Position Paper

EPEE POSITION PAPER ON BAM GUIDELINES FOR A DYNAMIC TEST METHOD

December 2019

INTRODUCTION

EPEE would like to provide comments on the BAM test guidelines for dynamic performance testing and calculation of the seasonal coefficient of performance for air conditioners and heat pumps with electricity driven compressors (lots 10 and 1).

EPEE considers that the test guidelines are not sufficiently detailed to judge the ability to run the methodologies both for air-conditioners and heat pumps. These guidelines should be redefined and provide additional information and details on tests already carried out by BAM, test chamber characteristics, settings and load adjustment as well as tests and measurement procedures. The below paper highlights several aspects that we think need to be clarified and considered.

EPEE believes that further analysis of the scope, feasibility, limits and requirements of this method must be carried out before reaching the RRT stage, which will require significant time- and resource-investment. As for now, the repeatability, reproducibility and cost-effectiveness of the described method in the guidelines are not sufficiently addressed.

As regards the feedback questionnaire, we are not able to provide answers as it contains very specific questions related to test room facilities, test handling, overall testing organisation and requests samples for round robin testing. Our members may submit individual responses to this questionnaire.

1. Further details need to be provided

- **Scope**: Both Lots 10 and 1 address a wide scope and it is unclear which parts of the scope are covered by the guideline documents. The following table shows each scope and highlights with "?" the elements that we think need to be clarified.

Air to air conditioners/heat pumps – split and multi split (Lot 10)					
Capacity range	**Ducted**	**Non ducted**			
		Wall mounted	**Cassette**	**Floor standing**	**Ceiling suspended**
≤6kW	?	Checked (split only)	?	?	?
6kW - 12kW	?	?	?	?	?

Heat pump space heaters (Lot 1)			
Capacity range		**Air to water**	**Water to water**
≤70kW	≤10kW	Checked	Checked
	10kW – 70kW	?	?
70kW – 400kW		?	?

- **Circumvention**: how does the new test method addresses circumvention?

- **Uncertainties**: what is the uncertainty of measurements on capacity, electricity consumption and efficiency?

- **Test duration**: The method uses a continuous sequence of 47.5 hours where the outdoor temperature is changed every 2.5 hours without reconditioning of the room. This means the results are dependent on the climate chamber's intrinsic characteristics. Thermal inertia generally depends on the test room size, form and the wall construction. Therefore, test room construction should be further specified, and the test guide should give information about the inertia effects detected during the already performed tests.
  In addition, notes to the reader about how to handle and minimize these effects would be expected.
  It is important to note that companies' testing facilities are already established with a certain room dimension and construction. Therefore, any change on this point would trigger the need to rebuild the testing rooms, when they are perfectly adapted to the current methodology.
  As the papers give no information about the upper and lower boundaries of inertia, the testing wall mass and construction and the testing rooms size, this lack of information could easily lead to increased measurement uncertainties.

- **Test disruption**: As a temperature sequence is tested over 47.5 hours, technicians cannot always be present. Therefore, if measurements are interrupted through loss of power or a problem with the test apparatus software/ hardware, it is unclear how to address this issue.

- **Automatization**: The method requires automatization of the test facility, but no details are given on the required control reactivity, software and hardware and the necessary equipment.

- **Out of the box testing**: Although the method claims to better reflect 'real life' operation with out of the box testing and several derogations to this concept introduced in the guidelines (replacement of sensors, temperature sequences arbitral omitted, unit control bypassed, etc.), it is not clear where the added value of BAM guidelines lies in this respect.

- **Defrosting**: There is a lack of information on the handling of this crucial operation point – Is a defrosting cycle is mandatory? Is defrosting specifically monitored? Can defrosting cycles be interrupted by the change of test temperature?

- **Wet-bulb temperature control regarding the testing of air conditioners**: As the wet-bulb temperature is based on the rating capacity (PLR=100%) condition, we believe this temperature control cannot be applied to all conditions, as the tested equipment usually has various SHR (Sensible Heating Ratio)

depending on the load ratio by outdoor temperature. Hence, there is a need to indicate the specification and control details of the already performed tests.

