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Indoor test methods for solar heating system performance

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Foreword

This Japanese Industrial Standard has been established by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Act.

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Indoor test methods for solar heating system performance

1 Scope

This Japanese Industrial Standard specifies the measuring methods for indoor test of hot water supply efficiency using the hot water supply standard usage mode of the liquid heat collection type and the air heat collection type, and the space heating efficiency of air heat collection type among solar heating systems composed of a solar collector, solar storage tank, auxiliary heat source, etc. mainly used for hot water supply and space heating in general households (hereafter referred to as systems).

This Standard does not cover a system composed of a solar storage tank using a heat pump.

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 A 4112 *Solar collectors*

JIS A 4113 *Solar storage tanks*

JIS B 7414 *Glass thermometers*

JIS C 1602 *Thermocouples*

JIS C 1605 *Mineral insulated thermocouples*

JIS K 2203 *Kerosine*

JIS S 2075 *Measurement method of efficiency for domestic gas and oil water heater under standard usage mode*

JIS S 2093 *Test methods of gas burning appliances for domestic use*

JIS Z 8703 *Standard atmospheric conditions for testing*

ISO 9060 *Solar energy—Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **JIS A 4112**, **JIS A 4113** and **JIS S 2075**, and the following apply.

However, the “modes” specified in **JIS S 2075** does not apply to this Standard.

3.1

solar heating system

equipment to consume solar heat directly, in which the heat collected by a solar collector is stored in a solar storage tank

When the required temperature is not attained, the temperature is raised using an auxiliary heat source.

3.2

solar collector

heat exchanger which raises the temperature of heat collecting medium (liquid or gas) passing through its inside by receiving solar radiation

3.3

solar storage tank

heat storage tank that stores solar energy as sensible heat by the heat exchange with the heat collecting medium, using a liquid which does not boil at an atmospheric pressure as a heat medium

Appliances related to heat storage such as a control device and pump unit are built-in. In the case of the solar storage tank in which related appliances and auxiliary heat source are integrated, the auxiliary heat source and its controller are also included.

3.4

auxiliary heat source

heat source device such as a boiler which makes up for shortage of the heat quantity, when the heat collection from solar is insufficient

3.5

hot water supply standard usage mode

mode concerning only the hot water supply part in the bath hot water supply standard usage mode

3.6

hot water supply action

one continuous action starting from the hot water supply based on the hot water supply standard usage mode

3.7

hot water supply efficiency

efficiency calculated on the basis of the energy amount measured based on the hot water supply standard usage mode specified in this Standard, which is a value obtained by dividing an output heating value by an energy amount

Unless otherwise specified, the hot water supply efficiency is calculated according to the solar irradiance on clear day as the rated condition and the system energy amount not considering the remaining hot water in a solar storage tank.

3.8

space heating efficiency

value obtained by dividing the heat quantity available for space heating attained by heat collection by the energy amount required for heat collection in the air heat collection type system

3.9

output heat quantity

heat quantity output based on the hot water supply standard usage mode from the heat quantities obtained by the solar heat collection and the heat from the auxiliary heat source in the hot water supply system

3.10

energy amount

overall energy amount obtained by adding gas heat quantity or oil heat quantity to the system electric energy

3.11

system electric energy

total amount of the secondary energy of the power consumed by a system

The value is the sum of the power consumption amount required for heat collection, the power consumption amount during tapping based on the hot water supply standard usage mode and the power consumption amount during the non-tapping.

3.12

gas heat quantity

total amount of heat quantities of gas consumed by an auxiliary heat source when hot water is used based on the hot water supply standard usage mode

The heat quantities of gas intermittently consumed in the pilot burner at the non-tapping and in the auxiliary heat source during the non-tapping are included.

3.13

oil heat quantity

total amount of heat quantities of oil consumed by an auxiliary heat source when hot water is used based on the hot water supply standard usage mode

The heat quantities of oil intermittently consumed in the auxiliary heat source during the non-tapping are included.

3.14

total usage amount of hot water supply

total amount of hot water supply used in every hot water supply action indicated in the hot water supply standard usage mode

It refers to the usage amount of hot water supply per day.

