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Requirements and testing procedures for energy, comfort, acoustic and hygienic assessment of Passive House split air conditioning systems for Certification as "Passive House suitable component"

Preliminary

Introduction

The following certification criteria describe the testing procedure and performance requirements for the energy, comfort, acoustic and hygienic assessment of split air-to-air conditioning heat pumps being considered as energy efficient cooling systems for Passive Houses [1].

Application

The split air-to-air conditioning heat pumps are composed of two parts, one situated outside of the building and the other inside. Both units are equipped with heat exchangers (HEX) and ventilators for recirculation of the surrounding air. The compressor is usually situated in outside unit. Inside unit further contains the control system and filters. The function can include cooling, heating, dehumidification and cleaning of the air.

Assessment in general

The testing procedure should include the following features to be investigated and documented:

- Acoustics
- Evaluation of comfort criterion (draught in the room)
- Determination of efficiency for heating (COP values)
- Determination of efficiency for cooling (EER values)
- Stand-by el consumption
- Control system settings and regulation
- Indoor hygiene/ filter cleanness
- Defrosting of evaporator during heating season

Required documentation to be provided by manufacturer prior to the testing

- Complete description of the unit (all the parts the unit is composed of)
- Manual for unit assembly and initialization (start-up)
- Description of settings of control system for all available operational modes

Efficiency

Requirements:

The air conditioning split units (ACSU) should be tested and evaluated using Calorimeter Test Method as defined in [2]. The unit should be tested in 3 test points differentiating in boundary temperatures. This includes cooling and heating case (if the ACSU is capable of both), as presented in Figure 1. If the ACSU unit has an inverter implemented for the speed control of compressor, then the unit should be also tested at different speeds defined at minimum, middle and maximum power for each test point. Furthermore, the measurements at all the test points should be carried out for air flow(s) through the HEX in inside unit. The air flow values available according to the certification criteria for sound power presented further in this document should be used.(Based on regulation of the air flow this could result in 2 or only 1 air flow value). The minimal COP/EER values should reach at least those presented in Figure 1. The seasonal performance factors similar to those defined in EN 14 825 cannot be used for the buildings with very low energy consumption [3]. The main reason is that the dependence on specific building and climate is very high in case of low energy buildings and therefore the “average” building and climate as presented in EN 14 825 cannot be used with sufficient precision.

Test point 1	Tout= -7°C	Tin=20°C
Frequency of compressor (rpm)	Power output	COP
MAX	measured	2.2
MIDDLE	measured	2.2
MIN	measured	2.2

Test point 2	Tout= 2°C	Tin=20°C
Frequency of compressor (rpm)	Power output	COP
MAX	measured	3.0
MIDDLE	measured	3.0
MIN	measured	3.0

Test point 3	Tout= 7°C	Tin=20°C
Frequency of compressor (rpm)	Power output	COP
MAX	measured	4.2
MIDDLE	measured	4.2
MIN	measured	4.2

Test point 1	Tout= 35°C	Tin=25°C
Frequency of compressor (rpm)	Power output	EER
MAX	measured	3.8
MIDDLE	measured	3.8
MIN	measured	3.8

Test point 2	Tout= 30°C	Tin=25°C
Frequency of compressor (rpm)	Power output	EER
MAX	measured	5.9
MIDDLE	measured	5.9
MIN	measured	5.9

Test point 3	Tout= 25°C	Tin=25°C
Frequency of compressor (rpm)	Power output	EER
MAX	measured	8.3
MIDDLE	measured	8.3
MIN	measured	8.3

Figure 1: Test points to be tested (heating scenario-left; cooling scenario-right)

Testing conditions:

The testing procedures differ slightly for full load and part load operation and both are described below. The difference is in the way the heating/cooling load is supplied to the inside test room during measurements according to Calorimeter Test Method [2].

For the measurements at a full load operation, the revolution of compressor will be fixed (locked) at maximum available revolution per minute (RPM) (the detailed description of how this should be done must be supplied by producer of the ACSU and producer also has to allow for the proper access to the control system of the ACSU). The indoor environment will be maintained at required temperature (20°C for heating case and 25°C for cooling case) by use of room conditioning unit (RCU) situated in indoor test room, see Figure 2 for description of the testing set up suitable for Calorimeter Test Method. The outdoor test room conditions should be kept at 25°C, 30°C und 35°C (cooling case) and -7°C, 2°C and 7°C (heating case) by RCU situated in outdoor test room. When a steady-state situation is reached, the relevant resulting values should be documented (specified later in the text).

For the measurements at part load operation, the heating/cooling power for part load operations should be defined as minimum and middle power available for investigated unit. **All of the measurements at part load operation should be done in indoor environment maintained by RCU situated in indoor test room**. This is different from the measurement at full load where the indoor environment was maintained by ACSU. The power output (principally the heat load of the room) of the RCU will be fixed (locked) during the whole testing procedure. For example, if the part load of ACSU was calculated to be 2 kW (for certain testing condition), then this number is required power output (heat load) of RCU situated in inside test room.