- **Test laboratories**: Most manufacturers use the air enthalpy method as it is a known practice, and in order to achieve a higher accuracy in heating mode. The current report is only considering the calorimeter method. It may be necessary for manufacturers to build or rebuild their testing facilities, which would require more time as well. In order to transition properly to load based testing or dynamic testing, air enthalpy method should be considered properly.

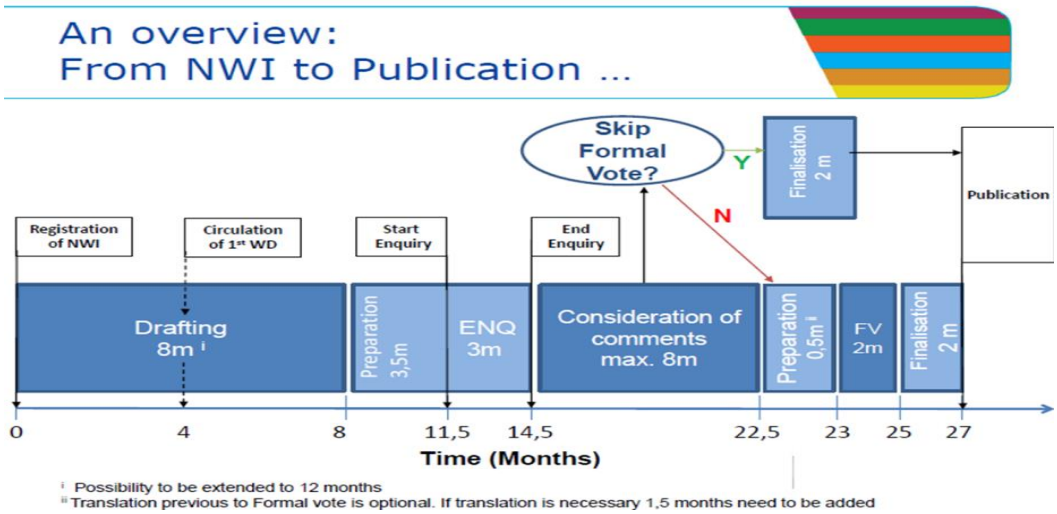
- **Energy Performance of Building**: The test results must be useable for EPB calculations as is the case with the current methodology. With EN 14825, hence Ecodesign, calculations are possible for each application in Europe. Currently, the 4 points are used, and the methodology has been developed to ensure that these points can be used properly to determine the performance in the building. Any new test method should correctly take into account this aspect.

2. The timeline to introduce new test methods must be reconsidered

- Considering the lack of information provided, the current timeline should be revised and redefined. As such, we would like to outline that:
  - Taking into account the use of the official CEN procedures, we can assume that at least 20 months will be necessary for a standard to be published (starting from a finished draft);
  - At least one and a half year is required for round robin testing (including manufacturers' facilities and time needed for evaluation) to obtain data on the repeatability, the reproducibility and the uncertainty of the test method (e.g. Ecotest which took 1.5 years).

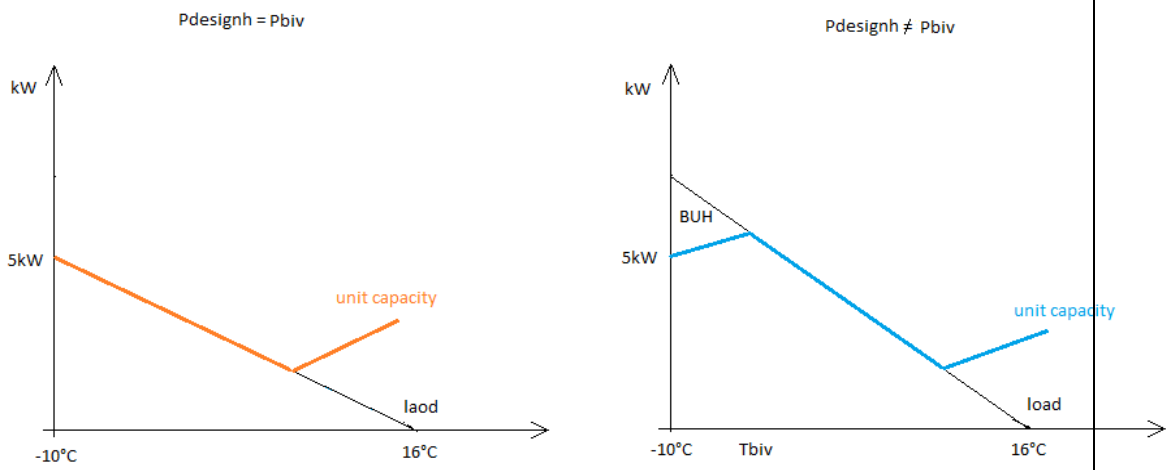
- Even 2025 might be an ambitious target for introducing a fundamentally new test method, let alone 2023.

