The calibration of Hygrometer
(Lecture and Training)

Japan Meteorological Agency
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川村 裕志

Outline

- Measurement methods of Humidity(theory)
- Traceability and calibration methods in JMA
- Calibration of Hygrometer (*practice*)
  - About today's practice

    Place: the inspection room at 1st floor

1. Measurement methods of humidity(theory)

1.1 Sorption methods（2types）

1.2 Psychrometric method

1.3 Condensation methods （2types）

1. Measurement methods of humidity(theory)

1.1 Sorption methods(1)

changes of the dimensions

hair hygrometer, hair hygrograph

1.1 Sorption methods(2)

changes of electrical properties

electronic hygrometer (capacitive type)

1.2 Psychrometric method

difference between the dry-bulb and wet-bulb temperatureis related to the ambient humidity

aspirated psychrometer

1. Measurement methods of humidity(theory)

1.3 Condensation method(1)

equilibrium vapour pressure

at the surface of a salt solution

lithium chloride heated condensation dewpoint hygrometer

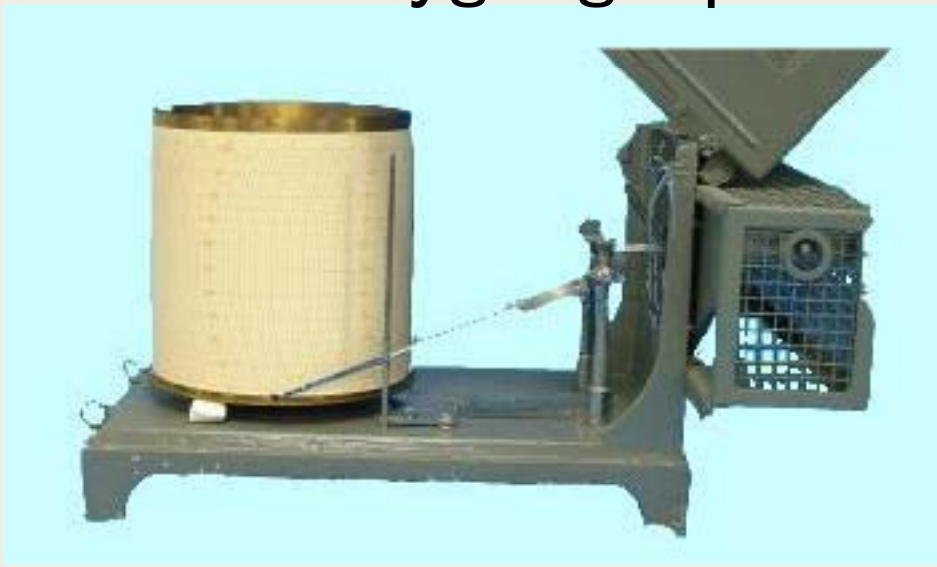
1.3 Condensation method(2)

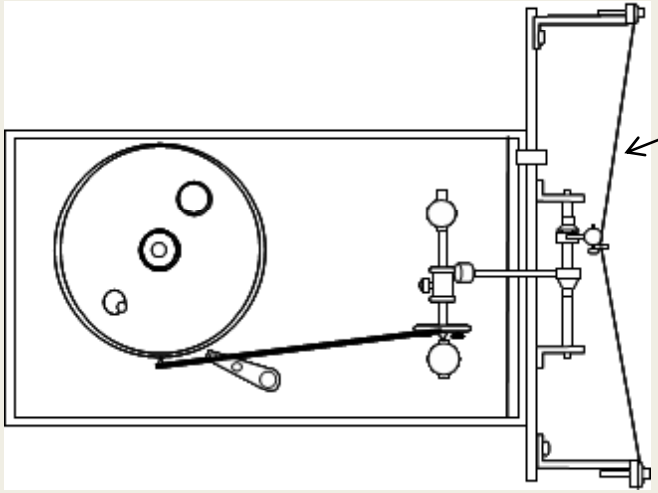
sense condensation with an optical detector

