Operation test of air-to-air heat pump Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND at low outdoor temperatures and determination of coefficient of performance including defrost periods

- set value of the heat pump +20 °C
- temperature of the indoor unit inlet air was allowed to lower at minimum to a value of +19,5 °C
- set value of the fan speed 5
- heating power demand 6 kW (at outdoor temperature of -26 °C)

Requested by: Oy Combi Cool Ab / Toshiba

VTT EXPERT SERVICES LTD

Requested by

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Order

15.6.2017, Tuomas Talvo

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Assignment

Operation test of air-to-air heat pump Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND at low outdoor temperatures and determination of coefficient of performance including defrost periods.

Sample

The customer delivered the air-to-air heat pump including indoor unit, outdoor unit, refrigeration circuit and a remote controller. Specifications of the sample are in appendix 1.

The sample was received 2.10.2017
Measurements were carried out 3.10.-5.10.2017

The customer installed the heat pump in to the test arrangement. The outdoor unit was installed into the 40 m³ climate room (VTT, Research hall 1, P104). The indoor unit was installed into the 64 m³ climate room (VTT, Research hall 1, P103).

Test methods

Operation test of air-to-air heat pump was performed according to test procedure determined by the customer. The operation of the heat pump was observed in the operation test which corresponds to low outdoor temperatures in Finland. The coefficient of performance (ratio of the heating capacity to the effective power input of the heat pump) of the heat pump was determined during the operation test applying the standard SFS-EN 14511 /1/. Deviate from the standard the coefficient of performance was determined from the measurements as a moving hourly coefficient of performance, which includes the defrost periods.

The heating capacity of heat pump was determined by the air enthalpy method which is described in the standard SFS-EN 14511 /1/ part 3, annex B. The heating capacity of the heat pump is a product of air heat capacity flow and the difference between inlet and outlet temperatures of the indoor unit. Effective power input is the average electrical power input of all components of the heat pump.

The air flow rate of the indoor unit in different operating points of the fan was determined in accordance with the standard SFS-EN 14511 /1/ part 3, annex J using the compensation method. The air flow rate was measured according to standards ISO 5167-1 and ISO 5167-2 /2/. Louvers were set for maximum air flow as instructed in standard.

The air flow rate of the indoor unit was measured continuously during the operation test using the sensor that was calibrated before the test using the compensation method. Differing from the compensation method there was no plenum attached to the indoor unit during the operation test.

Air intake temperatures of the indoor and outdoor units were measured with Pt-100 resistance sensor. Outlet air temperature of the indoor unit was determined as an average of temperatures of four thermocouples mounted at the outlet opening of the indoor unit. Relative humidity of outdoor air was measured with a capacitive sensor (Vaisala HMP 233).

Total power input of the air-to-air heat pump was measured with electric power meter (Norma D4155).

Deviate from the standard SFS-EN 14511 /1/

- the set value of the temperature was +20 °C instead of maximum set value
- temperature of the indoor unit inlet air was allowed to lower at minimum to a value of +19,5 °C
- heating power demand was changed during the operation test in a way presented in appendix 2
- air intake temperature of the indoor unit was measured at one measuring point
- air intake temperature of the outdoor unit was measured at one measuring point
- the fan speed was set for value 5
- measuring interval was 30 seconds during the whole test
- negative heating capacity of the indoor unit was taken into account concerning the defrost periods (in calculation of the moving average)
- the average of the variation of the temperature of the indoor unit air flow was not calculated in 5 minutes periods (a test period with the value above varying over 2,5 % is considered to be in a transition phase)
- humidity of air was determined directly as relative humidity instead of measuring wet-bulb temperatures.

Results

Measurement results are presented in appendix 3. The results are only valid for the tested item. Except defrost periods the heat pump operated continuously at the heating mode during the whole operation test. Condensation water pool (equipped with an electrical resistor to keep it melted) of the outdoor unit remained dry during the whole operation test.

