

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 8609 : 2008

(JCI/JSA)

**Performance tests of mechanical draft
cooling tower**

ICS 27.200

Reference number : JIS B 8609 : 2008 (E)

PROTECTED BY COPYRIGHT

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japan Cooling Tower Institute (JCI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 8609:1981** is replaced with this Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

Date of Establishment: 1981-11-01

Date of Revision: 2008-03-20

Date of Public Notice in Official Gazette: 2008-03-21

Investigated by: Japanese Industrial Standards Committee

Standards Board

Technical Committee on Industrial Machinery

JIS B 8609 : 2008, First English edition published in 2008-09

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 2008

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

MT

PROTECTED BY COPYRIGHT

Contents

	Page
1 Scope	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Classification of test methods.....	2
5 Tests	2
5.1 General	2
5.2 Test methods.....	3
Annex 1 (normative) Test method for cooling capacity.....	5
Annex 2 (normative) Test methods for noise	24
Annex 3 (normative) Test methods for water-drop loss.....	30
Annex 4 (informative) The example of cooling capacity test	32

Performance tests of mechanical draft cooling tower

1 Scope This Japanese Industrial Standard specifies the performance tests at the atmospheric pressure for mechanical draft cooling tower of 233 kW or less in design standard cooling capacity which is the equipment for cooling the cooling water warmed by packaged conditioner, refrigerating apparatus or the like by means of direct contacting operation with the atmosphere, and for using the cooling water by circulation.

However, for the noise test, this Standard may apply to the tower of 4 535 kW or less in design standard cooling capacity used for a compression refrigerating machine, and apply to the tower of 4 892 kW or less in design standard cooling capacity used for a double effect absorption refrigerating machine.

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 8346 *Fans, blowers and compressors—Determination of A-weighted sound pressure level*

JIS C 1509-1 *Electroacoustics—Sound level meters—Part 1: Specifications*

JIS Z 8731 *Acoustics—Description and measurement of environmental noise*

3 Terms and definitions For the purpose of this Standard, in addition to the definitions stated in JIS C1509-1, JIS B 8346 and JIS Z 8731, the following terms and definitions apply:

- a) **standard design temperature** the standard temperature when testing the tower used for a compression refrigerating machine, that is inlet water temperature 37 °C, outlet water temperature 32 °C and inlet air wet bulb temperature 27 °C

When the tower is used for a double effect absorption refrigerating machine, the standard design temperature shall be inlet water temperature 37.5 °C, outlet water temperature 32 °C and inlet air wet bulb temperature 27 °C.

- b) **standard design water quantity** the standard water quantity when testing the tower used for a compression refrigerating machine, that is 13 L/min per cooling quantity-of-heat 4.535 kW at the standard design temperature

When the tower is used for a double effect absorption refrigerating machine, the standard design water quantity shall be 17 L/min per cooling quantity-of-heat 6.523 kW at the standard design temperature.

- c) **design standard cooling capacity** the cooling capacity obtained at the standard design temperature and at standard design water quantity

- d) **standard cooling capacity** the cooling capacity obtained by Test method 1 or Test Method 2 of the cooling capacity test
- e) **performance curve** the curve expressing the thermal characteristics of the specimen machine or the cooling tower designed same as the specimen machine
- f) **water temperature range** the difference between the inlet- and the outlet-water temperatures
- g) **water mass velocity** the value of water quantity divided by the front area at right angles to the water flow
- h) **air mass velocity** the value of air quantity divided by the front area at right angles to the water flow
- i) **number of transfer units** $\frac{U}{N}$ the value $\frac{U}{N}$ of counterflow type cooling tower obtained by using the state lines I and II obtained by Annex 1 figure 5 and by using Annex 1 figure 7 and an approximate calculation method of formula (5)

In the case of the crossflow type cooling tower, the value is obtained by the method of formula (6).
- j) **specimen machine** the cooling tower to be used for performance test
- k) **counterflow type cooling tower** the cooling tower of the type in which water flows in opposition to air
- l) **crossflow type cooling tower** the cooling tower of the type in which water flows in cross at right angles to air
- m) **stationary conditions** the conditions when the measured values of the specimen machine have reached the equilibrium in time
- n) **water-drop loss** the sum of the quantity of discharged water drops accompanied by discharge air and the quantity of water spattering from louver to outside

4 Classification of test methods The test methods specified in this Standard shall be classified as follows:

- a) Cooling capacity test
- b) Noise test
- c) Water-drop loss test
- d) Consuming power and operating current test
- e) Insulation resistance test
- f) Withstand voltage test
- g) Starting current test

5 Tests

5.1 General The tests shall be carried out by use of the instrument specified in a) and under the conditions specified in b), unless otherwise specified.