- The relevant WG in TC113 should evaluate whether there is a feasible method and if yes, take the necessary steps to adapt it. A new method should be quicker, repeatable, and easy to use and accepted by laboratories and manufacturers.



3. Detailed comments on the two test guidelines

Test guideline for dynamic performance testing and calculation of the seasonal coefficient of performance for heat pumps with electrically driven compressors for space heating

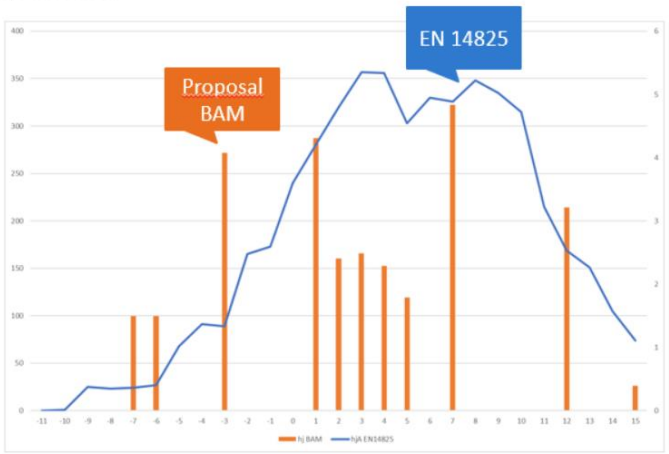
CLAUSE	COMMENT
1	The scope shall be clearly defined, similar to EN 14825: A/W, W/W and capacity ranges.
3.1.5.	Figure 1: 1) When Tdesign = Tbiv, the design capacity will be tested according to EN 14511 while when Tdesign ≠ Tbiv, the design capacity will be tested for 2 hours. Depending on the bivalent point declared by the manufacturer, this can lead to different COP values for the same capacity declared. In the example below, in both cases, the unit is providing 5kW but the measured capacity will be different as it will be according to EN 14511 for one and 2 hours measurement for the other one.  2) When this is not according to EN 14511, what is the test method to be used to measure defrost? When do we have to start and stop the testing during defrost? This is not clear. In the dynamic test method, the unit is under test continuously for different temperatures. The coil can be wet and not clean for some test points where defrosting occurs. In this case, it is not possible to obtain the same defrost cycle.
4.2.2.	In Table 3, the permissible deviation on water conditions is 1K. This is a big deviation allowed which impacts the unit behaviour. If there is a sudden jump of 1K on the entering water temperature, the unit can stop. For example, this phenomenon can happen when the radiator is turned off so there is a need to stop the unit. With the dynamic test method, if there is a sudden jump of 1K due to the compensation load, the unit can also stop. Therefore, the compensation load must be as accurate as possible. It has to be noted that in the current standard (EN 14511), these tolerances are allowed as the unit is fixed. In free operation, this will have a direct impact on unit behaviour.
4.2.3.	Sensors in manufacturing process are not calibrated. Currently it is no industry practise to calibrate them.