References

/1/ SFS-EN 14511:2013, parts 1-4, Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling.
/2/ ISO 5167-1:2003. Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full. Part 1: General principles and requirements.

ISO 5167-2:2003. Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full. Part 2: Orifice plates.

Espoo 16.10.2017

Mikko Nyman
Product Manager

Ville Matveinen
Expert

APPENDICES 3

DISTRIBUTION

Customer	Original
Archive	Original

Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

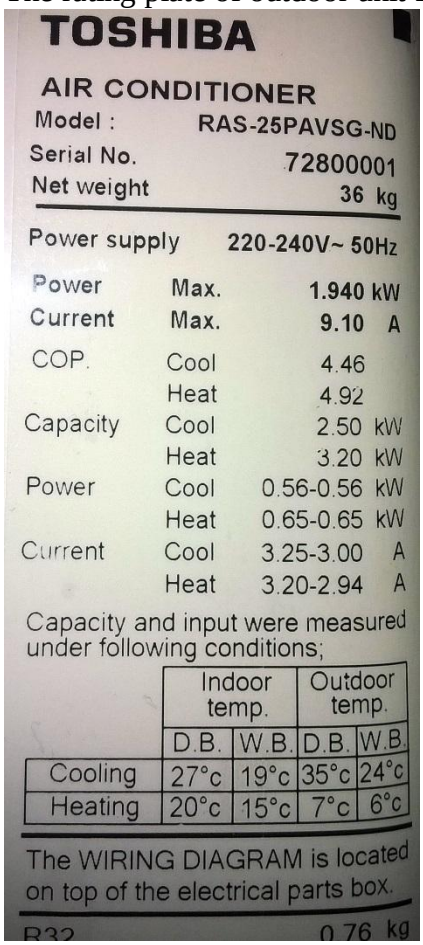
DESCRIPTION OF THE SAMPLE

Dimensions (width x height x depth), mm:
Indoor unit: 797x292x232
Outdoor unit: 860x550x320

Length of refrigerant lines: 5 m
Refrigerant: R32
Mass of refrigerant: 0,76 kg

The rating plate of indoor unit RAS-25PKVPG-ND:

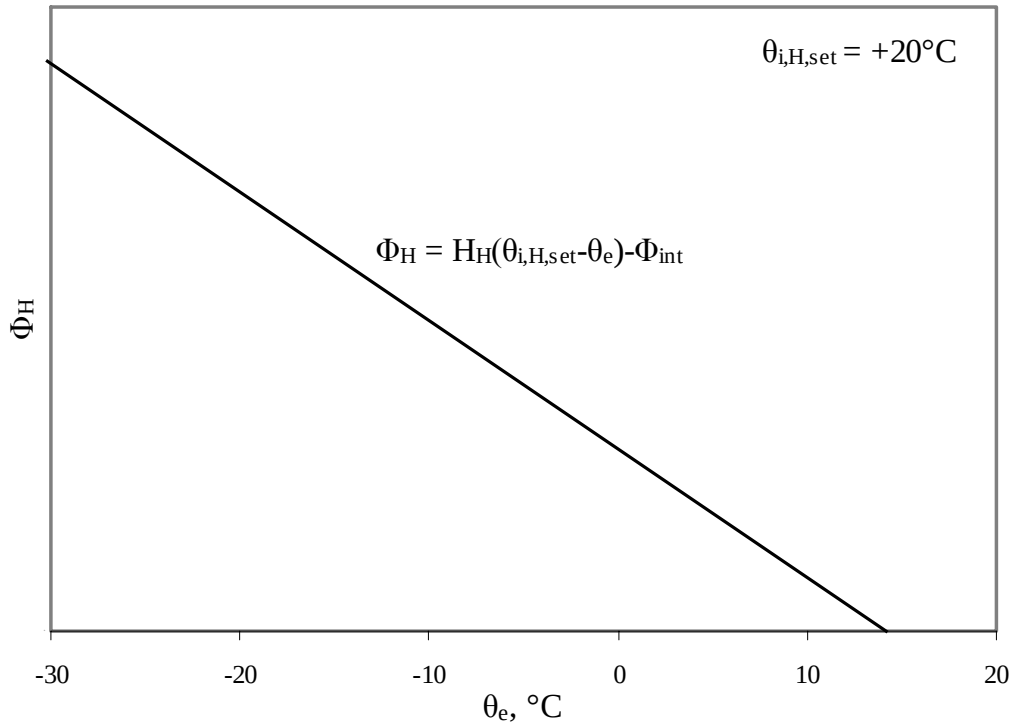
The rating plate of outdoor unit RAS-25PAVPG-ND**:**



Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

HEATING POWER DEMAND

Heating power demand Φ_H was changed during the operation test as follows:



Heating power demand follows the equation:

$$\Phi_H = H_H(\theta_{i,H,set}-\theta_e)-\Phi_{int},$$

where

Φ_H	is the heating power demand, W
H_H	is the overall heat transfer coefficient, W/ºC
$\theta_{i,H,set}$	is the set-point temperature of the building zone for heating (+20 ºC), ºC
θ_e	is the temperature of the external environment (outdoor temperature), ºC
Φ_{int}	is the internal heat flux rate, W.

The following constants were used in the operation test:

H_H = 146 W/ ºC
Φ_{int} = 1 kW.

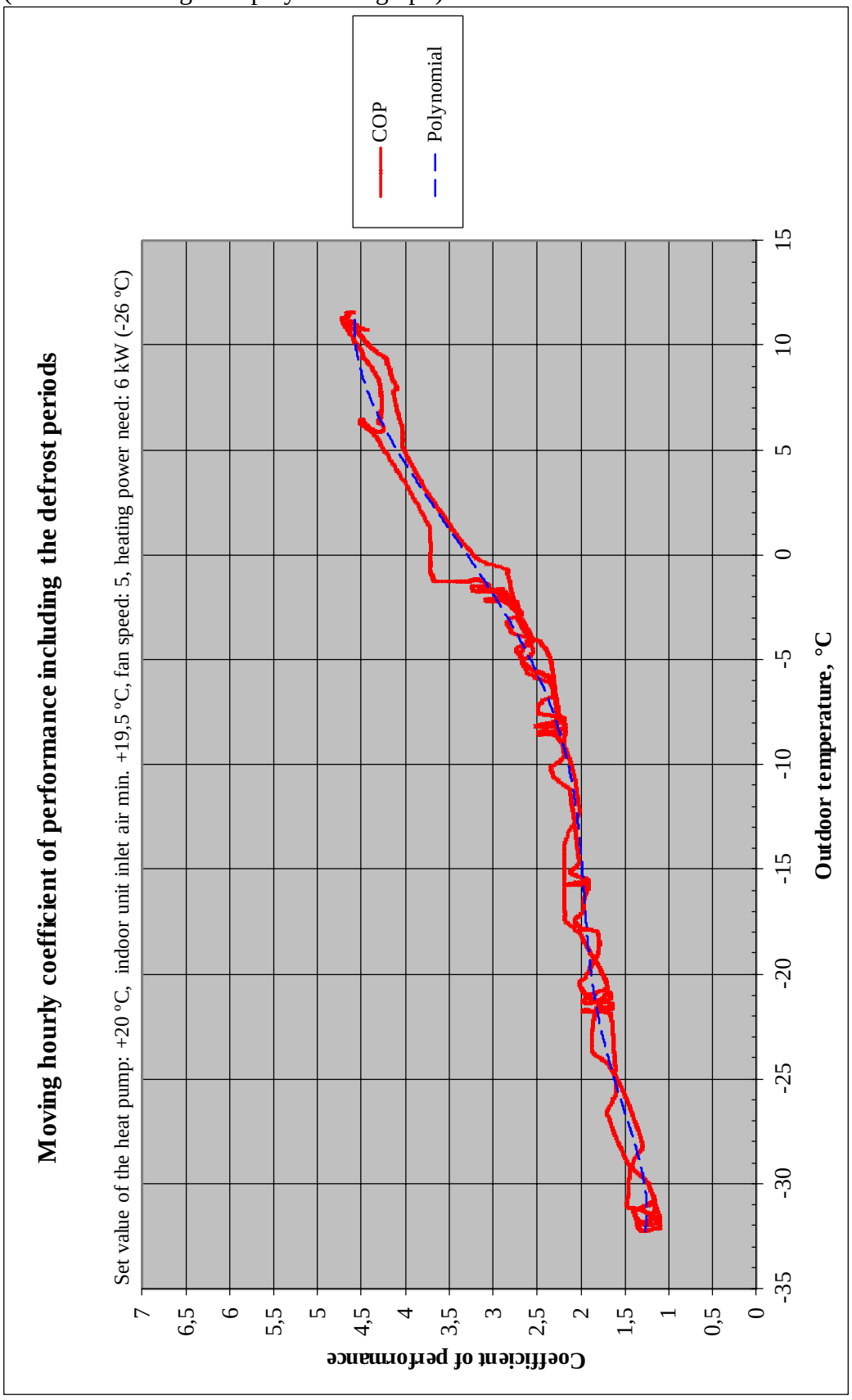
For example at the outdoor design temperature of - 26ºC the heating power demand is 6 kW. The heating power of the air-to-air heat pump covers a part of the heating power demand at low outdoor temperatures. Then part of the heating power demand has to be covered with another heating system.