- a) **Types and accuracy of instruments** The types and accuracy of the instruments to be used for test shall be in accordance with table 1.

Table 1 Types and accuracy of instruments

Division	Type	Accuracy
Thermometer	Liquid-in-glass bar thermometer	Air dry bulb temperature and air wet bulb temperature $\pm 0.1\text{ }^{\circ}\text{C}$
	Thermocouple	
	Resistance thermometer	Water temperature $\pm 0.1\text{ }^{\circ}\text{C}$
Flowmeter	Recording type	
	Indicating type	$\pm 2\%$
	Integrating type	
Anemometer	Biram's wind meter	$\pm 10\%$
Electrical instrument	Indicating type	$\pm 0.5\%$
	Integrating type	$\pm 1\%$

- b) **Test conditions** The test conditions, other than those specified in 5.2, shall be in accordance with the following:

- 1) Water quantity, inlet water temperature, inlet air wet bulb temperature and inlet air relative humidity shall be in accordance with the conditions given in table 2.
- 2) Permissible variations of voltage and frequency shall be $\pm 2\%$ of respective rated values.

Table 2 Water quantity, temperature and relative humidity conditions

Kind of test method		Water quantity	Inlet water temperature	Inlet air wet bulb temperature	Inlet air relative humidity
Cooling capacity test	Test method 1	Design water quantity	Standard design temperature $\pm 2\text{ }^{\circ}\text{C}$	10°C to 30 °C	—
	Test method 2	Design water quantity $+10\%$ -20%	Standard design temperature $\pm 2\text{ }^{\circ}\text{C}$	10°C to 30 °C	—
Noise test		Design water quantity $+10\%$ 0 %	—	—	—
Water-drop loss test		Design water quantity $+10\%$ 0 %	—	—	70 % min.

5.2 Test methods

5.2.1 Cooling capacity test For the cooling capacity test, place the specimen machine on the testing place shown in clause 3 of Annex 1, operate the machine at the rated voltage and rated frequency, and under the conditions for cooling capacity test in table 2, without makeup water and drainage, and after reaching the stationary conditions, carry out the test based on Annex 1.

Further, the water shall be clean water containing no impurities that may affect the cooling capacity.

5.2.2 Noise test For the noise test, the specimen machine shall be tested in accordance with Annex 2 and the noise reference value of that measurement result shall be indicated.

5.2.3 Water-drop loss test For the water-drop loss test, place the specimen machine on the testing place shown in clause 2 of Annex 3, operate the machine at the rated voltage and rated frequency, and under the conditions for water-drop loss test in table 2 without makeup water and drainage, and after reaching the stationary conditions, carry out the test based on Annex 3.

5.2.4 Consuming power and operating current test For consuming power and operating current test, measure the consuming power and operating current of the specimen machine when the cooling capacity test specified in 5.2.1 is carried out. Further, calculate the operating power factor from those measured values.

5.2.5 Insulation resistance test For the insulation resistance test, measure the insulation resistance between the live part and the non-live metallic part which might earth by use of 500 V insulation resistance tester, immediately before and after the cooling capacity test in 5.2.1.

5.2.6 Withstand voltage test Carry out the withstand voltage test, following the insulation resistance test of 5.2.5. For the test, apply between the live part and the non-live metallic part for 1 min continuously the nearly sinusoidal voltage of 50 Hz or 60 Hz in frequency and at 1000 V for the specimen machine with the rated voltage of 100 V, and at 1 500 V for specimen machine with the rated voltage of 200 V.

If many products of the same design are to be tested and they cause no doubt, then the voltage of the 120 % test voltage, instead of the above-mentioned, may be applied for 1 s.

5.2.7 Starting current test For starting current test, measure the current when the rated voltage at the rated frequency is applied under the conditions where the rotor of motor is constrained. However, in the case where the rotor of motor is not able to be constrained, apply the voltage at the rated frequency under the conditions where the rotor of motor is stopped, pass the current near the operating current measured by the consuming power and operating current test of 5.2.4, then measure the voltage, and calculate the starting current from the following formula:

$$I_s = I_s' \frac{E}{E_s'}$$

where, I_s : starting current (A)

I_s' : current near the operating current measured by the consuming power and operating current test of 5.2.4 (A)

E : rated voltage (V)

E_s' : voltage when current I_s' is passed (V)

NOTE : In the case where two or more motors start at the same time by the ordinary operation, the starting current shall be the starting current when the currents are passed simultaneously, or the sum of starting currents of respective motors.