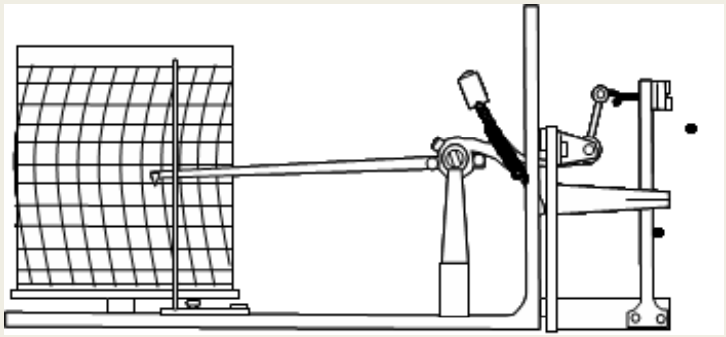
chilled-mirror dewpoint hygrometer

1.1(1) Sorption methods

hair hygrograph

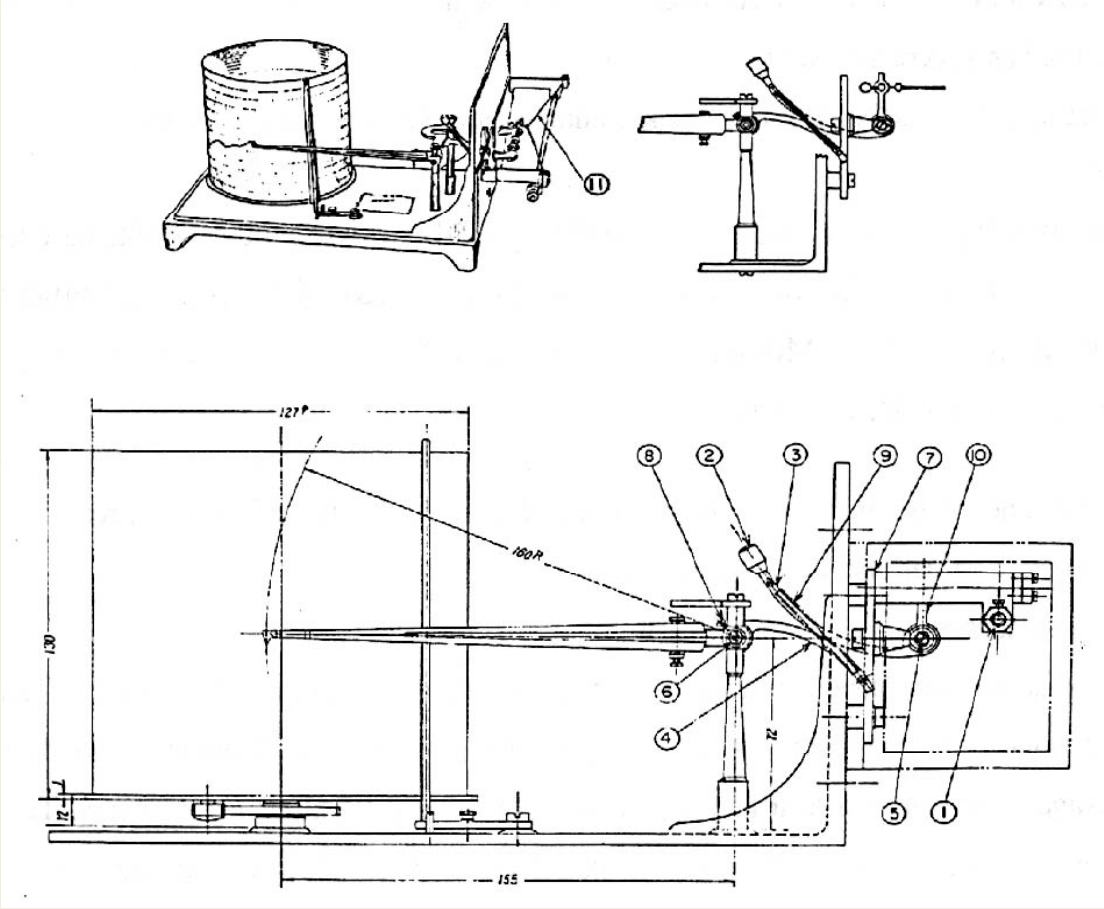






1.1(1) Sorption methods

hair hygrograph

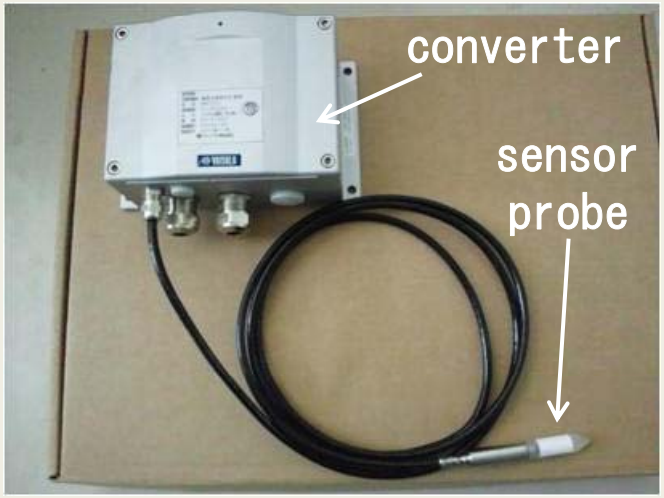