CLAUSE	COMMENT
4.2.4.	A leaving water of +- 2K gives important tolerances on the capacity measured and COP. For example, it can have an effect of 2.5 % on capacity and 10% to 15 % on COP. This will have an impact on the final result which is the seasonal space heating energy efficiency ($\eta_{s,h}$). The tolerance on the $\eta_{s,h}$ declaration would have to be drastically increased!
6	1) The supplementary heater is connected during testing if present. The measured capacity will depend on 2 points: duration of the test (In 2,5 hours, it is not possible to test a behaviour of the combination: heat pump + BUH) and the uncertainty allowed (activation of the BUH depends on the parameters measured by the unit which depend on the test set up and its accuracy.) 2) It is proposed to connect the BUH and test it. Today, the BUH is assumed in the calculation and this will not be the case anymore. Is the explanation also applicable for boiler BUH?
6.4.	It is proposed to replace the sensor if there is a defect on it. - What is meant by "defect"? - If it is replaced by another sensor, how will this be selected? The test engineer cannot know and have all type of sensors and connectors used by manufacturers. If a wrong sensor is fixed, the measurement will be wrong. In the equipment of air-to-water and brine-to-water, the replacement of temperature sensors and outdoor temperature simulation by electrical resistance are permitted, therefore such methods should also be applied to the air-conditioner including indoor side (room air temperature sensor).
6.7.	It is recommended to control on fixed volume flow. Nowadays, most flow controls are variable ones. Fixed volume flow was used in the past. Such requirement to use a certain type of flow control is technology prescriptive.
7.2.	It is unclear how the weighting factors are determined. It is recommended to clarify for all climates (warm, average and cold).
7.3.	Please explain the background of the used formula to be able to understand the details.

Test guideline for dynamic performance testing and calculation of the seasonal coefficient of performance for Air conditioners with electrically driven compressors for space heating and cooling

CLAUSE	COMMENT
1	The scope shall be clearly defined, also the capacity ranges.
3.1.	In a calorimeter room, having several testing points to perform in a short time won't let the walls reach the test temperatures. - How to assure the stability of the room if the walls don't reach the test temperature? Is this unbalance counted in a positive or in a negative way? - What is the effect of the different loads in the dry/wet bulb of the indoor side? Is it possible to reach the stability and the measurement period within the two hours? - How is the uncertainty considered? Is it on the individual measurement points or the total? - In cooling mode, when the coil is wet, how condensates affect the capacity measurement to the individual points where the unit is not dehumidifying (latent capacity = 0)? - How is the latent capacity measured?
3.1.1.	1) What is a "verified" Pdesign?

CLAUSE	COMMENT
	At design temperature, the maximum capacity of the unit is not always equal to Pdesign. This means that the measured capacity according to the dynamic test will lead to a different capacity than the one declared. For example, a unit declared with 10kW of capacity can have during the free operation test, 12kW which is his maximum capacity. How to make the correction if the capacity is different?
3.2.1.	1) 19 bins are specified for heating, compared to 26 in EN 14825. The PLR is determined in relation to Tbiv. This does not really seem to make a difference, but it is a different approach. 2) How many defrost cycles are considered before changing condition? According EN 14511, the measurement time is 4h. 3) The wet bulb condition should be defined for the outdoor side. Since the transition time of outside temperature and heating load varies depending on the specification of test facilities and units, the accuracy of the temperature sensor of the indoor units must be considered.
3.2.2.	1) Going from a wet coil to a dry coil takes more time than the other way around. The capacity has also biggest impact going from a wet coil to a dry coil if test duration is too short. 2,5 hours will not be enough to dry the coil and the necessary time will depend on the unit itself. 2) The wet bulb condition should be defined for the indoor side. Since the transition time of outside temperature and heating load varies depending on the specification of test facilities and units, the accuracy of the temperature sensor of the indoor units must be considered.
3.3.	The permissible deviation on indoor and outdoor temperature is relatively high compared to 5% on capacity. 3K deviation may result in far higher differences on capacity. The accuracy on temperature should be increased. 1) For the wet bulb, the uncertainty should also be according to EN 14511. Otherwise, this will have a big impact on the capacity measured and on the resulting efficiency. 2) As an example, from the excel file provided, the average of the WB test data is 20.5 C and it is out of the allowance from the testing condition EN14825 (19 C). The delivered latent heat is not possible to control (or need to take time) since the delivered total heat must be stable during a testing condition (the delivered sensible heat must be adjusted when the delivered latent heat changes).
4.2	The test will be carried out in a calorimeter room by changing the loads inside it. - How are this loads going to be changed and in function of what? - In the cooling test, only a heater is used, no dehumidifier. Is that correct understanding? To adjust so that the energy balance keeps within a range of ± 4% each time means that the performance cannot be continuously measured by the sequential outside air temperature change.
5	1) Test duration: 150 minutes are specified as test duration. It is unclear which statistical methods are applied to edit the raw data.
5.2.	1) In point 4.2/5.2, it is mentioned *"the optimum setting for the remote control should already be evaluated during the test at Tdesign/Tbiv".* How is it going to be evaluated?