During the operation test the temperature of the indoor unit inlet air was allowed to lower at minimum to a value of +19,5°C. When the heating power of the air-to-air heat pump wasn't enough to keep the indoor unit inlet air temperature at +19,5°C, then part of the heating power demand was covered with another heating system than air-to-air heat pump.

Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

OPERATION TEST

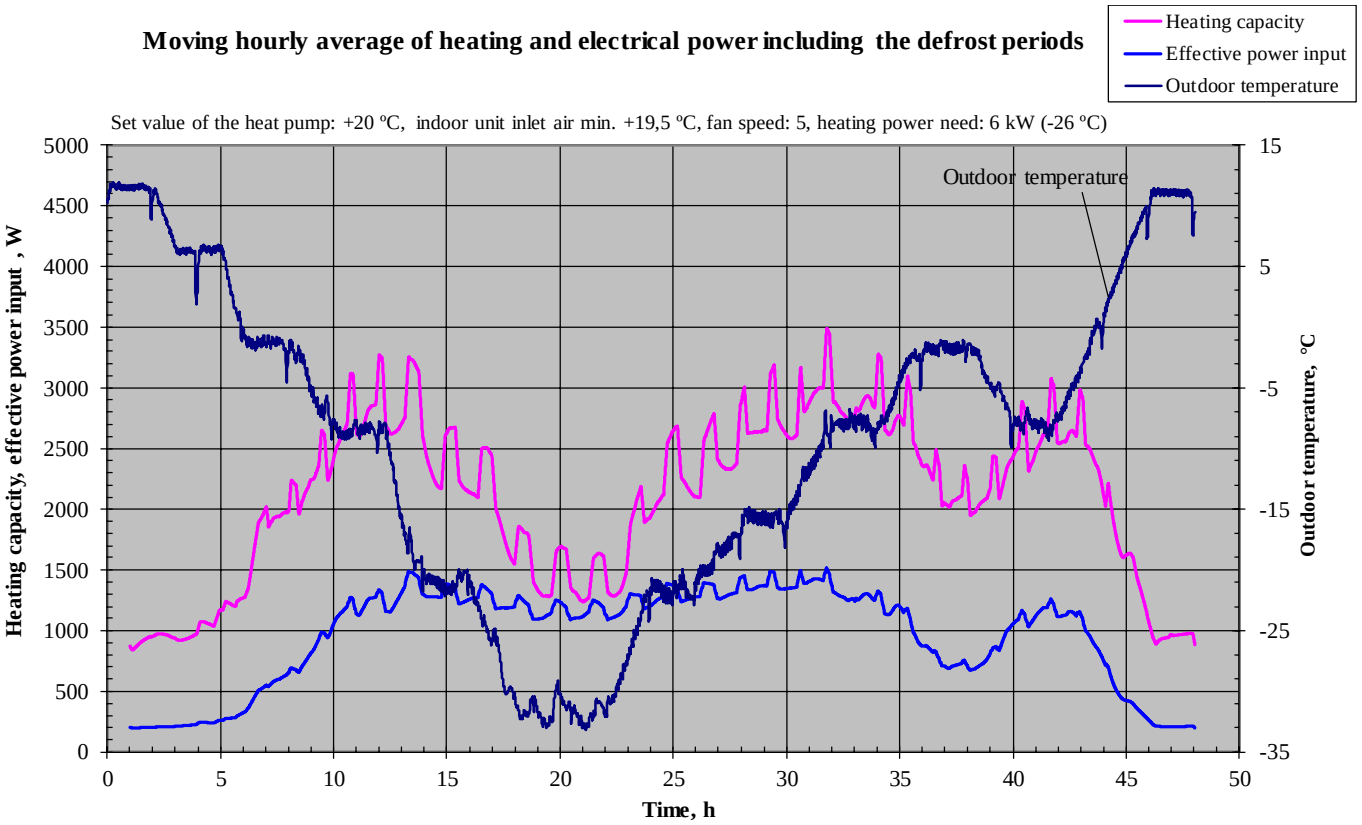
Moving hourly coefficient of performance, including defrost periods
(dash line is a degree 6 polynomial graph).