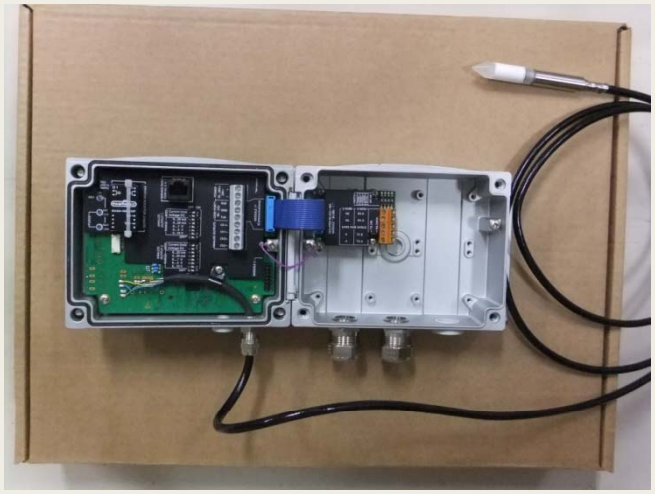
①Indicator adjusting screw
②Weight
③Main cam
④Sub cam
⑤Rotation axis for main cam
⑥Rotation axis for sub cam
⑦Plate attaching sensor part of humidity
⑧Screw attaching sub cam
⑨Connecting spring
⑩lever
⑪Hair bundle

