~36°C/35%~~		1
45°C				**C2**		⇨0,X
55°C	**E** (1,66) 55°C/100%	**A** (1,98) ~~52°C / 88%~~	**B** (3,17) ~~42°C/54%~~	**C** (4,2) ~~36°C/35%~~	**D** (5,82) ~~30°C/15%~~	⇨0,X
65°C				**C3**		⇨0,X
Weighting factor $\boldsymbol{\vartheta}_{\mathbf{in}}$	⇩ **0,84**	⇩ **0,62**	⇩ **0,75**	1	⇩ **1,39**	

Figure 4: EN 14825 values reported in a EN 15316-4-2 performance map

Without additional testing, the performance map at full load could then be constructed with the default weighting factors for the sink temperatures (last column).
With **only three additional testing** (C1 to C3 in figure 4) the **complete performance map** could be constructed at **full load**.

Part load

In EN 14825, **four** part load ratios are defined per climate conditions (e.g. for the average climate 88%, 54%, 35%, 15%). But they are **all at different sink and source temperatures.** Therefore, it is not straight forward to define the influence of the part load on the COP.
EN 14825 and EN 15316-4-2 differentiate between **continuous operation a**nd **on/off functioning**.
To check the change of COP on part load by testing, it is proposed to add **two testing points** (**figure 5):**

- at **min continuous operation load**;
- in the **middle of full load and min continuous operation load**

The correction of the COP from full load to part load conditions is determined as **a function of four points** (see **figure 5**):

- 100% load;
- Xopt % - optimum load (between full load and minimum continuous operation);
- Xmin % - minimum continuous operation;
- 0 % - stand by.

It is supposed that the same partial load correction of the COP applies to all operation conditions.

	Part load ratio			
Sink/Source	**100%**	**Optimum Xopt (100%-Xmin)/2 + Xmin**	**Min continuous operation Xmin%**	**0%**
ϑ_{out}				
25°C/ 7°C				
35°C/7°C				
45°C/7°C			**C2**	
55°C/7°C	**E** (1,66) 55°C/100%	**E1**(2,16)	**E2**(1,08)	
65°C/7°C			**C3**	
Weighting factor ϑ_{in}	**1**	⇩ **1,3**	⇩ **0,5**	

Figure 5a: The part load performance map

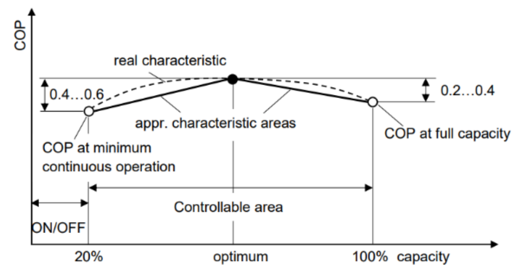

Figure 5b: The part load curve

Performance Map

The whole performance map, with **all sink and source temperature** and **including part load correction** can now be constructed and **checked with a minimum amount of measurements**.

The performance map can then be used to recalculate the COP and thermal capacity requested by EN 14825. The accuracy of that approach is largely enough for product information under standardised condition, because the real energy efficiency will largely be dependent on the installation.

- **Conclusion**

With **max nine measurements all climates** and **all temperature applications** of **EN 14825** can be covered and at the same time the calculation with **EN 15316-4-2** can be **secured** by measured data. It is remembered that in the existing EN 14825 **already 5 measurements** are needed for **only one climate** and **only one temperature application**.

By harmonising the test conditions for heat pumps between EN 14825 (Ecodesign) and EN 15316-4-2 (EPBD) the consistency and reliability of Ecodesign/ErP and EPBD will be increased and the testing simplified.