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JIS

JAPANESE INDUSTRIAL STANDARD

Humidity—Measurement methods

JIS Z 8806-1995

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JAPANESE INDUSTRIAL STANDARD — J I S

Humidity—Measurement methods — Z 8806-1995

1. Scope This Japanese Industrial Standard specifies main methods adopted when the humidity in air is measured.

Remarks: The standards cited in this Standard are as follows:

JIS B 7306 Hygrographs

JIS B 7920 Hygrometers – Test method

JIS K 0211 Technical terms for analytical chemistry (general part)

JIS Z 8103 Glossary of terms used in instrumentation

JIS Z 8704 Temperature measurement – Electrical methods

JIS Z 8705 Method of temperature measurement by liquid-in-glass thermometer

2. Definitions For the purpose of this Standard, in addition to the definitions in JIS Z 8103 and JIS B 7920, the definitions given below apply. The terms relating to the expression and unit of humidity, however, shall follow 3.

(1) air Gas composing lower layer of atmosphere covering the earth. It is mixture gas of water vapor, oxygen, nitrogen, and others.

(2) dry air The gas composed of gaseous elements which have remained after removing water vapor out of air, and considered as an ideal gas of single component.

(3) wet air Mixed gas of water vapor and dry air.

(4) saturated vapor pressure The pressure of water vapor which appears when both water or ice and water vapor coexist in equilibrium state.

(5) humidity-sensitive part Sensor or sensing part which has the function to detect humidity.

(6) humidity-sensitive element The part of a sensor, that is the detective end whose function to detect the humidity has an intrinsic meaning to the whole function.

3. Expression, units, and relation formulas of humidity Out of the quantities expressing humidity, important ones are mentioned with symbols and units.

(1) Mixing ratio r (kg/kg) The ratio of the mass of water vapor in wet air to the mass of dry air. The unit of g/kg or mg/kg is also used.

$$r = \frac{m_v}{m_a} = \varepsilon \cdot \frac{e}{p-e} \quad \cdots\cdots (1)$$

(2) Mole fraction x_v (mol/mol) The ratio of the amount of substance of water vapor in wet air to the whole amount of substance.

$$x_v = \frac{n_v}{n_v + n_a} = \frac{\frac{m_v}{M_v}}{\frac{m_v}{M_v} + \frac{m_a}{M_a}} \quad \cdots\cdots (2)$$

(3) Specific humidity q (kg/kg) The ratio (mass fraction) of the mass of water vapor in wet air to the whole mass. The unit of g/kg is also used.

$$q = \frac{m_v}{m_v + m_a} \quad \cdots\cdots (3)$$

(4) Water vapor pressure e (Pa) The partial pressure of water vapor in wet air.

$$e = px_v = \frac{m_v}{V} \cdot \frac{RT}{M_v} \quad \cdots\cdots (4)$$

(5) Absolute humidity d_v (kg/m³) Mass of water vapor in a unit volume of wet air. The unit of g/m³ is also used.

$$d_v = \frac{m_v}{V} \quad \cdots\cdots (5)$$

(6) Relative humidity U (%) The percentage ratio of the mole fraction x_v of water in wet air (at a temperature and pressure), to the mole fraction x_{vs} of water in saturated wet air at the said temperature and pressure. In case where wet air is treated as ideal gas, the percentage ratio of the vapor pressure e in wet air (at a temperature) to the saturated vapor pressure e_s at the said temperature. Unit symbol of % is also expressed as %RH in order to clarify it to be relative humidity.

$$U = \frac{x_v}{x_{vs}} \times 100 \doteqdot \frac{e}{e_s} \times 100 \quad \cdots\cdots (6)$$

(7) Percentage humidity ψ (%) The percentage ratio of the mixing ratio r of wet air (at a temperature and pressure) to the mixing ratio r_s of saturated wet air at the said temperature and pressure.

$$\psi = \frac{r}{r_s} \times 100 \quad \cdots\cdots (7)$$

(8) Dew-point temperature t_d (°C) The temperature at which the vapor pressure in wet air is equal to the saturated vapor pressure of water.

$$e_{sw}(t_d) = e \quad \cdots\cdots (8)$$

(9) Frost-point temperature t_f (°C) The temperature at which the vapor pressure in wet air is equal to the saturated vapor pressure of ice.

$$e_{si}(t_f) = e \quad \cdots\cdots (9)$$

Remarks 1. The symbols in the formulas mean the following.