3.15

heat storage tank tapping temperature

temperature of hot water tapped from a heat storage tank built-in a solar storage tank

In the case of the solar storage tank having a mixing valve etc. to mix water in order to adjust the tapping temperature, it refers to the hot water temperature tapped through the mixing valve etc.

3.16

preset tapping temperature

tapping temperature preset in a solar storage tank having an auxiliary heat source

3.17

target tapping temperature

tapping temperature preset in a solar storage tank without a built-in auxiliary heat source and with a built-in mixing valve

3.18

external heating device

electric heater and control device which simulate the heat collection amount of the heat collector existing outside the radiation range of a solar simulator

The electric heater is controlled so as to be in a state where the heat collector outside the radiation range is exposed to the same radiation intensity as that of the solar simulator.

3.19

tapping temperature control device

control device such as a mixing valve to mix water in order to adjust the tapping temperature from a heat storage tank

A control device of solar storage tank built-in type or that equipped outside a solar storage tank is available.

3.20

heat collection unit

unit in an air heat collection type system, in which a fan, heat exchanger and damper are included

3.21

heat collecting medium heating device

device which simulates air heating according to the heat collection amount (heat collection temperature/air quantity) of an air heat collection type system

4 Classification of systems

The systems shall be classified as given in Table 1 and Table 2.

Table 1 Classification by heat collecting medium and application

Heat collecting medium	Application	Heat storage tank tapping temperature control function	Burning
Liquid	Hot water supply	As given in Table 2	Yes
Air	Space heating	—	No
	Hot water supply	As given in Table 2	Yes

Table 2 Classification by type of heat storage tank

Tapping temperature control function	Installation of auxiliary heat source	Auxiliary heat source fuel
Yes	Separated	—
No		—
Yes	Integrated	Gas
		Oil

5 Measurement principle

The correspondence among the heat collecting medium, input device and test content in the indoor test shall be as given in Table 3.

The input device shall be used in order to keep the test conditions constant.

The radiation by a liquid heat collection type solar simulator shall be controlled every 1 h in a stepwise manner according to the radiation condition of **6.5**. In the case of a liquid heat collection type system, the control method of an external heating device to be used when the second and the subsequent heat collectors are tested shall be as given in Annex D.

In the case of an air heat collection type system, the heat collection amount shall be simulated using a heat collecting medium heating device. The control method of heat collecting medium heating device of an air heat collection type system shall be as given in Annex E.

The heat collection efficiency property of heat collector shall be evaluated in advance.

Table 3 Heat collecting medium, input device and test content

Heat collecting medium	Input device	Test content
Liquid	Solar simulator and external heating device	Hot water supply
Air	Heat collecting medium heating device	Space heating
		Hot water supply

6 Test conditions

6.1 Conditions of test room

The conditions of test room shall be as given in Table 4.

Table 4 Conditions of test room

Item	Condition
Test room temperature	The test room temperature during test shall be $20\text{ }^{\circ}\text{C} \pm 4\text{ }^{\circ}\text{C}$.
Test room humidity	The test room humidity shall be normal humidity (45 % to 85 %) specified in JIS Z 8703 .
Test room atmosphere (applicable only to the case with burning)	The test room atmosphere shall not contain carbon dioxide of not less than 0.2 % and carbon monoxide of not less than 0.002 %. Also, there shall be no air current which affects burning.

6.2 Water supply condition

The water supply temperature of stable tapping during the test shall be $15\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

In this test imitating the intermittent tapping, the water supply piping shall be devised to be as short as possible. The difference between the test room temperature and the water supply temperature shall be $5\text{ K} \pm 2.0\text{ K}$, because the appliance in which burning starts intermittently during the non-tapping is strongly affected by the test room temperature and the water supply temperature.

6.3 Installation and usage states of system

The system constituent appliances shall be installed under normal state as shown in an operation manual etc. The usage state shall be the shipping state. Special remodelling and connection affecting the test results are inhibited.