Annex 1 (normative)

Test method for cooling capacity

1 Scope This Annex specifies the test method for cooling capacity of counterflow type and crossflow type mechanical draft cooling towers.

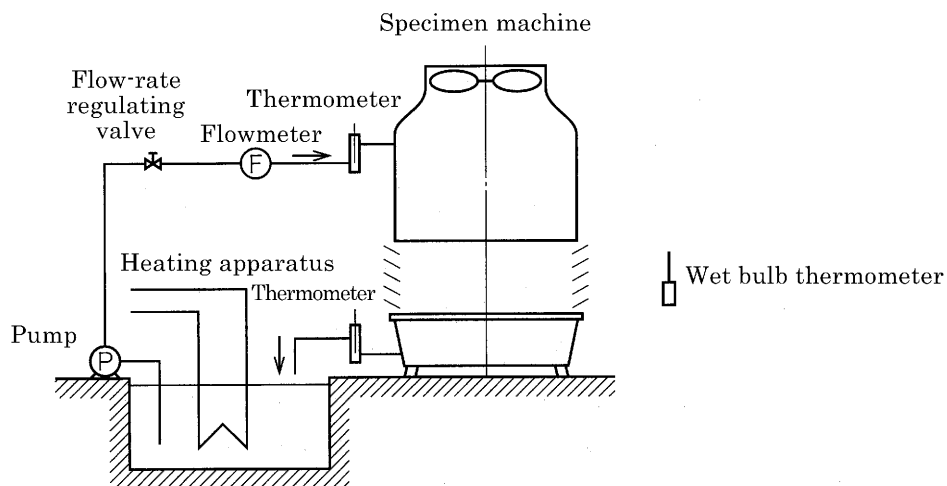
2 Classification of test methods The test method shall be either of the following methods:

- a) **Test method 1** The method to obtain the water temperature range and standard cooling capacity when the inlet water temperature and the inlet air wet bulb temperature is at the standard design temperature by use of the results of the test carried out under the conditions of Test method 1 of table 2 in the text
- b) **Test method 2** The method to obtain the water quantity and the standard cooling capacity at the time of standard design temperature by use of the results of the test carried out under the conditions of Test method 2 of table 2 in the text

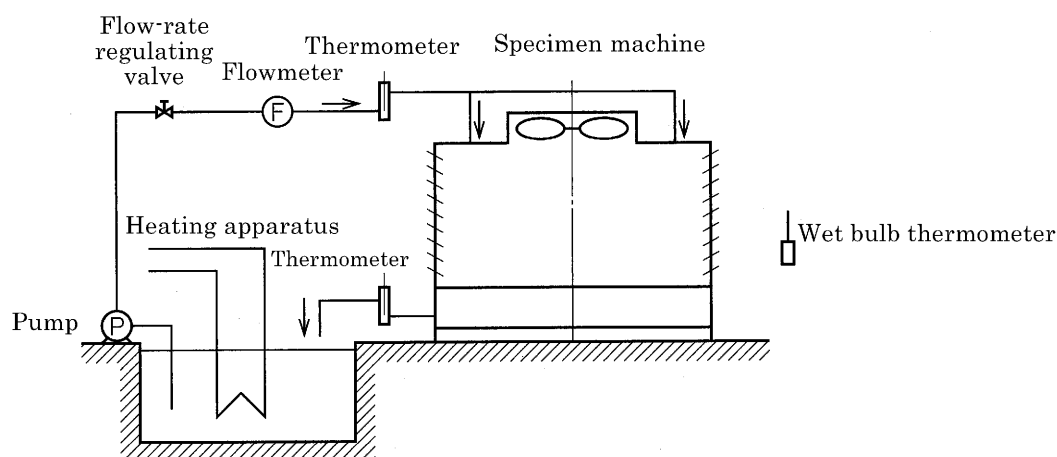
3 Testing place The testing place shall be as flat as possible and have little affect of wind⁽¹⁾, and the place where the discharged air from the specimen machine does not recirculate.

Note ⁽¹⁾ The wind velocity shall be not more than 5 m/s.

4 Testing apparatus An example of testing apparatus is shown in figure 1 a) and b) in Annex 1.



a) Counterflow type cooling tower



b) Crossflow type cooling tower

Annex 1 Figure 1 Cooling capacity testing apparatus

5 Test method

5.1 Test method 1 The test method, calculating method of standard cooling capacity and evaluation shall be as follows:

- a) **Test method** In 30 min after the lapse of time of not less than 30 min under the stationary conditions permitted by Annex 1 table 1, from the time when the specimen machine has reached the test conditions of Test method 1 specified in table 2 of the text, carry out four times the measurement of water quantity, inlet water temperature, outlet water temperature and inlet air wet bulb temperature.