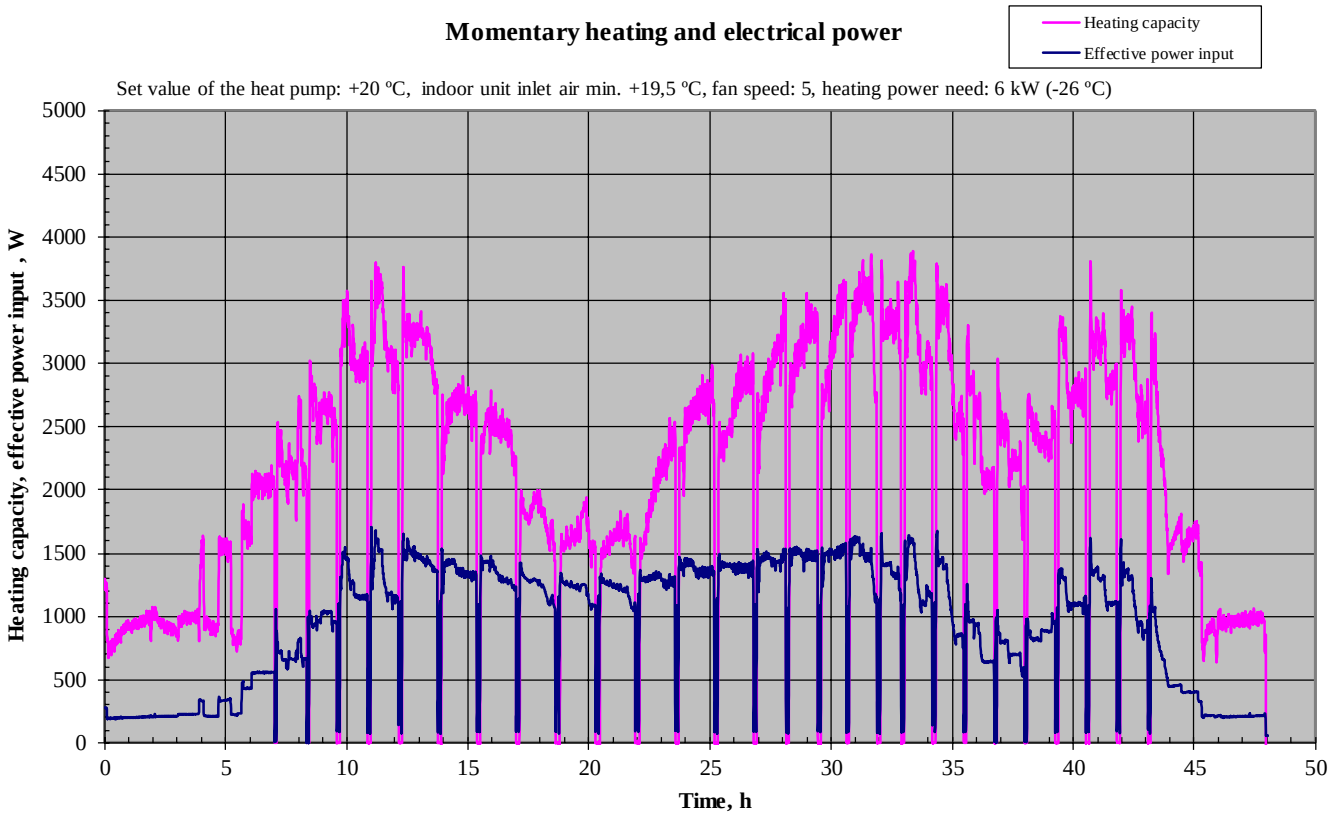


Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

OPERATION TEST

Heating capacity, effective power input and outdoor temperature during the operation test.