In the air heat collection type system, the material recommended by the manufacturer shall be used for a duct. The usage state of the system constituent appliances used for tests such as a heat storage tank and a heat collection unit shall be the shipping state. Special remodelling and connection affecting the test results are inhibited.

6.4 Preset of tapping temperature

The tapping temperature shall differ as given in Table 5 according to the preset (possible/impossible) of tapping temperature.

In the system in which the tapping temperature can be preset, the temperature shall be preset to $40\text{ }^{\circ}\text{C}$ which is the same as the service temperature of hot water supply. In other systems, the tapping temperature shall be adjusted to the target temperature shown in Table 5.

Table 5 Preset tapping temperature/target tapping temperature of system

Unit: °C

Preset of tapping temperature ^{a)}	Mixture of hot water and cold water	Hot water and cold water mixing temperature ^{b)}	Preset tapping temperature/target tapping temperature ^{c)}
System in which tapping temperature can be preset to 40 °C using a remote controller etc.	Auxiliary heat source integrated type	—	40
	System in which hot water and cold water are mixed using a mixing valve which can communicate with appliance	40	40
	System in which hot water and cold water are mixed using a temperature fixed type mixing valve separately installed	30	40
Other systems	System in which hot water and cold water are mixed using a mixing valve which can communicate with appliance	40	40
	System in which hot water and cold water are mixed using a temperature fixed type mixing valve separately installed	30	40
NOTE In the case of equipment in which a tapping temperature control device is not built in a solar storage tank and an external mixing device is not installed, the test condition shall be as agreed between the testing laboratory and the manufacturer beforehand. Notes ^{a)} The allowable fluctuation range of tapping temperature during the test shall be -2.0 K against the preset value of 40 °C. ^{b)} Upstream temperature of auxiliary heat source ^{c)} Downstream temperature of auxiliary heat source			

6.5 Radiation condition for liquid heat collection type

The radiation condition by a solar simulator shall be within $\pm 10 \%$ of the irradiance of each time of day specified in Table 6.

When the irradiance by a solar simulator is less than the lower limit of solar simulator control, the setting method of radiation condition shall be as given Annex H.

Table 6 Radiation condition

Clear	Time of day	7:00 to 8:00	8:00 to 9:00	9:00 to 10:00	10:00 to 11:00	11:00 to 12:00	12:00 to 13:00	13:00 to 14:00	14:00 to 15:00	15:00 to 16:00	16:00 to 17:00	17:00 to 18:00
	Irradiance (W/m ²)	98	291	501	679	793	832	793	679	501	291	98
	Period (h)	1	1	1	1	1	1	1	1	1	1	1
	Irradiation amount (Wh/m ²)	98	291	501	679	793	832	793	679	501	291	98
Fine	Time of day	7:00 to 8:00	8:00 to 9:00	9:00 to 10:00	10:00 to 11:00	11:00 to 12:00	12:00 to 13:00	13:00 to 14:00	14:00 to 15:00	15:00 to 16:00	16:00 to 17:00	17:00 to 18:00
	Irradiance (W/m ²)	73	216	391	548	652	684	652	548	391	216	73
	Period (h)	1	1	1	1	1	1	1	1	1	1	1
	Irradiation amount (Wh/m ²)	73	216	391	548	652	684	652	548	391	216	73
Cloudy	Time of day	7:00 to 8:00	8:00 to 9:00	9:00 to 10:00	10:00 to 11:00	11:00 to 12:00	12:00 to 13:00	13:00 to 14:00	14:00 to 15:00	15:00 to 16:00	16:00 to 17:00	17:00 to 18:00
	Irradiance (W/m ²)	55	150	284	411	501	531	501	411	284	150	55
	Period (h)	1	1	1	1	1	1	1	1	1	1	1
	Irradiation amount (Wh/m ²)	55	150	284	411	501	531	501	411	284	150	55

6.6 Fuel for test

The fuel for test shall be as given in Table 7.

Table 7 Fuel for test

Type	Requirement
Gas	As specified in JIS S 2093 .
Oil	No. 1 kerosene specified in JIS K 2203 .