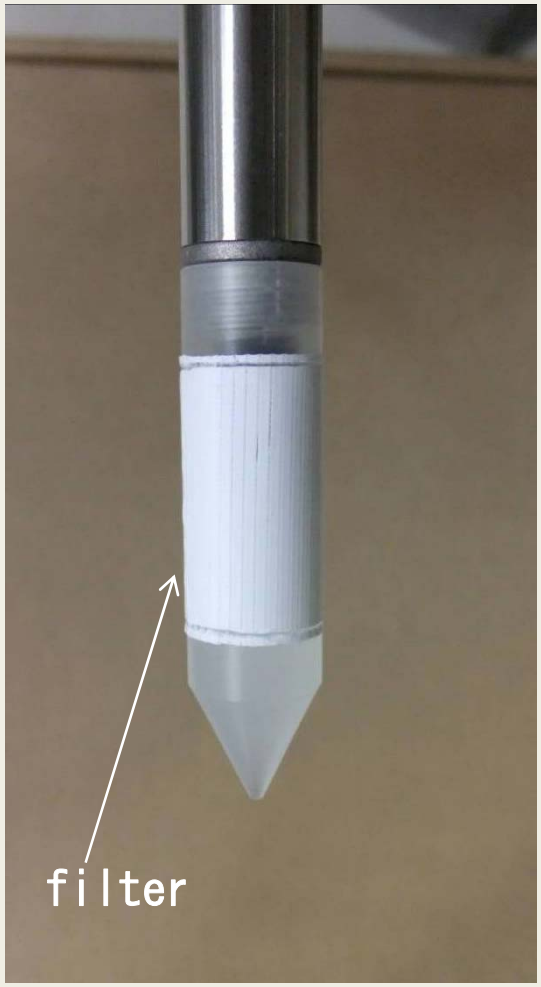
Structure of hair hygrograph

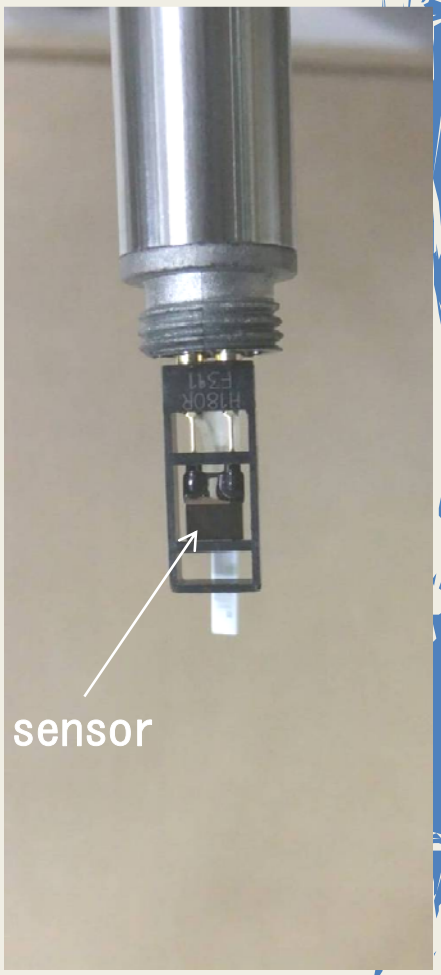
1.1(2) Sorption methods

electronic hygrometer(capacitive type)

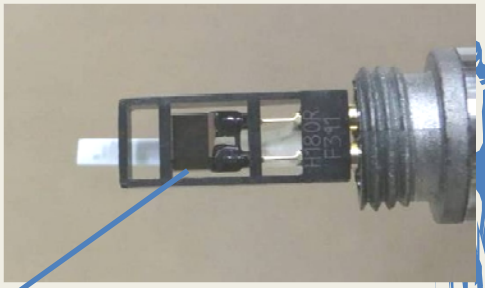




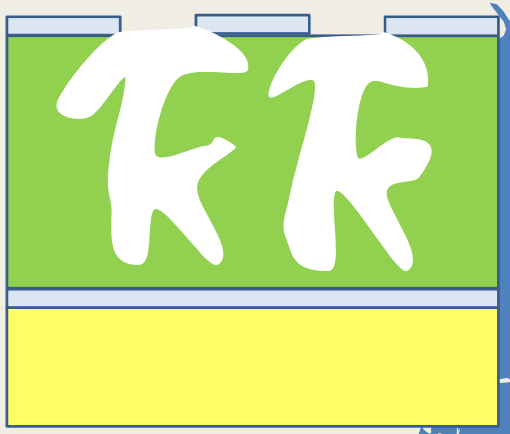




electronic hygrometer(capacitive type)



upper electrode
(high-porosity)

