BAM
Bundesanstalt für Materialforschung und -prüfung

2020-09-21

Test guideline for a load-based performance testing

Air conditioners with electrically driven compressors for space cooling

BAM, S.4 Ecodesign and energy labelling

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1. Scope

This test guideline describes a test method for a load-based performance test of air conditioners with electrically driven compressors to be applied for the round robin test of BAM.

1.1 General

The procedures described in this test guideline apply to unitary air conditioners that are

a. air-source and air-sink;
b. single-split systems with matching assemblies or single package for use in ducted and/or non-ducted distribution systems;
c. designed for space cooling;
d. electrically driven, mechanical, vapor-compression-type systems; and
e. rated below 12 kW heating or cooling at standard rating conditions (in accordance with EN14511).

2. Normative references

The procedures described in this test guideline refer to the following publications:

a. EN 14825:2018
b. EN 14511:2018

3. Symbols, abbreviated terms and units

Table 1: Symbols, abbreviated terms and units.

Symbol and abbreviated terms	Denomination	Units
DB	Dry bulb	°C
EER	Energy Efficiency Ratio	-
$\dot{Q}_c$	Cooling capacity	kW
T_{design}	Reference design temperature conditions	°C
ϑ_o	Outdoor temperature	°C
ϑ_i	Indoor temperature	°C
WB	Wet bulb	°C

4. General requirements

During a compensation test the indoor room is subjected to a simulated building load and the air conditioner to be tested responds accordingly as it tries to maintain the desired indoor conditions, while outdoor room conditions are held constant. The test conditions in both, indoor room and outdoor room, are provided by the test bench's conditioning apparatus. The building loads shall be applied by the test bench via an electrical heater (compensation load). Single-speed, multiple-speed and variable-speed ACs under test shall be operated under control of the equipment and not in a fixed-speed mode. ACs are thus permitted to switch into on/off operation.

The units tested shall be installed in accordance to the installation manual from manufacturer and EN14511-3:2018. The ACs shall be tested at the settings they are available on the market (factory settings). Fan speed and louvers position shall be set according to the instructions given by BAM.

4.1 Permissible deviations from set values

For load-based testing, in dependence on the operating condition the following permissible deviations apply:

- During continuous / steady state operation of the AC the permissible deviations to be applied are shown in Table 2. Continuous operation / steady state operation starts from 5 minutes after the compressor is switched on.
- During off operation of the AC the permissible deviations to be applied are shown in Table 3.

Table 2: Permissible deviations during continuous / steady state operation of the AC.

Measurand	Permissible deviation of the arithmetic mean values from the target values	Permissible deviations of the individual measured values from the target values
Indoor		
inlet temperature (DB)	± 0,3*K	± 1,0K
inlet temperature (WB)	± 0,4*K	± 1,0K
Outdoor		
inlet temperature (DB)	± 0,3K	± 1,0K
Electrical voltage	± 4%	± 4%
Compensation load (indoor side)	± 5%	± 5%

* if a test within these limits is not possible even after adjusting the set indoor temperature on the remote control of the unit tested, the method of interpolation described in section 7.2.2 shall be applied.

Table 3: Permissible deviations during off operation of the AC.

Measurand	Permissible deviation of the arithmetic mean values from the target values	Permissible deviations of the individual measured values from the target values
Indoor		
inlet temperature (DB)	± 0,5*K	-
inlet temperature (WB)	± 0,6*K	-
Outdoor		
inlet temperature (DB)	± 0,6K	± 1,0K
Electrical voltage	± 4%	± 4%
Compensation load (indoor side)	± 5%	± 5%

* if a test within these limits is not possible even after adjusting the set indoor temperature on the remote control of the unit tested, the method of interpolation described in section 7.2.2 shall be applied.

5. Test setup

Air conditioners shall be tested with the calorimeter method according to EN 14511-3:2018 Annex A. Figure 1 shows two possible options for the test setup: (a) single calorimeter and (b) double calorimeter.