Annex 1 Table 1 Permissible variations under stationary conditions

Water quantity	± 2 %
Inlet water temperature	± 0.4 °C
Inlet air wet bulb temperature	± 1 °C

- b) **Calculating method of standard cooling capacity** Obtain the arithmetic mean value of measured values, and using the measured water temperature range and measured inlet air wet bulb temperature, calculate the water temperature range at the standard design inlet water temperature from the following formula:

$$\Delta t_{IB} = \Delta t_{IA} \left\{ 1 + \frac{t_{IA} - t_{IA}' + 45 - \Delta t_{IA}}{45(t_{IA} - t_{IA}') - \frac{\Delta t_{IA}^2}{3}} (t_{IB} - t_{IA}) \right\} \dots\dots\dots (1)$$

where, Δt_{IB} : water temperature range at the standard design inlet water temperature (°C)

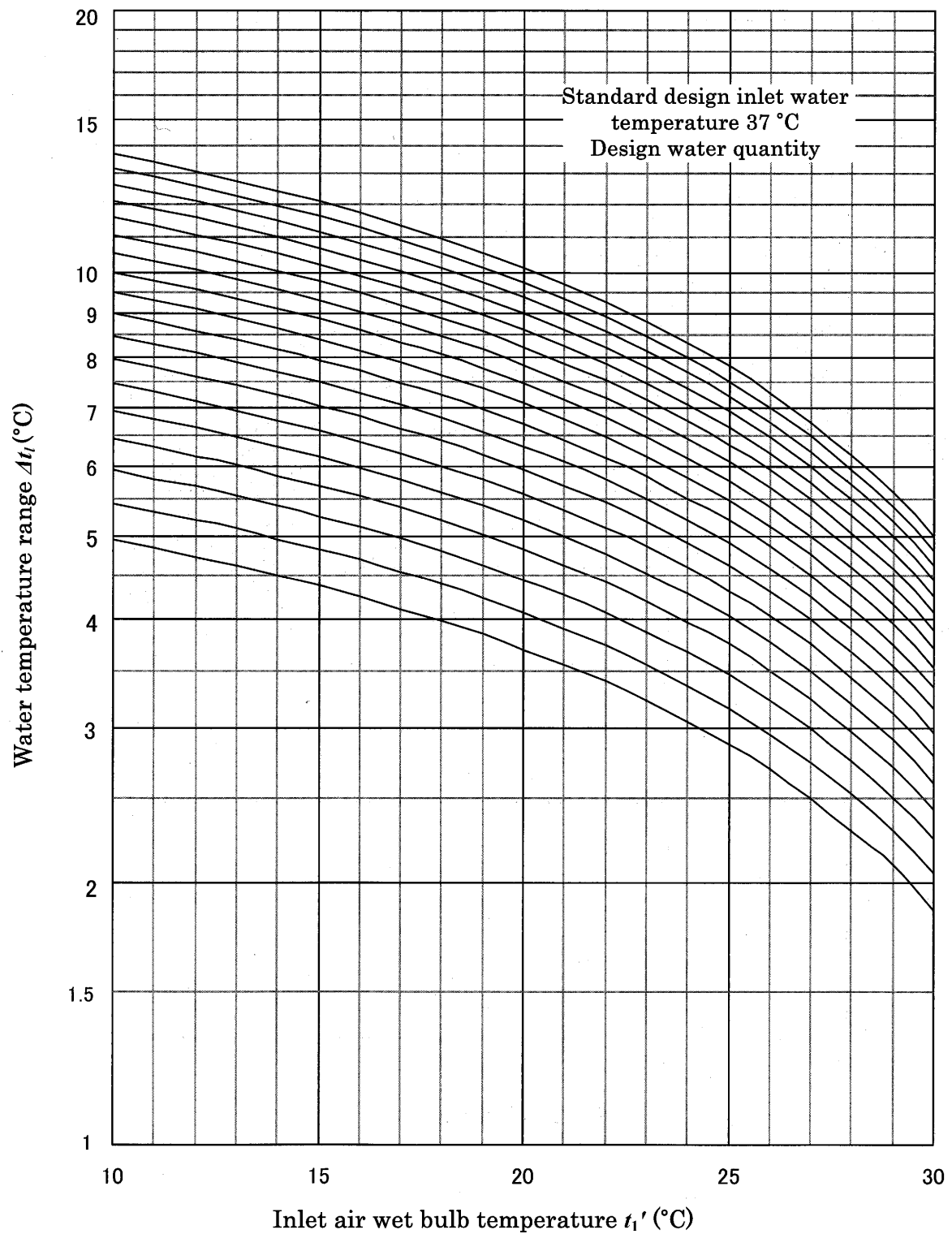
Δt_{IA} : measured water temperature range (°C)

t_{IA}' : measured inlet air wet bulb temperature (°C)