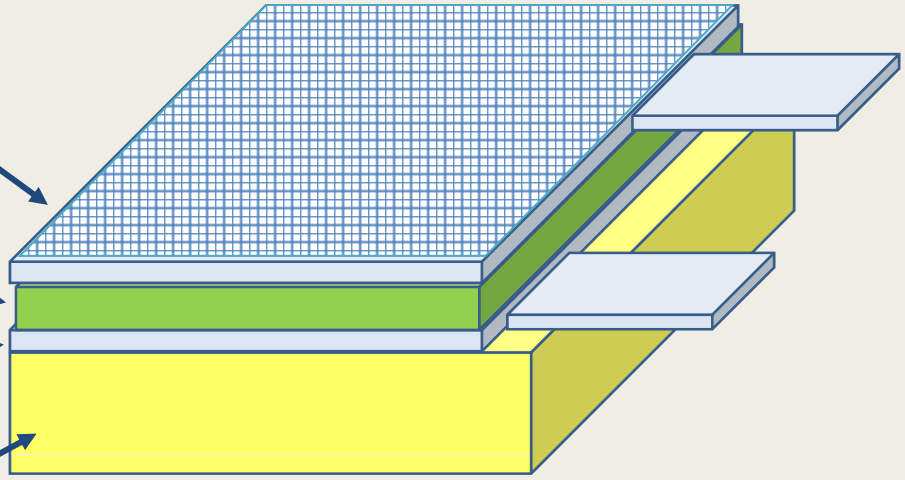


upper
electrode

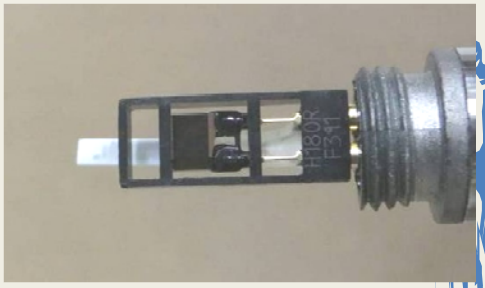
polymer
membrane

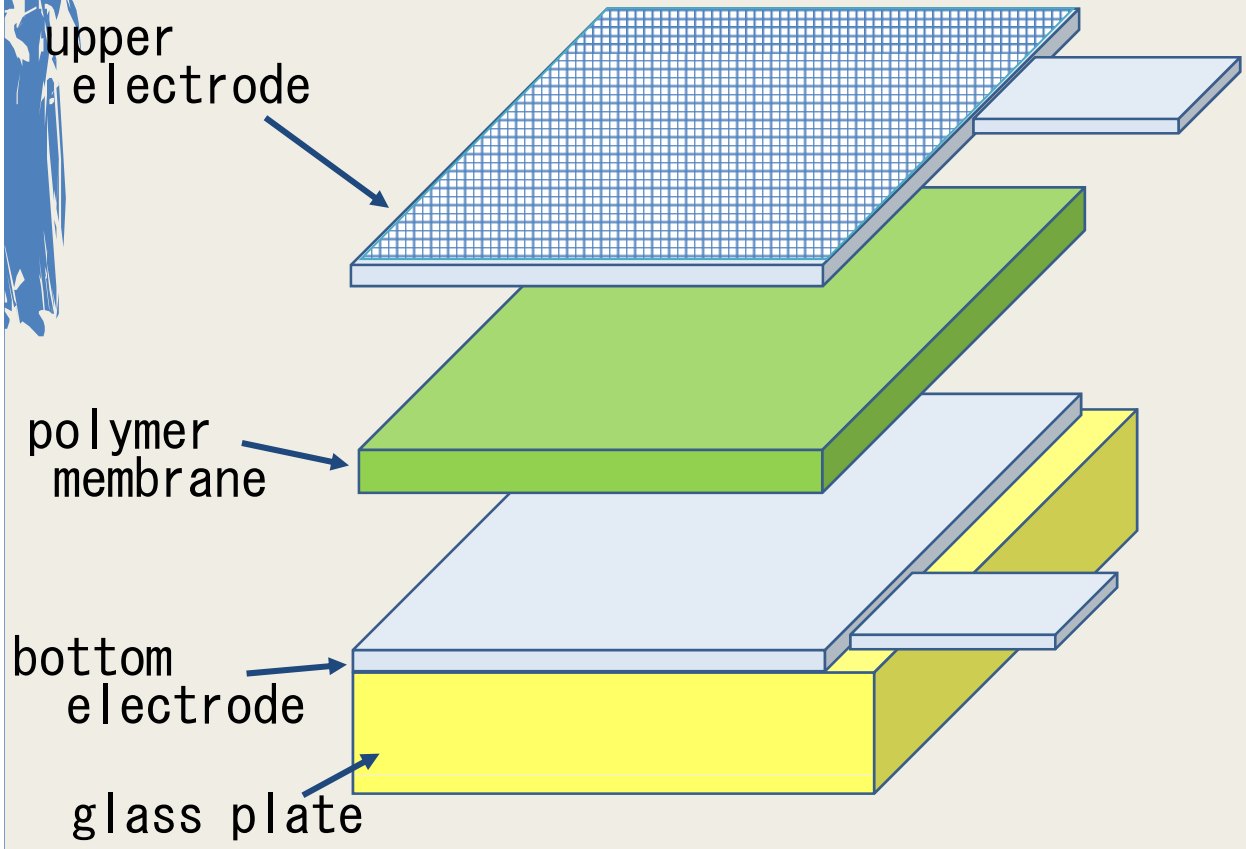
bottom
electrode

glass plate

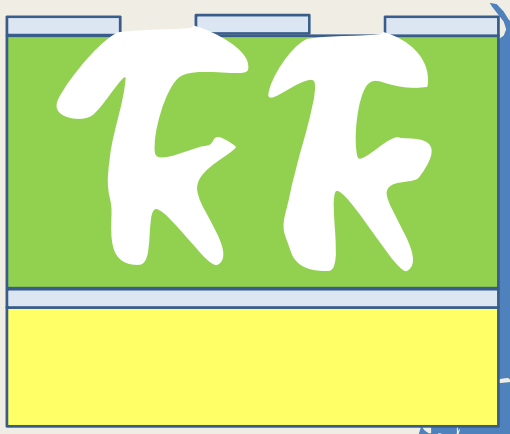


electronic hygrometer(capacitive type)