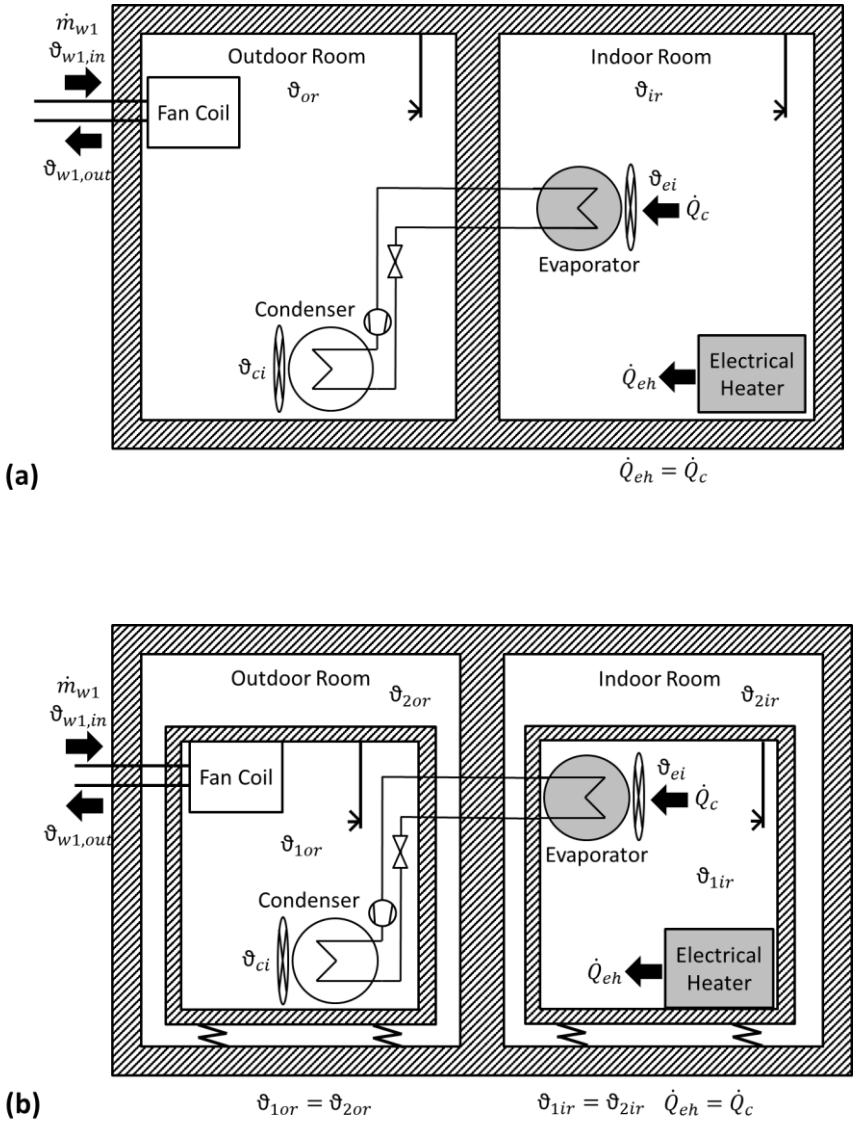


Figure 1: Test setup for testing air conditioners in a) a single calorimeter and b) a doubled calorimeter room.

6. Test conditions

Table 4: Part load conditions for the cooling capacity tests according to EN 14825:2018 at average climate.

Test interval	DB outdoor temperature ϑ_o (°C)	DB indoor temperature ϑ_i (°C)	WB indoor temperature ϑ_i (°C)	Compensation load (kW)
A	35	27	19	$\frac{35-16}{(T_{design}-16)}\dot{Q}_{design}$
B	30	27	19	$\frac{30-16}{(T_{design}-16)}\cdot\dot{Q}_{design}$
C	25	27	19	$\frac{25-16}{(T_{design}-16)}\cdot\dot{Q}_{design}$
D	20	27	19	$\frac{20-16}{(T_{design}-16)}\cdot\dot{Q}_{design}$

7. Test preparation and procedure

During the compensation tests, the indoor room is used to maintain the indoor test conditions, which are updated based on the building load model (Table 4) that includes interaction with the unit performance in real-time. The outdoor room is used to maintain constant outdoor conditions over a temperature range associated with different climate zones. In Figure 2 the test preparation and test procedure are shown.

