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The methods of performance test for water chilling (heat pump) packages using the vaper compression cycle

蒸气压缩循环冷水（热泵）机组性能试验方法

[Including Amendment 2015XG1]

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The methods of performance test for water chilling (heat pump) packages using the vaper compression cycle

1 Scope

This standard specifies the terms and definitions, test provisions, test methods, test deviations, gross electric power, evaluation of performance coefficients, etc. of the main performance parameters of chilling water (heat pump) packages driven by electric motors using vapor compression refrigeration cycles.

This standard applies to the performance test of chilling water (heat pump) packages (hereinafter referred to as "packages") driven by electric motors that use vapor compression refrigeration cycles. The cooling tower integrated package, brine package, glycol package, etc. can be implemented with reference to this standard.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

GB/T 2624.1 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 1: General principles and requirements

GB/T 2624.2 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates

GB/T 2624.3 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 3: Nozzles and Venturi nozzles

GB/T 2624.4 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 4: Venturi tubes

Under the specified heating capacity test conditions, the ratio of the package's heating capacity to the gross electric power of heating, expressed in W/W.

4 Test requirements

4.1 General rules

4.1.1 Eliminate the non-condensable gas in the refrigeration system of the package and confirm that there is no refrigerant leakage.

4.1.2 There shall be enough refrigerant in the refrigeration (heating) system of the package (according to the requirements of the instruction manual). If the refrigerant is a mixed working fluid, it shall ensure its composition and constitution; it shall maintain the amount of lubricating oil for normal operation in the compressor.

4.1.3 The test system shall be equipped with thermometer casing and pressure gauge outlet joints.

4.1.4 The test equipment and instruments used in the test shall not hinder the normal operation and operation of the package.

4.1.5 The water side of the package which uses side heat exchanger, heat exchanger on the heat source side and oil cooler shall be cleaned.

4.1.6 The water quality used by the package shall meet the requirements of GB 50050.

4.1.7 The test environment of air-cooled and evaporative cooling packages shall be sufficiently spacious. The air velocity at a distance of 0.5 m from the package shall not be greater than 2 m/s.

4.2 Test requirements

4.2.1 The performance test of the water-cooled package shall include the main test and the verification test, both of which shall be measured at the same time. When the air-cooled and evaporative cooling package are subjected to the main test, two sets of instruments shall be used for simultaneous measurement. During the performance test of the package, a set of measuring instrument interfaces shall be reserved at the corresponding measuring point for third-party testing.

The verification test is only applicable to water-cooled packages. The air-cooled and evaporative cooling packages are not subject to verification test.

- Liquid refrigerant flow meter method (see 5.3).

4.3.3 The air inlet temperature measurement of air-cooled and evaporative-cooled packages shall be carried out in accordance with Appendix B.

4.4 Test parameters

During the test, the test parameters are executed in accordance with the provisions of GB/T 18430.1 or GB/T 18430.2.

4.5 Instrumentation

4.5.1 Test instruments and meters shall be qualified by the statutory metrological inspection department and within the validity period.

4.5.2 The type and accuracy of test instruments and meters shall be in accordance with Appendix C.

4.6 Test data

4.6.1 Generally, the data to be recorded are:

- Test date, location and personnel;
- Package model and exit-factory number;
- Power supply voltage and frequency;
- The gross electric power of the package;
- Cold (hot) water inlet and outlet temperature at user side;
- Cold (hot) water volume flow at user side;
- Pressure drop at water inlet and outlet side at user side;
- Refrigerant, lubricating oil and its filling volume;
- Atmospheric pressure and ambient temperature;
- Instructions for heat exchanger insulation at user side.

4.6.2 For water-cooled packages, it shall also record:

- Water inlet and outlet temperature on the heat source side;
- Water volume flow on the heat source side;
- The pressure drop on the inlet and outlet side of the heat source.