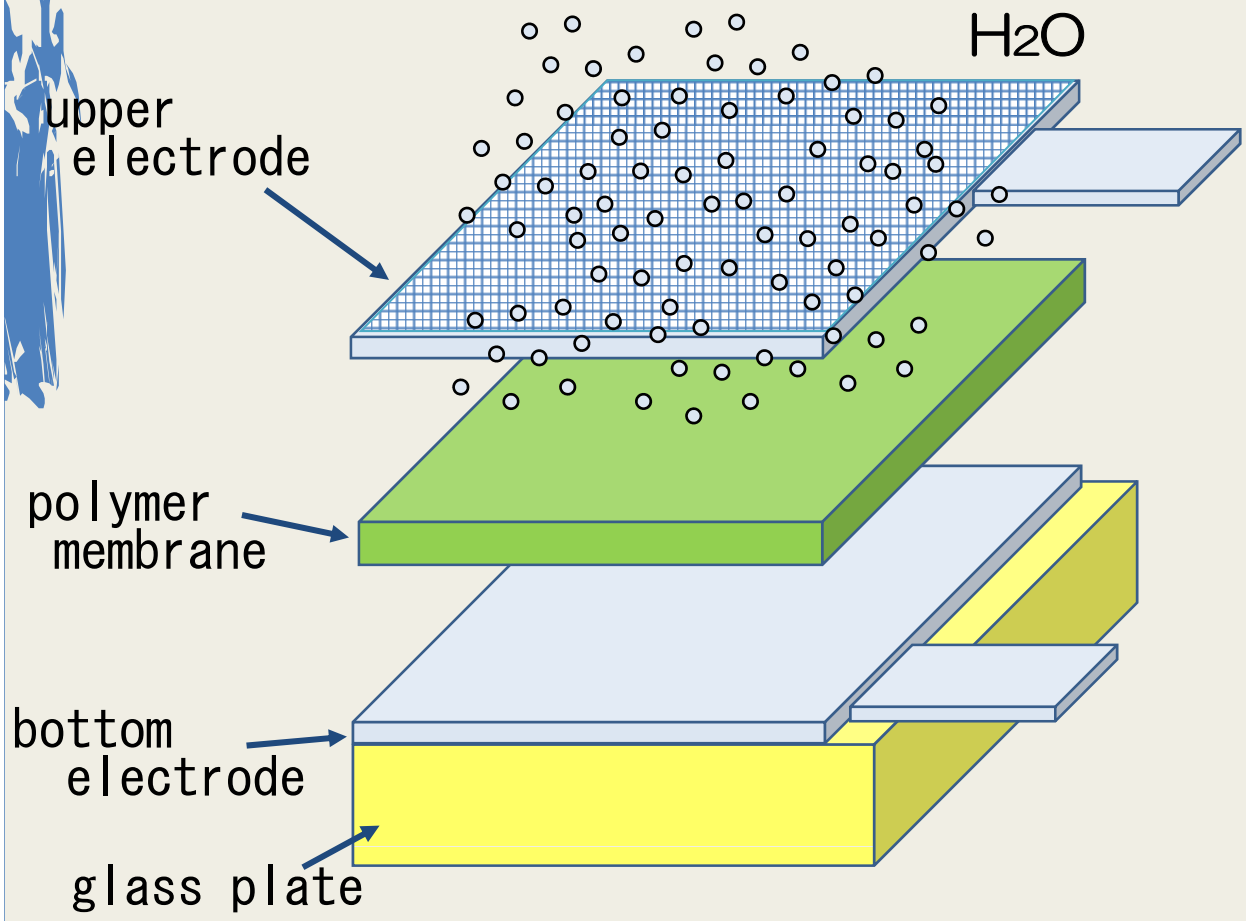


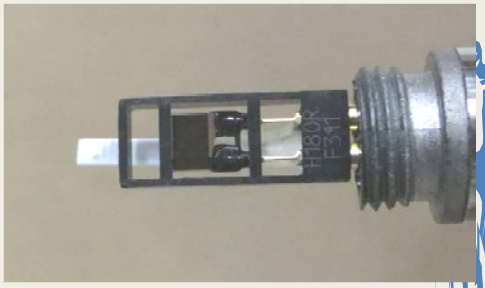


upper electrode
(high-porosity)