The measurement starts by setting RCU in outdoor and indoor test rooms to reach the desired conditions in both test rooms (as example of one test point in cooling case: 35°C in outside test room representing outdoor conditions and 25°C in inside test room representing indoor conditions). When is this setup stabilized and quasi-steady state conditions are reached, the indoor RCU is set to produce the desired cooling/heating output representing the relevant part load operation (as previously described). This value is fixed during the measurement of corresponding test point. The tested ACSU is then turned on and we let the ACSU to reach the required temperature in the indoor test room. It can be necessary to adjust the power output of ACSU by use of remote control in order to reach the desired temperature in indoor test room (25°C for cooling case and 20°C heating case). Certain fluctuations of temperature in indoor test room can be expected during this method (±1°C). This slightly transient behavior is caused by work of inverter as a result of previously described method. The tested ACSU's capacity can be then calculated based on calorimeter principles when the stable operation was reached. The method allows to reach the desired cooling/ heating capacity with precision of about ± 3%.

The described method accounts for fluctuating behaviour of the ACSU present in real operational conditions. The range of RPM at which the compressor of unit will work when trying to reach the correct temperature inside the room should be documented.

The resulting values to be documented (for full and part load measurements) include:

- Power delivered by ACSU
- COP/EER
- Power consumption of ventilators (inside/outside)
- Air flow values through HEX (inside/outside)
- Temperature and relative humidity of air coming in and leaving the HEX (inside/outside)

- Temperature of evaporator and condenser

The length of the pipes between the outside and inside unit should be also documented, as well as the thickness and λ-value of the insulation material.
One measurement has to be done with complete defrost cycle of evaporator (heating case). If this was not achieved in already investigated test points, then one additional measurement has to be done with appropriate temperature and humidity of outside air. The time and COP value for the complete defrost cycle should be documented.

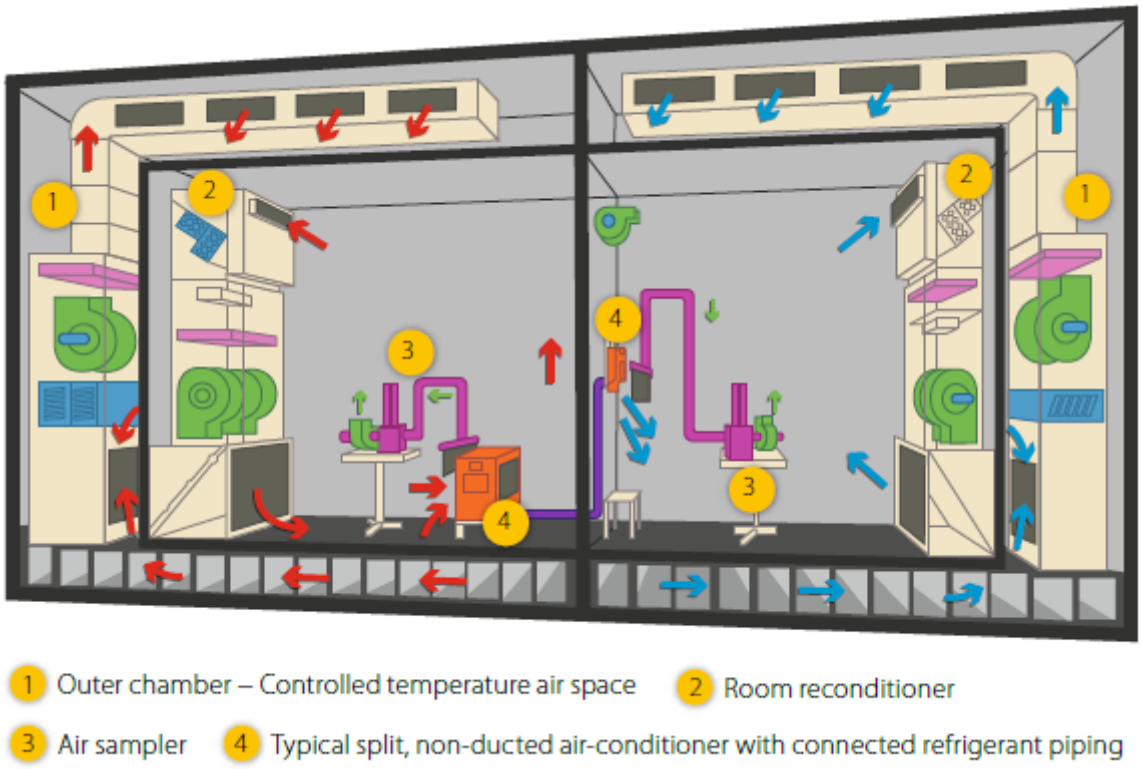

Figure 2: Calorimeter method setup (source [11])

Evaluation:
The output of the investigation should be presented in the table similar to the one shown in Figure 1. The values from Figure 1 will be then processed in PHPP software to evaluate the seasonal performance of the ACSU [4]. This process should be further discussed with Passive House Institute [5].