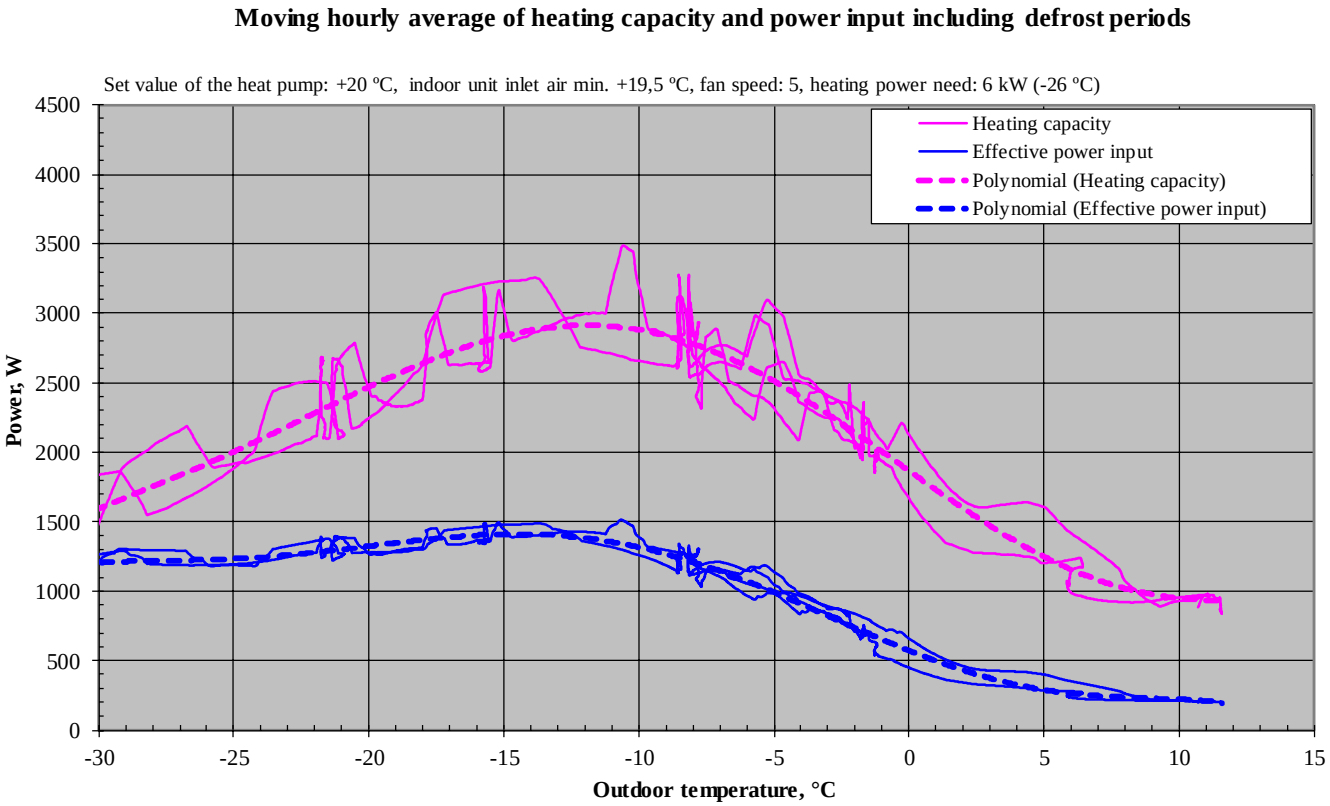




Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

OPERATION TEST

Moving hourly average of heating capacity and power input as a function of outdoor temperature.