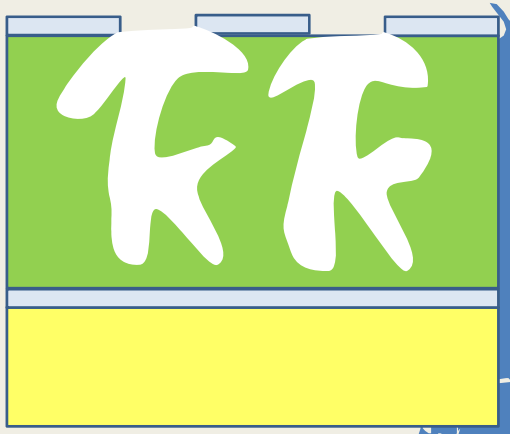


electronic hygrometer(capacitive type)





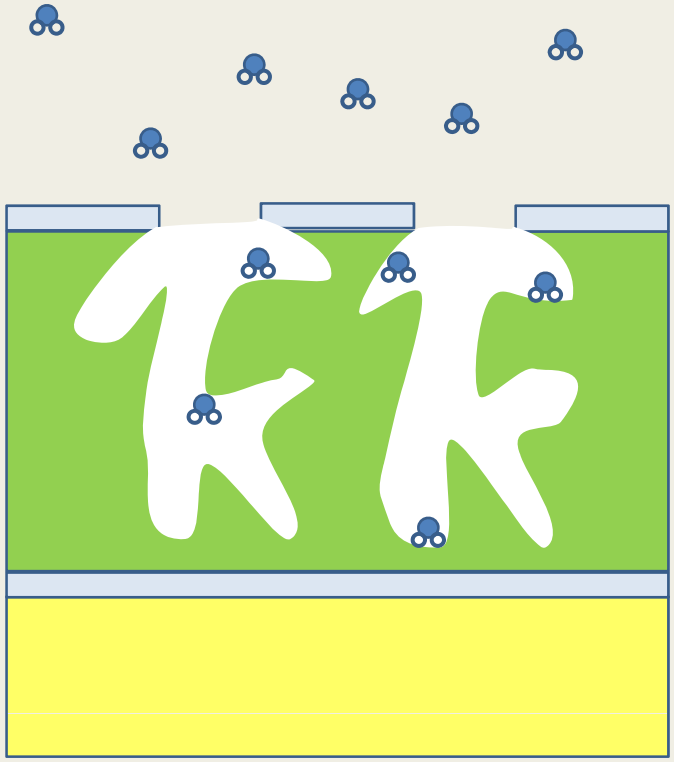
upper electrode (high-porosity)



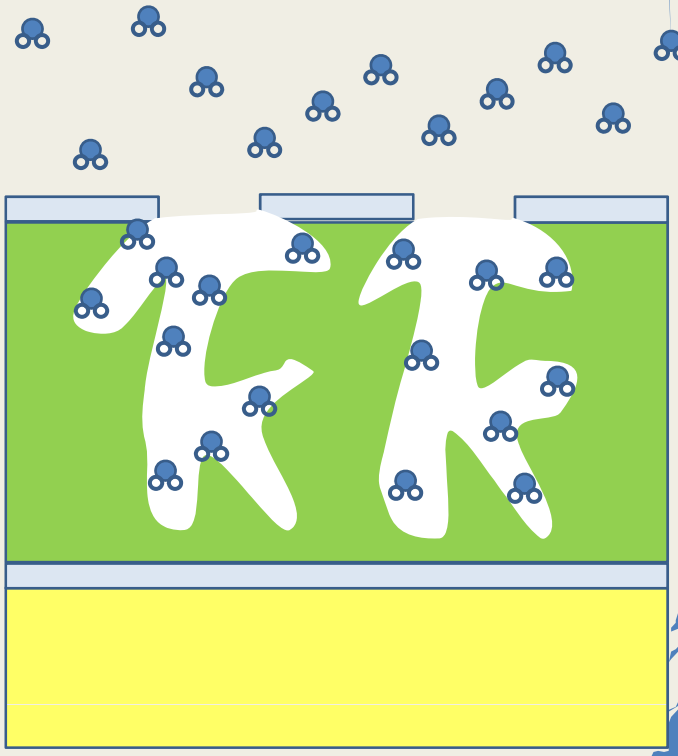
electronic hygrometer(capacitive type)

changes in capacitive between electrodes

(low humidity)