6.7 Hot water supply usage condition

The hot water supply standard usage mode to be used shall be as given in Annex B (see Table 8 of **JIS S 2075**).

6.8 Test start condition

The specimen shall be left as it is for sufficient time in a test room until the temperature inside the specimen can be regarded to be equivalent to the test room temperature.

6.9 Operation switch of remote controller during test

In the case of the system having an operation switch of remote controller, the switch shall be maintained to ON state even during the night without tapping.

7 Test apparatus

7.1 Outline of test apparatus

7.1.1 Outline of liquid heat collection type test apparatus

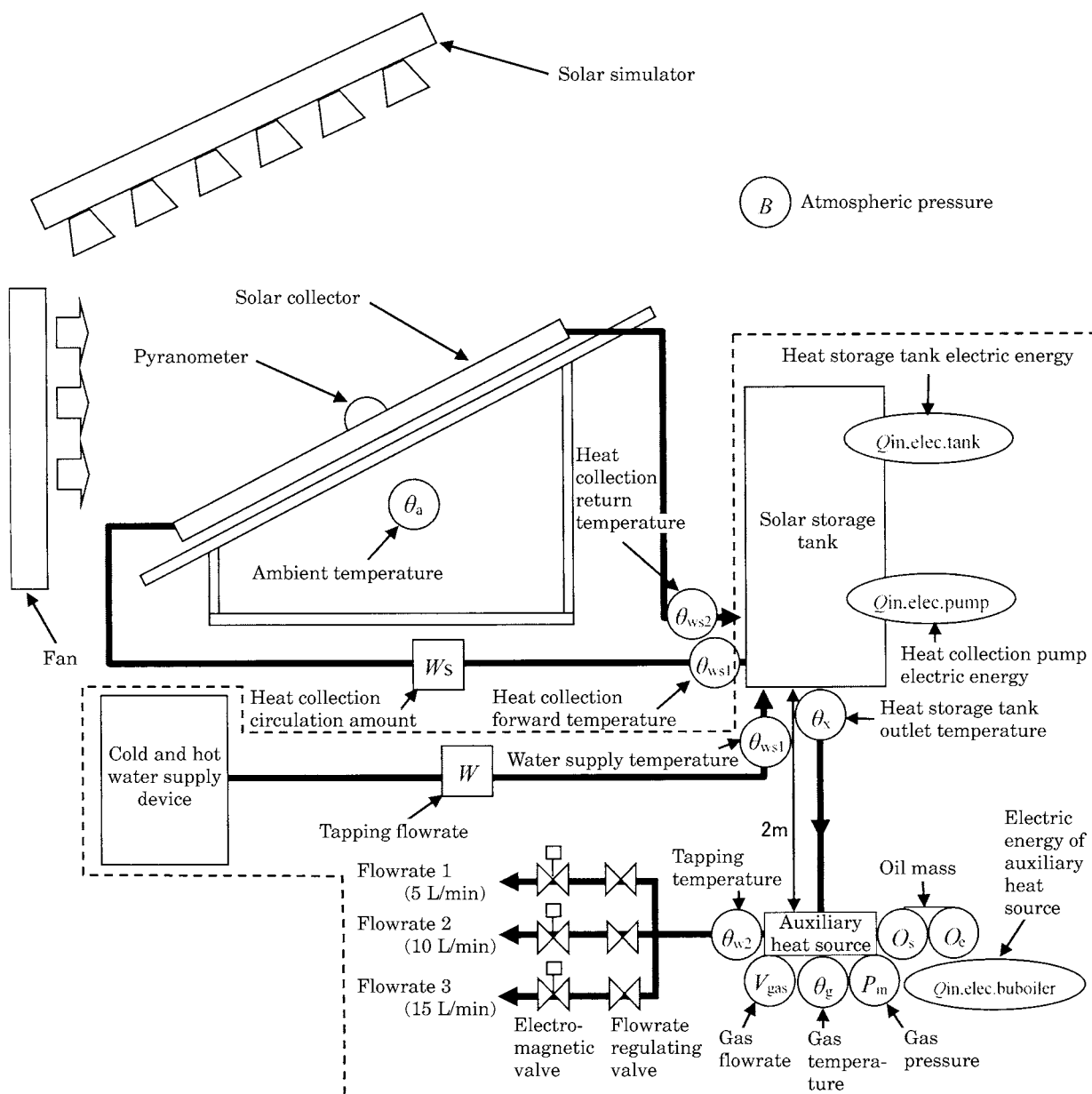
The outline of a liquid heat collection type test apparatus shall be as follows.