CLAUSE	COMMENT
5.2.3	Please explain the background of the used formula to be able to understand the details.
6	No measurement uncertainties are mentioned in none of the points.
6.2.1	1) 19 bins are specified for cooling, compared to 24 in EN 14825. 2) Weighting factors are unclear: It is unclear based on the document how the weighting is done of each of the bins tested. Furthermore, it is unclear how these are then integrated into the SCOP calculation. Weighting seems unnecessary and same system of interpolation can be done as in EN 14825 using the results of the test. Weighting factors  3) The proposed weighting gives discrepancies when comparing with the calculation according to EN 14825. This results in systematic errors and therefore needs to be addressed accordingly. 4) Can you give an explanation of the following formulas? Where do 35,19s and 7200s coming from? $Q_{h,design} = Q_{h,design,exp} \cdot \frac{35{,}19s}{7200{,}00s}$ $E_{el,design} = E_{el,design,exp} \cdot \frac{35{,}19s}{7200{,}00s}$ We understand the red values to be added in the Formula, but why 35,19/7200? 7200s is because of 2h of test but 35,19s is not clear where it is coming from. We believe that this is an example as the test duration is minimum 2h, it can be more so the factor should be changed accordingly. $SCOP = \frac{Q_{h,design} + \sum_{i=1}^{19} Q_{h,i}}{E_{el,design} + \sum_{i=1}^{19} E_{el,i} + H_{SB} \cdot P_{SB} + H_{CK} \cdot P_{CK} + H_{off} \cdot P_{off} + H_{TO} \cdot P_{TO}}$

	EN 14825	BAM PROPOSAL
Weighted average temperature	5°C	2,8°C

CLAUSE	COMMENT
	5) K10 value is not correct. **Example:** Sequence: $i = 10$ Target outdoor temperature: $\vartheta_{o,target} = 15°C$ Target indoor temperature: $\vartheta_{indoor,target} = 20°C$ Weighting factor: $K_{10} = 1{,}9360$ 7 0,8947 8 2,4180 9 1,6050 10 0,3952 11 1,6050 12 2,4180
6.2.3.	1) Adjustments of power consumption The method proposes adjustments of the power consumption for excessive deviation. However, if deviations exceed permissible deviations, the sequence should be retested. 2) It is not logic to use 20°C since the correction must be done with the temperature difference between evaporator/condenser refrigerant. This will lead to a wrong correction. It also has to be investigated whether such correction is giving favourable data or not. This shouldn't lead to design a product with a very low accurate sensor with a very good efficiency. Measured power consumption: $E_{el,4} = 1\ kWh$ $E_{el,4,kor} = E_{el,4} \cdot \frac{\vartheta_{indoor,4,target} - 0{,}5K}{\vartheta_{indoor,4,exp}} = 1\ kWh \cdot \frac{20 - 0{,}5}{19} = 1{,}03\ kWh$
6.3.2.	1) The following formula considers dry bulb only. Wet bulb needs to be considered as this has also an important impact on the obtained result. If $\vartheta_{indoor,exp} < \vartheta_{indoor,target}$: $F_{indoor,i} = \frac{\vartheta_{indoor,i,target} - 0{,}5K}{\vartheta_{indoor,i,exp}}$ If $\vartheta_{indoor,exp} > \vartheta_{indoor,target}$: $F_{indoor,i} = \frac{\vartheta_{indoor,i,exp}}{\vartheta_{indoor,i,target} + 0{,}5K}$ Please explain the background of the used formula to be able to understand the details.

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ABOUT EPEE:

The European Partnership for Energy and the Environment (EPEE) represents the refrigeration, air-conditioning and heat pump industry in Europe. Founded in the year 2000, EPEE's membership is composed of 40 member companies, national and international associations.

EPEE member companies realize a turnover of over 30 billion Euros, employ more than 200,000 people in Europe and also create indirect employment through a vast network of small and medium-sized enterprises such as contractors who install, service and maintain equipment.

EPEE member companies have manufacturing sites and research and development facilities across the EU, which innovate for the global market.

As an expert association, EPEE is supporting safe, environmentally and economically viable technologies with the objective of promoting a better understanding of the sector in the EU and contributing to the development of effective European policies. Please see our website (www.epeeglobal.org) for further information.

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