Acoustical testing

Requirements:
The sound power of the outside unit should be tested in accordance with BS EN 12102:2013 [6]. The standard ISO 3743-2 [7] should be used to determine the sound power of inside unit. If the laboratory is not equipped with special reverberation test room, the standard ISO 3743-1 [8] can be followed instead.
The limiting factor for the sound power of the inside unit is 25 db (A) for night operation. For “time-limited” operation for maximum power delivery during the day, this value can

be increased up to 35 db (A). The manufacturer of ACSU can suggest the combination of ACSU with appropriate silencer when he finds this suitable. This mainly concerns concealed units, however can include also wall and ceiling suspended units.
The sound power for outside unit should be lower than 50 dB(A) during days and 35 dB(A) during nights as defined in TA Larm [9].

Testing conditions:

The measurement of sound power emitted by the inside unit is done for highest air flow through the inside unit as defined in presented certification scheme.
The unit should be positioned/fixed according to the manufacturer's instructions as defined in ISO 3743-1 [8].

Evaluation:

Sound emissions are to be presented in third-octave band steps (31.5 Hz – 8000 Hz) as a table and in a diagram.

Control system

Requirements:

The description of the settings should be detailed enough so that the operation of the unit can be reproduced in calculation model when necessary (for example defrost or dehumidification mode). Therefore, all the relevant boundary conditions have to be stated as well.
The available control strategies of following functions (as set by producer of the ACSU) should be described:

- Speed of compressor
- Air flow through the outside/inside units
- Airflow direction in the room
- Defrost mode
- Dehumidification mode

De-humidification

Requirements:

The level into which the unit can be used for dehumidification should be evaluated and documented.

Testing conditions:

The measurement has to be done with condensation created on evaporator. If this was not achieved in already investigated test points, then additional measurements has to be done with appropriate temperature and humidity of inside air. The measurement should be done at minimum and maximum air flow value through evaporator available according to the certification criteria presented in this document for 2 different speeds of compressor.

Evaluation:

The sensible heat ratio (SHR) should be presented for selected operating conditions in addition to the other resulting values to be documented as defined in section “Efficiency”.

Comfort requirements

Requirements:

The maximum allowed draught rating at investigated position is 15% according to ISO 7730 [10].

Testing conditions:

The comfort conditions of occupants are to be evaluated for cooling case at full load for highest air flow through the inside unit as defined in presented certification scheme. The temperature, relative humidity and velocity of the room air should be measured at horizontal distance of 1.5m from the wall where the internal unit is situated. The unit will be mounted according to the producer’s requirements. In case of internal unit which is to be installed in the ceiling (cassette unit) should the measurements take place directly below the unit at height of 1.1m above the floor.

Evaluation:

The draught rating should be calculated and presented for both scenarios- cooling and heating and for two speeds of ventilator (minimal and full speed available). The evaluation should be based on ISO 7730 [10].

Hygienic requirements

Requirements:

The main aspect here include the easy access to the filters situated inside of the internal unit. The user should be able to exchange the filters without the need for assistance of professionals. It should be also possible for the user to remove the front plate of the internal unit in order to do the basic maintenance (including the cleaning of the heat exchanger).
The drainage of the condensate from the internal unit is to be evaluated. The construction of the drainage system should allow immediate removal of condensate from the unit in order to avoid creation of mould.

Testing conditions:

The condensate should not stay in the unit for longer time- it should be either carried out to the drain system or evaporated again. The internal unit should be during measurements tilted about 2° in the direction towards the “condensate pan”, allowing the proper condensate drainage. The solution for drainage of condensate is to be evaluated also for external unit when is this used during the heating operation (split units with reverse mode option).

Evaluation:

The way the access to the internal/external units is solved should be documented.
The process of filter exchange should be described in sufficient details allowing to be reproduced.

Standby mode electrical efficiency

Requirements:

The energy consumption during stand-by mode should not exceed 1 W, otherwise the manufacturer should provide the possibility of a complete disconnection from the electrical supply as a standard.

Evaluation:

The energy consumption (including control system) of the ACSU during stand-by mode is to be documented.

Miscellaneous

All specified test procedures apply for most of the typical cases. Additional or alternative testing can be necessary for certain ACSU units. This possibility should be discussed with Passive House Institute at early stages of testing. The same applies also for limitations of laboratories- alternative testing should be always discuss with Passive House Institute.

Nomenclature

ACSU	Air conditioning split unit
COP	Coefficient of Performance
EER	Energy Efficiency Ratio
HEX	Heat exchanger
RCU	Room conditioning unit
RPM	Revolutions per minute

References

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