Examples of the test apparatus of an indirect heat collection type (having a heat exchanger in a heat storage tank of heat collection system) are shown in Figure 1 and Figure 2.

- a) A cold and hot water supply device shall be capable of attaining the stable water temperature continuously.
- b) A fan used for the test of liquid heat collection type shall be capable of attaining the stable air quantity continuously.
- c) In the tapping of hot water supply system, the usage flowrate of hot water supply shall be adjusted beforehand so that the usage amount of hot water supply becomes 5 L/min, 10 L/min and 15 L/min. At this time, when the apparatus shown in Figure 1 b) is used, the downstream flowrate of the tapping temperature control device shall be adjusted to the usage flowrate of hot water supply. In the test, the electromagnetic valve installed in piping shall be automatically opened/closed by sequence control, relay, etc. based on the start time and duration in the hot water supply system of the hot water supply standard usage mode. The flowrate regulating valve shall be surely confirmed before the start of system performance test so that the flowrate becomes within $\pm 5 \%$ of each usage flowrate of hot water supply during stable tapping.
- d) In the test using the auxiliary heat source separated type solar storage tank having a tapping temperature control device [Figure 1 a)], the length of piping between the solar storage tank and the auxiliary heat source shall be 2 m, and the member recommended by the manufacturer shall be used for the piping material.
- e) In the test using the auxiliary heat source separated type solar storage tank not having a tapping temperature control device [Figure 1 b)], the length of piping between the solar storage tank and the tapping temperature control device shall be 2 m and the length of piping between the tapping temperature control device and the auxiliary heat source shall be 2 m, and the member recommended by the manufacturer shall be used for the piping material.
- f) In the case of the heat collection piping of liquid heat collection type system, the length of both-way from a heat collector to a solar storage tank shall be taken as the piping length. The piping length shall be 40 m for installation. The water supply temperature shall be measured at the point near a solar storage tank, and the tapping temperature at the point near a solar storage tank or an auxiliary heat source. On the examination etc. of the influence by the change in piping length in practical use, the measurement of the piping heat insulation performance shall be as given in Annex C.
- g) The piping length without tolerance specification shall be taken as a reference value $^{+5}_0 \%$.

h) The following four items shall be measured on the energy amount.

- 1) Solar irradiance on inclined surface
- 2) Solar storage tank power consumption
- 3) Heat collection pump power consumption
- 4) Gas (gas flowrate, gas temperature and gas pressure) or oil mass



a) Equipment in which solar storage tank has tapping temperature control device

Figure 1 Example of test apparatus for liquid heat collection type system in which solar storage tank and auxiliary heat source are separated

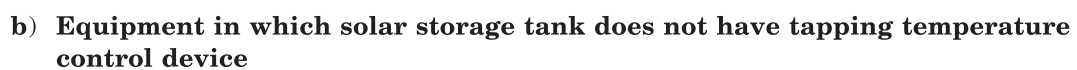


Figure 1 (concluded)