$Q_{l,r}$ - The correction term of heat as released from the refrigerant side of the heat exchanger on the heat source side to the ambient air, in watts (W);

Q_{ll} - The total heat released (absorbed) by auxiliary equipment such as the oil separator and oil cooler from the compressor to the condenser segment to the ambient air, in watts (W);

P - The input power of the compressor motor, oil pump motor, electric heater, etc. of the water-cooled package, in watts (W);

$Q_{r,r}$ - The correction term of the heat as introduced from ambient air into the refrigerant side of the heat exchanger on the user side, in watts (W);

K_f - The heat transfer coefficient between the outer surface of the above auxiliary equipment and the ambient air, in watts per square meter Celsius [W/(m^2 • °C)];

A_f - The external surface area of the aforementioned auxiliary equipment, in square meters (m^2);

t_r - The average temperature of the outer surface of the above-mentioned auxiliary equipment, in degrees Celsius (°C);

t_a - The ambient air temperature, in degrees Celsius (°C);

$Q_{h,f}$ - The package's heating capacity measured in the verification test (of water-cooled heat pump package), in watts (W);

$Q_{l,h}$ - The correction item of heat as released by the refrigerant side of heat exchanger on the user side to the ambient air, in watts (W);

$Q_{r,h}$ - The correction term of as introduced from the ambient air into the refrigerant side of the heat exchanger on the heat source side, in watts (W);

K_e - The heat transfer coefficient between the outer surface of the heat exchanger and the ambient air, in watts per square meter [W/(m^2 • °C)][can take K = 20 W/(m^2 • °C)];

A_e - The external surface area of the water side of the heat exchanger on the user side, in square meters (m^2);

$t_{r,m}$ - The average temperature of the outer surface of the refrigerant side of the heat exchanger on the user side (i.e., the saturation temperature of the refrigerant), in degrees Celsius (°C);

K_h - The heat transfer coefficient between the outer surface of the heat exchanger on the heat source side and the ambient air, in watts per square meter Celsius [W/(m^2 • °C)];

Q_{n1} - The cooling capacity of the package tested and measured with a set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

Q_{n2} - The cooling capacity of the package tested and measured with another set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

Q_{h1} - The heating capacity of the package tested and measured with a set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

Q_{h2} - The heating capacity of the package tested and measured with another set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

N_n - The total electric power of cooling of the package measured in the main test (for water-cooled), in watts (W);

N_h - The total electric power of heating of the package measured in the main test (for water-cooled), in watts (W);

N_{n1} - The total electric power of cooling of the package tested and measured with a set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

N_{n2} - The total electric power of cooling of the package tested and measured with another set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

N_{h1} - The total electric power of heating of the package tested and measured with a set of test instruments (for air-cooled or evaporative-cooled), in watts (W);

N_{h2} - The total electric power of heating of the package tested and measured with another set of test instruments (for air-cooled or evaporative-cooled), in watts (W).

9 Example of performance uncertainty analysis

Refer to Appendix E for an example of uncertainty analysis of heating performance measurement of water-cooled packages.

[a] Applicable to the heating mode of the heat pump, except for the defrosting process and the first 10 minutes after the end of the defrosting.
[b] Applicable to the heat pump's defrosting process and the first 10 minutes after the defrosting.

A.4 Heating capacity test results

A.4.1 Calculation of steady-state heating capacity

A.4.1.1 Use the average heating value recorded in 35 minutes of the data collection stage as the average heating value.

A.4.1.2 Use the average input power recorded in 35 minutes or the integrated input power recorded in 35 minutes during the data acquisition stage as the average input power.

A.4.2 Calculation of non-steady-state heating capacity

A.4.2.1 For the data collection period, if one or more complete cycles are included, the average heating capacity of the package shall be determined by the integrated heating capacity and all the time included in the data collection period; the average input electric power shall be determined by the integrated input power and the time which is same as the measured heating capacity in the data collection stage.

Note: A complete cycle includes a heat pump heating process and a defrosting process from the end of the defrost to the end of the next defrost.

A.4.2.2 For a complete cycle that does not occur during the data collection period, the average heating capacity of the package shall be determined by the integrated heating capacity and the occurrence time during the data collection period; the average input electric power shall be determined by the integrated input power and the time which is same as the measured heating capacity in the data collection stage.

A.5 Example diagram of heating performance test process during defrosting

A.5.1 All examples include a case where a defrost cycle is used to end the pretreatment stage. The data collection cycle of the non-steady state test needs to last 3 hours or 3 complete cycles.

A.5.2 Example diagrams of heating performance test process during defrosting are as shown in Figure A.1 ~ Figure A.6.

Appendix B

(Normative)

Air inlet temperature measurement of air-cooled and evaporative-cooled chilling water (heat pump) packages

B.1 Overview

This Appendix specifies the measurement method of the air inlet temperature of air-cooled and evaporative-cooled chilling water (heat pump) packages; meanwhile specifies the air inlet temperature distribution requirements of the package during the test of this type of package.

B.2 Definition

B.2.1 Air sampler

The air sampler is an air sampling tube assembly that extracts air through the sampling tube, to provide a uniform air sample entering the air-cooled heat exchange coil.