V : volume of wet air

T : temperature of wet air

p : pressure of wet air

m_v : mass of water vapor in wet air

m_a : mass of dry air in wet air

n_v : amount of substance of water vapor in wet air $n_v = \frac{m_v}{M_v}$

n_a : amount of substance of dry air in wet air $n_a = \frac{m_a}{M_a}$

e_s : saturated vapor pressure (refer to Attached Tables 1.1 to 1.3)

e_{sw} : saturated vapor pressure of water

e_{si} : saturated vapor pressure of ice

x_{vs} : mole fraction of water in saturated wet air

r_s : mixing ratio of saturated wet air

R : gas constant $R = (8.314510 \pm 0.000070)\,\mathrm{J \cdot K^{-1} \cdot mol^{-1}}$

M_v : molar mass of water $M_v = 18.01528 \times 10^{-3}$ kg/mol

M_a : average molar-mass of air $M_a = 28.9645 \times 10^{-3}$ kg/mol

ε : ratio of molar masses $\varepsilon = \frac{M_v}{M_a} = 0.62198$

2. Broadly speaking, both dew-point temperature and frost-point temperature are generically called dew-point temperature.

4. Classification of measuring methods of humidity The measuring methods of humidity are classified as follows:

(1) Method by separation determination Take sample air, let contained water vapor to react and be absorbed by passing it through the tube packed with absorbent, and weigh directly the mass increment. Otherwise, measure the reacted amount by means of the quantity of electricity needed for electrolysis. Or, obtain it from the titrated quantity of Karl Fischer's reagent. These methods are applied as follows:

(a) Weighing-type hygrometer

(b) Coulometric method (absorption electrolysis method by phosphorus pentaoxide)

(c) Karl Fischer method

(2) Method by measuring thermodynamic equilibrium temperature The evaporation and condensation of water depend upon temperature and humidity of sample air. The thermometer wrapped with moistened cloth shows thermodynamic equilibrium temperature when it is exposed air, and the surface of a body begins to make dew when its surface temperature reaches dew-point temperature. In case of the water solution of salt, contrarily, when it reaches the temperature corresponding to water vapor pressure of saturated solution, it becomes equilibrium condition. These methods are applied as follows:

(a) Ventilated psychrometer

(b) Dew-point hygrometer

(3) Method by measuring physical property of air Detect and measure such as: the amount of electromagnetic wave, in the range from ultraviolet through infrared to microwave, absorbed by water molecules in sample air; the amount of fluorescence relating this; or the affected amount of thermal conductivity, refractive index or propagation speed of supersonic wave which are properties of air. These methods are applied as follows.

(a) Thermal conductivity-type hygrometer

(b) Measuring method by absorbed ultraviolet ray, measuring method by fluorescence, and measuring method by absorbed infrared ray

(c) Measuring method by loss in dielectric resonator caused by microwave

(d) Measuring method by propagation speed of supersonic wave

(4) Method by measuring physical property of hygroscopic materials Generally, swelling materials as hair, finely porous high-molecular membrane, or porous sintered body as ceramics, easily absorb, adsorb, or desorb the water vapor in sample air, and thus they change their mechanical properties, electrical properties, and optical properties. These changed quantities are detected and measured. These methods are applied as follows:

(a) Hygrometer using such as hair, or nylon

(b) Electronic hygrometer with 2 terminal impedance element

(c) Indicator method by cobalt chloride

(d) Propagation-speed measuring method of elastic surface wave on surface of piezoelectric material

5. Measuring method and measuring instruments Among the methods for humidity measuring stated in 4., the chemical process and physical process of (1) to (3) are now being elucidated, but (4) has a lot of uncleared processes yet.

When methods in (4) are to be applied on measuring instruments, the purpose of measurement is made clear and then it is necessary to take the following items into account.

(1) Existence or non-existence of technical problems

(2) Employed environments and environmental conditions

(3) Accuracy for measurement

(4) Preventive or decreasing counterplan to polluting materials in environment

(5) Necessity of periodical calibration

Especially, some measuring instruments, stated in humidity measuring method (4) of 4., which are in the market, have not yet enough checked on the change in their humidity characteristics, therefore it is necessary to select either (1) or (2) in measuring methods 4. or the testing method specified in JIS B 7920, and combinedly use the selected one as the base of humidity.