7.1 Test preparation

Before starting with a test interval, set the indoor temperature on the remote control of the AC to 27°C. Continuously evaluate the deviations between the measured conditions and the test condition setpoints. The measurement data should be recorded at least every 10 seconds. If the arithmetic mean values of the indoor temperature are not within the prescribed permissible deviations (Table 2 or Table 3), the settings on the remote control of the AC shall be adjusted to utmost achieve the required indoor room temperature (DB and WB). If arithmetic mean values of the indoor temperature cannot be achieved within the permissible deviations, two tests shall be conducted under the same conditions but with two different settings on the remote control according to the interpolation procedure described in section 7.1.3.

7.2 Test procedure

Each test interval includes two major parts following the EN14511-3:

1) Equilibrium phase of at least 60 min and

2) Data collection period of

a) at least 35 min, if steady-state conditions,

b) or at least 4 complete on/off cycles, if discontinuous operation.

The test intervals shall be carried out in the following order:

1. Test interval A
    a. if necessary, additional second test of test interval A according to interpolation procedure (sec. 7.2.2)
2. Test interval B
    a. if necessary, additional second test of test interval B according to interpolation procedure (sec. 7.2.2)
3. Test interval C
    a. if necessary, additional second test of test interval C according to interpolation procedure (sec. 7.2.2)
4. Test interval D
    a. if necessary, additional second test of test interval D according to interpolation procedure (sec. 7.2.2)