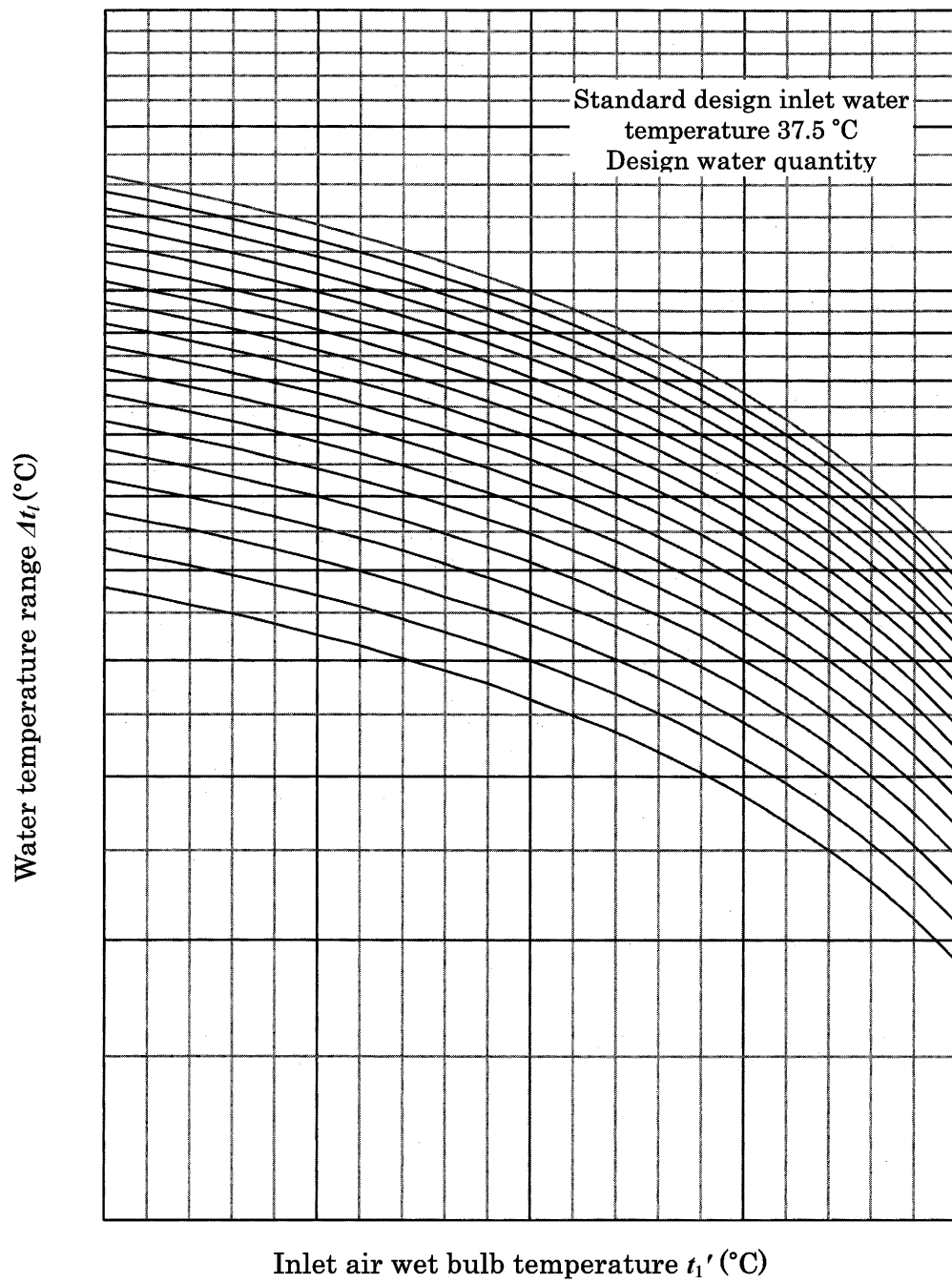
t_{IA} : measured inlet water temperature (°C)

t_{IB} : standard design inlet water temperature (°C)

Using the values of above-mentioned t_{IA}' and Δt_{IB} , obtain the water temperature range Δt_{IC} at the standard design inlet air wet bulb temperature (27 °C) by using the relevant value in Annex 1, figure 2 a) or b). Δt_{IC} is given by the intersecting point C of the dotted line drawn parallel to the group of curves from the intersecting point B of t_{IA}' and Δt_{IB} , and t_{IC}' (standard design inlet air wet bulb temperature 27 °C), as shown in Annex 1, figure 3.