B.2.2 Temperature and humidity measuring box

The temperature and humidity measuring box is a device connected with an air sampler, to install a probe for measuring air temperature and humidity.

B.3 General requirements

B.3.1 The temperature measuring instrument and its accuracy shall meet the requirements of Appendix C.

B.3.2 The test chamber and the test device shall be reasonably designed and operated, to ensure sufficient air distribution and sufficient air mixing.

B.3.3 The test environment shall avoid the recirculation of the exhaust air of the air-cooled heat exchanger coil of the package. The following methods can be used to check whether the exhaust air of the heat exchanger is recycled back to the heat exchanger coil: install multiple single reading thermocouple evenly around the exhaust outlet of the package (at least one for each sampling position), the installed thermocouple is located below the air-cooled heat exchange coil fan's exhaust plane and just over the top of the air-cooled heat exchanger coil. The difference between the temperature of these thermocouples and the temperature measured at the temperature and humidity measuring box shall not exceed 2.8 °C.

Celsius (°C);

$t_{w2,c}$ - The temperature of the water outlet on the heat source side, in degrees Celsius (°C);

P_0 - The input power of the compressor motor, oil pump motor, electric heater, etc. of the water-cooled package, in watts (W);

$U(Q_{nc})$ - The expanded uncertainty of the package's cooling capacity measured in the verification test;

k - Inclusion factor;

u_7 - Category A standard uncertainty component as caused by repeated measurement of verification test;

u_8 - Category B standard uncertainty component of the flow test system in the verification test;

u_9 - The category B standard uncertainty component of the inlet water temperature test system in the verification test;

u_{10} - The category B standard uncertainty component of the outlet water temperature test system in the verification test;

u_{11} - Standard uncertainty of input power.

E.2 Evaluation of standard uncertainty components

E.2.1 Category A evaluation of standard uncertainty components

Carry out no less than 7 independent repeated measurements on the tested water chilling package; the measurement data (example values) are as shown in Table E.1.

E.2.2.1 Overview

Based on the average value of each measurement, calculate the sensitivity coefficients, then obtain the measurement uncertainty components.

E.2.2.2 Uncertainty components of main test measurement parameters

The sensitivity coefficient c_2 is 20869 kJ/m^3; the uncertainty given by the verification/calibration certificate is 0.1%FS (example value); then it obtains $u_2 = 3 \times 10^{-5}$ m^3/s, then the uncertainty component of the flow of the main test is c_2u_2 = 0.626 kW. The sensitivity coefficient c_3 is 60.86 kW/K; the uncertainty given by the verification/calibration certificate is u_3 = 0.03 K (example value); then the uncertainty component of the inlet water temperature of the main test is c_3u_3 = 1.757 kW. The sensitivity coefficient c_4 is -60.86 kW/K; the uncertainty given by the verification/calibration certificate is u_4 = 0.03 K (example value); then the uncertainty component of the outlet water temperature of the main test is c_4u_4 = -1.757 kW.

E.2.2.3 Category B standard uncertainty of input power

The maximum allowable error of the power meter is ±0.5% (example value). Considering the uniform distribution, the category B standard uncertainty of the input power is:

$$u_6 = \frac{60.428 \times 0.5\%}{\sqrt{3}} = 0.174 \text{ kW} \qquad \cdots\cdots\cdots\cdots\cdots\cdots (\text{E.14})$$

E.2.2.4 Uncertainty components of measurement parameters in the verification test

The sensitivity coefficient c_8 is 20635 kJ/m^3; the uncertainty given by the verification/calibration certificate is 0.1%FS (example value), so it obtains the standard uncertainty $u_8 = 3 \times 10^{-5}$ m^3/s; then the uncertainty component of flow rate of the calibration test is c_8u_8 = 0.619 kW. The sensitivity coefficient c_9 is -72.67 kW/K; the uncertainty given by the verification/calibration certificate is u_9 = 0.03 K (example value); then the uncertainty component of the inlet water temperature in the verification test is c_9u_9 = -2.181 kW. The sensitivity coefficient c_{10} is 72.67 kW/K; the uncertainty given by the verification/calibration certificate is u_{10} = 0.03 K (example value), then the uncertainty component of the outlet water temperature in the verification test is $c_{10}u_{10}$ = 2.181 kW.

E.3 Evaluation of composite standard uncertainty

Table E.2 gives the standard uncertainty data.

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