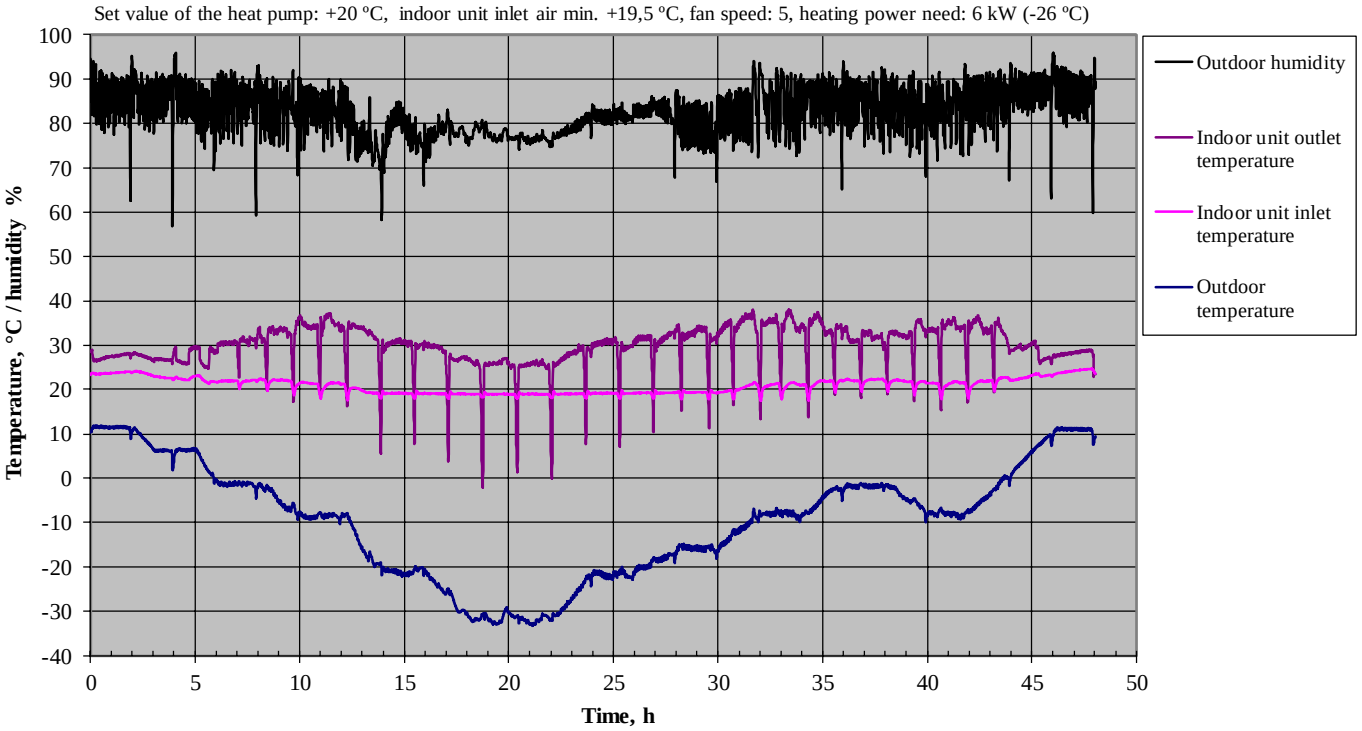


Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

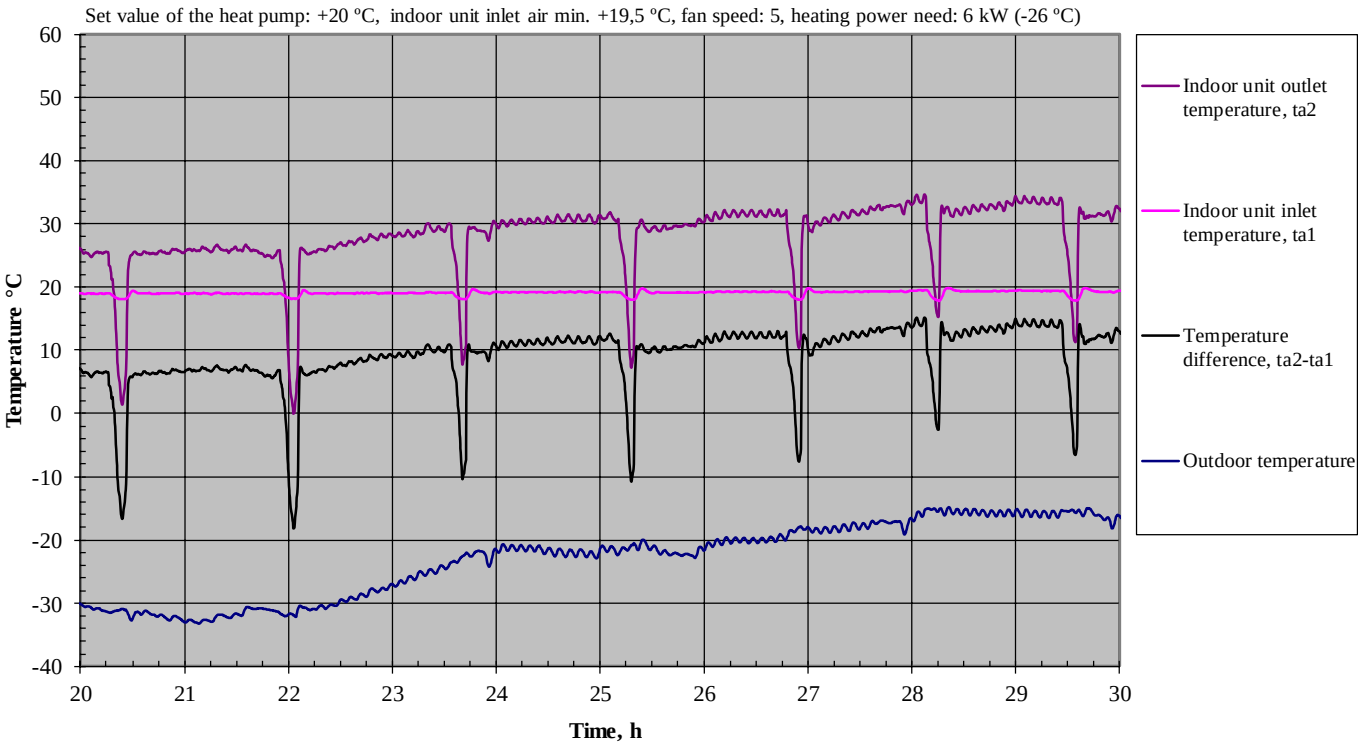
OPERATION TEST

Temperatures and outdoor humidity during the operation test.

Air temperature and humidity during the test



Temperatures and temperature difference of indoor unit



Air-to-air heat pump: Toshiba RAS-25PKVSG-ND + RAS-25PAVSG-ND

OPERATION TEST

Temperatures and airflow of the indoor unit during the operation test.