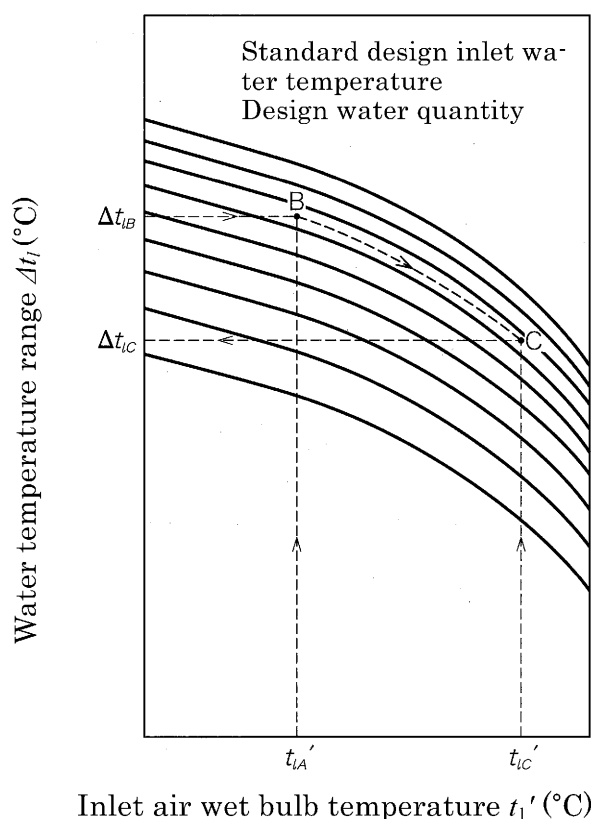


Annex 1 Figure 2 $t_1' - \Delta t_i$ diagram of cooling tower
a) In the case of standard design temperature of 37 °C



Annex 1 Figure 2 (concluded)

b) In the case of standard design temperature of 37.5 °C



Annex 1 Figure 3 Method of obtaining water temperature range

Calculate the standard cooling capacity from the following formula:

$$Q = \frac{1}{3600} C_l L \Delta t_{lc} \dots \dots \dots (2)$$

where, Q : standard cooling capacity (kW)

C_l : specific heat of water (4.186 kJ/kg °C)

L : design water quantity (kg/h)

Δt_{lc} : water temperature range obtained by Annex 1 figure 3 (°C)

- c) **Evaluation** Evaluate the cooling capacity of the specimen machine according to the following formula:

$$\frac{\text{Standard cooling capacity}}{\text{Design standard cooling capacity}} \times 100 = \frac{\Delta t_{lc}}{\Delta t_{la}} \times 100 \text{ (}\%) \dots \dots \dots (3)$$

where, Δt_{la} : standard design water temperature range (°C)

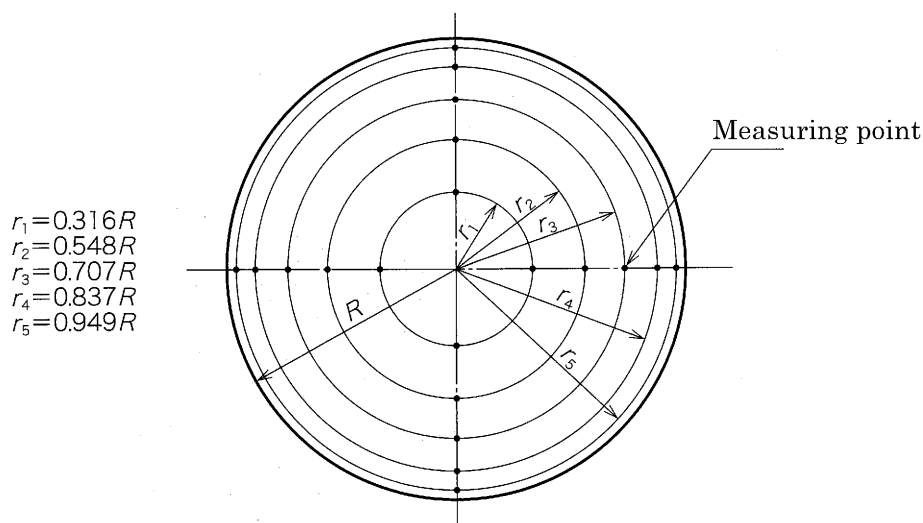
5 °C, in the case of a cooling tower for a compression refrigerating machine