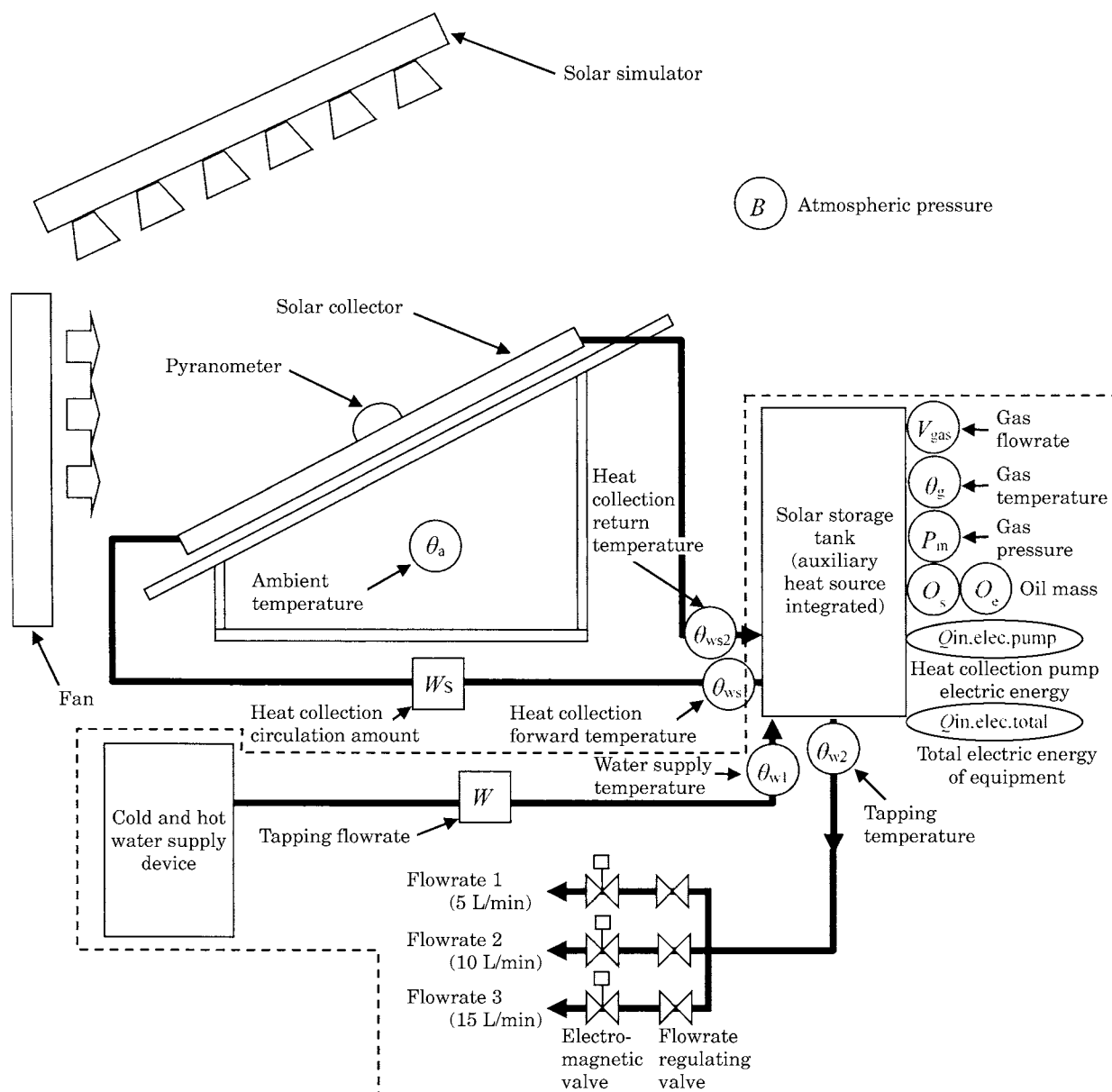


Figure 2 Example of test apparatus for liquid heat collection type system in which solar storage tank and auxiliary heat source are integrated

7.1.2 Outline of air heat collection type test apparatus

The outline of an air heat collection type test apparatus shall be as follows.

An example of test apparatus is shown in Figure 3.

Figure 3 a) shows the test apparatus for the space heating/hot water supply system in which the outdoor air heated to high-temperature by heat collection is used for space heating directly, and further as necessary, by the heat exchange with liquid to obtain hot water which is used for hot water supply. Figure 3 b) shows the test apparatus for the dedicated space heating system in which the hot water obtained by the heat exchange between the air heated to high-temperature by heat collection and the liquid is used for space heating.