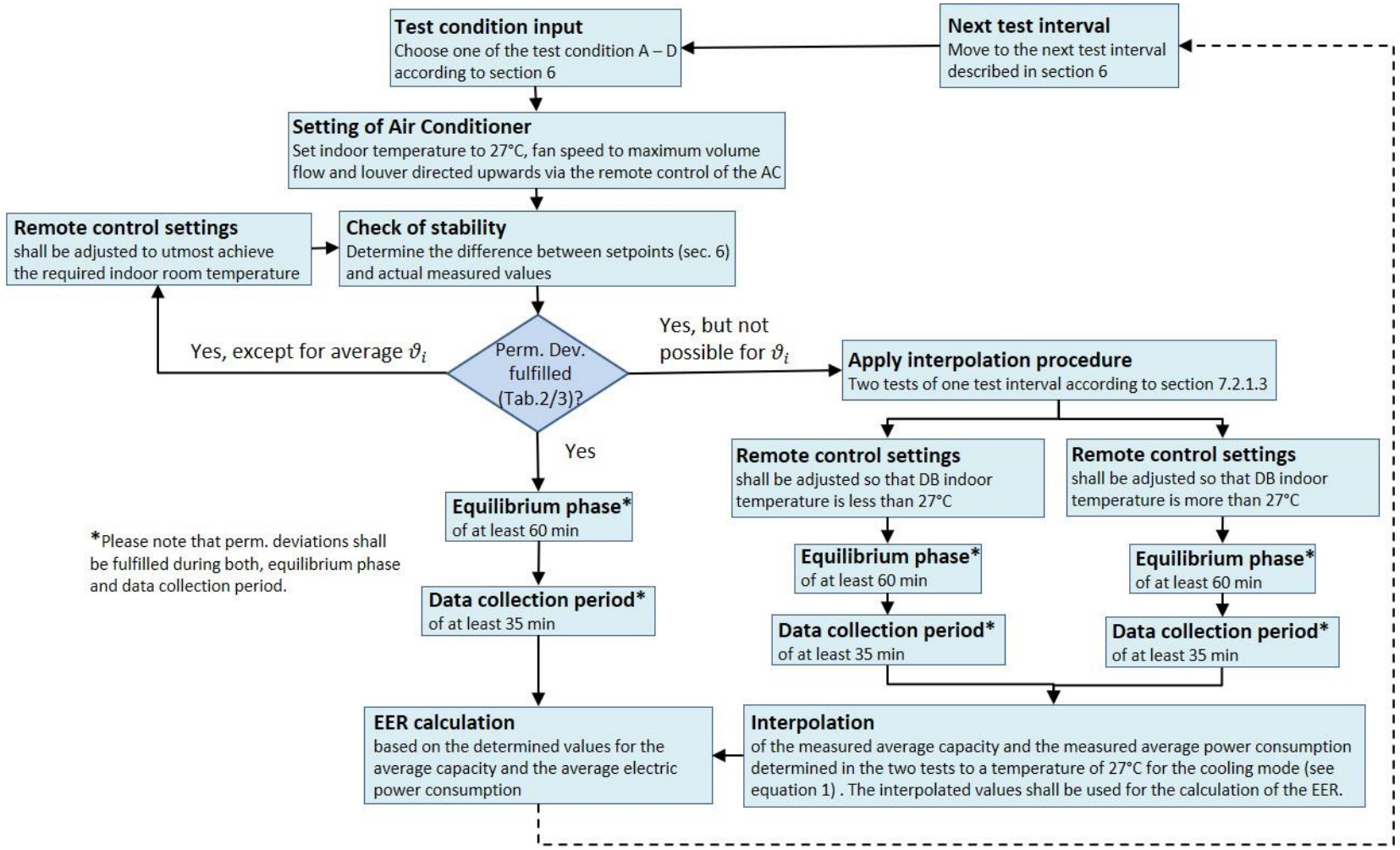


Figure 2: Test procedure for the capacity tests.

The capacity tests at A, B, C and D shall be carried out according to the prescribed procedure in section 7.2 and the test conditions according to Table 4. The compensation loads for the test intervals A, B, C and D will be provided by BAM.

7.2.1 On/Off behavior

If the air conditioner switches to cyclic operation during the test, the average capacity and average power consumption considering the entire test interval time (incl. off cycles of the AC) shall be used for the EER calculation, beginning at the start of an off-cycle and ending at the end of an on-cycle.

7.2.2 Interpolation procedure

If a test within the permissible deviations of the arithmetic mean indoor temperature from the set indoor temperature according to in Table 2 / Table 3 is not possible, even after adjusting the set indoor temperature on the remote control of the AC, the following procedure shall be applied.

Two capacity tests shall be conducted for the affected test interval, one at indoor temperature settings on the remote control that are higher than 27°C ($\vartheta_{i,2}$) and one at indoor temperature settings on the remote control that are lower than 27°C ($\vartheta_{i,1}$). The conditions of both tests and the prescription for the test stand, however, are identical according to Table 4. The differences of indoor temperature are achieved by adjusting the settings on the remote control of the AC only. The test results y_x of the tests 1 and 2 (namely the determined average values for the cooling capacity, the power consumption and the EER) shall be interpolated subsequently according to the following equation:

$$y_{27°C} = y_1 + \frac{y_2 - y_1}{\vartheta_{i,2} - \vartheta_{i,1}} * (\vartheta_{27°C} - \vartheta_{i,1}) \quad (1)$$

, where y_x is the test result for the capacity, power consumption or EER of the specific test x.

8. Evaluation of the RRT

8.1 General Information

- Photo documentation of wooden box, photo documentation of damage due to transport
- Photos of installation and instrumentation location
- RI-Scheme of test stand
- Volume size of test stands (calorimeter room)
- Was the room equipped with additional metal plates?
- Measurement uncertainties incl. method of determination
- expansion factor k
- level of confidence
- Information of AC behavior for each test interval (On/off or continuous? Defrost?)
- Settings on the remote control for each test interval and each test run

8.2 Evaluation of measurement data

- Raw data for each test interval
- Development of DB Outdoor Temperature, DB Indoor Temperature, WB Indoor Temperature, Rel. Humidity (Indoor), Cooling Capacity, Electric Power Consumption and EER for each test interval
- Average Values of each test interval at least for the DB Outdoor Temperature, DB Indoor Temperature, WB Indoor Temperature, Rel. Humidity (Indoor), Cooling Capacity, Electric Power Consumption and EER