5.5 °C, in the case of a cooling tower for a double effect absorption refrigerating machine

5.2 Test method 2 The test method, calculating methods of air quantity, of $\frac{U}{N}$ and of standard cooling capacity, and the evaluation shall be as follows:

- a) **Test method** In 30 min after the lapse of time of not less than 30 min under the stationary conditions permitted by Annex 1 table 1, from the time when the specimen machine has reached the test conditions of Test method 2 specified in table 2 of the text, carry out four times the measurement of water quantity, inlet water temperature, outlet water temperature and inlet air wet bulb temperature, and once the measurement of air quantity. In this case, where there are no performance curves of the specimen machine, carry out measurement on the not less than two points in the range of water quantity of Test method 2 specified in table 2 of the text.

Further, the measurement of air quantity shall be carried out on the air discharge side of the specimen machine, and an example of the measuring point is shown in Annex 1, figure 4.



Annex 1 Figure 4 Air quantity measuring points

- b) **Air quantity calculating method** The air quantity shall be calculated from the following formula:

$$G_b = \frac{3.31 \times 10^6 S_2 V_b - C_l L_b \Delta t_{lb}}{728 + h_{lb}} \dots \dots \dots (4)$$

where, G_b : air quantity [kg (DA)/h] (2)

h_{lb} : enthalpy of inlet air⁽³⁾ [kJ/kg (DA)]

S_2 : front area of air quantity measuring part (m²)

V_b : arithmetic mean value of measured wind velocity (m/s)

C_l : specific heat of water (4.186 kJ/kg °C)

L_b : measured water quantity (kg/h)

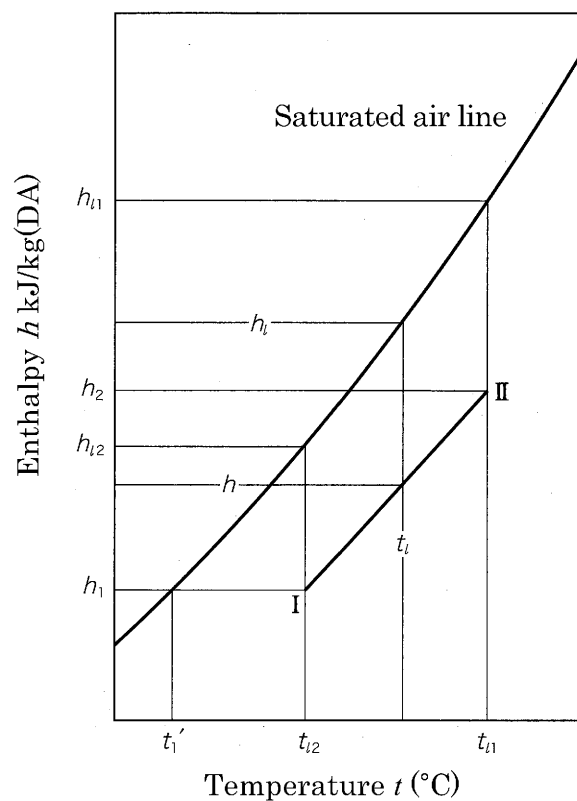
Δt_{lb} : measured water temperature range (°C)

Notes ⁽²⁾ The symbol of kg (DA) indicates the unit of mass of dry air in the wet air.

⁽³⁾ The value of inlet air enthalpy h_{1b} obtained by using the value of measured inlet air wet bulb temperature t_{1b}' instead of t_1' in Annex 1, figure 5.

c) $\frac{U}{N}$ Calculating method

- 1) **In the case of counterflow type cooling tower** The state line I, II on the t - h diagram which indicates the change of state of water and air in the counterflow type cooling tower shall be obtained by connecting by straight lines the intersecting point I of t_{l2} and h_1 with intersecting point II of t_{l1} and h_2 by using Annex 1, figure 6, as shown in Annex 1, figure 5.



where, t_1' : inlet air wet bulb temperature (°C)

t_l : water temperature (°C)

t_{l1} : inlet water temperature (°C)

t_{l2} : outlet water temperature (°C)

h : air enthalpy [kJ/kg (DA)]

h_1 : inlet air enthalpy [kJ/kg (DA)]

h_2 : outlet air enthalpy ⁽⁴⁾ [kJ/kg (DA)]

h_l : enthalpy of saturated air at the same temperature as the water temperature [kJ/kg (DA)]

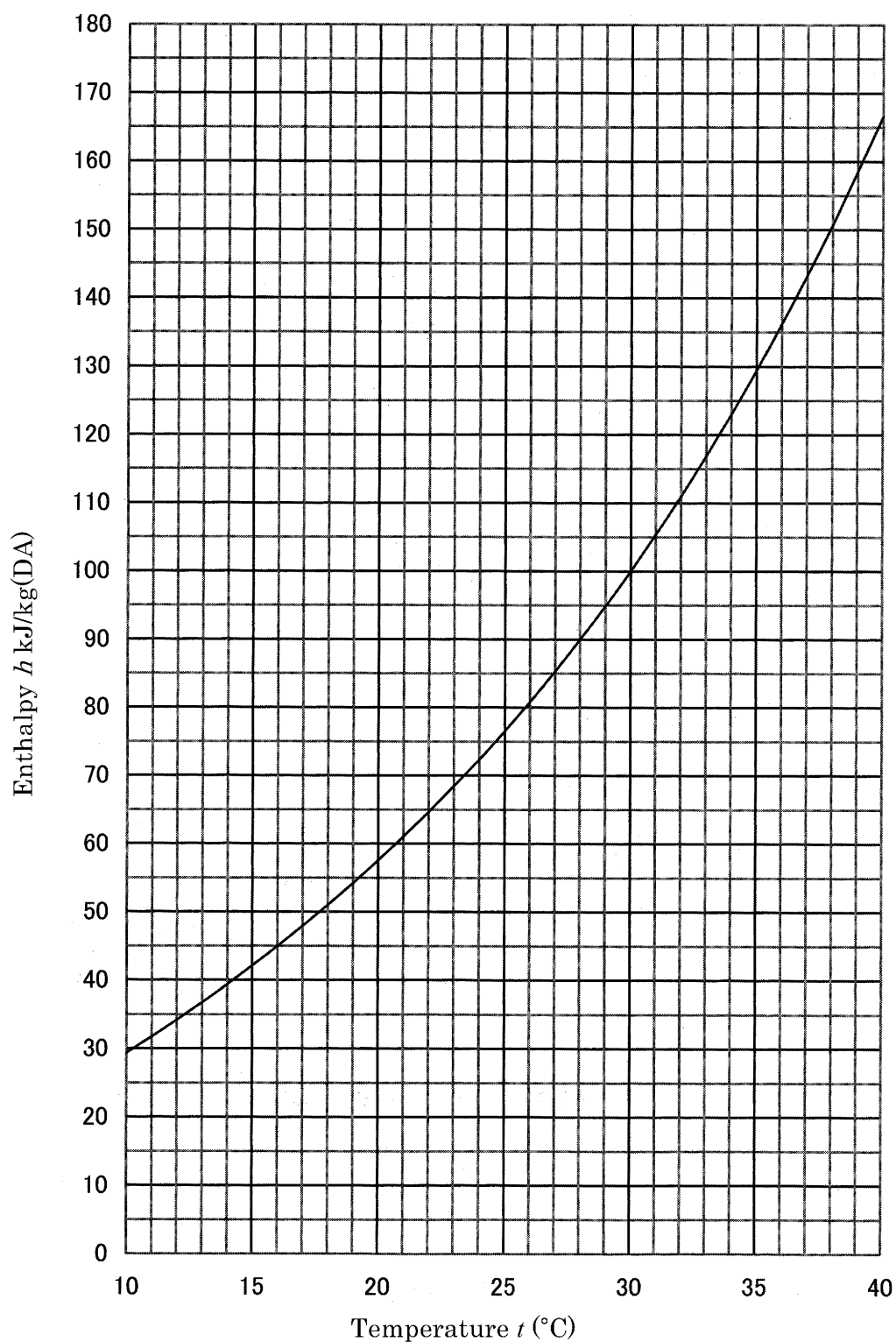
h_{l1} : enthalpy of saturated air at the same temperature as the inlet water temperature [kJ/kg (DA)]

h_{l2} : enthalpy of saturated air at the same temperature as the outlet water temperature [kJ/kg (DA)]

Note ⁽⁴⁾ h_2 shall be obtained from the following formula:

$$h_2 = h_1 + C_l \frac{L}{G} (t_{l1} - t_{l2})$$

Annex 1 Figure 5 Change on t - h diagram



Annex 1 Figure 6 t - h diagram of wet air