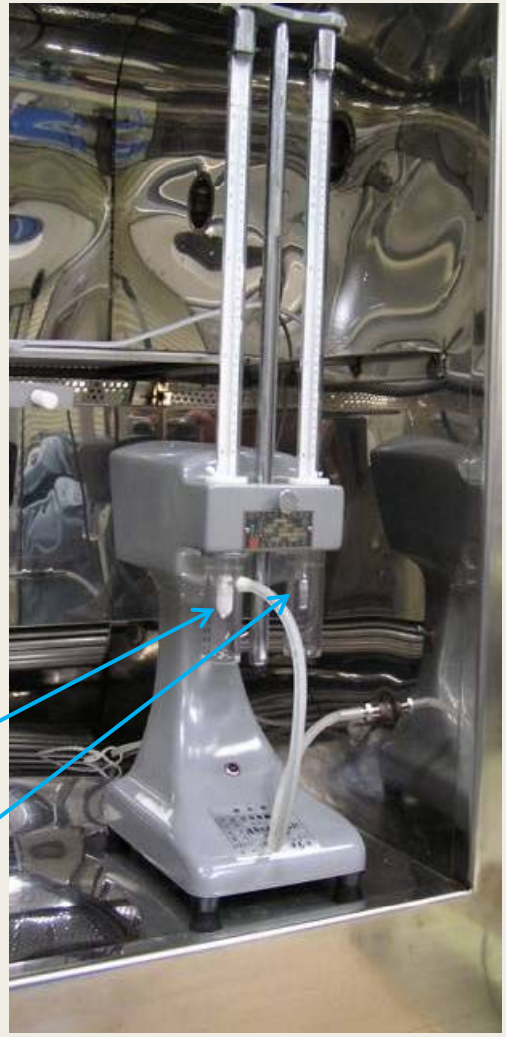


(high humidity)

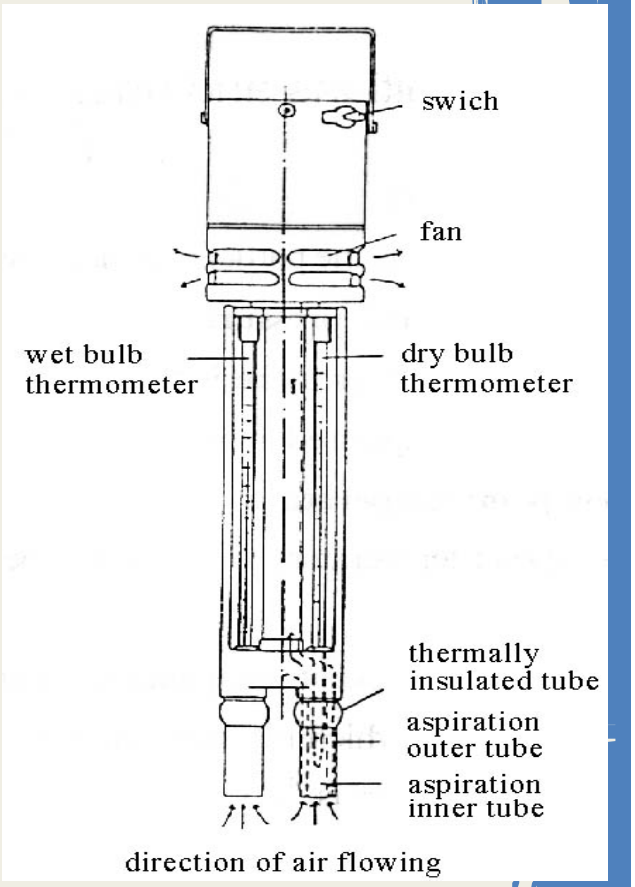


1.2 Psychrometric method
aspirated psychrometer

JMA type



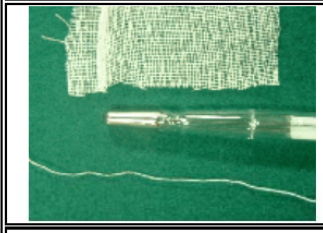
Assuman type



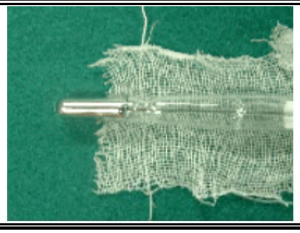
Replacing the wet sleeve of liquid-in-glass themometer

Pre-treatment:

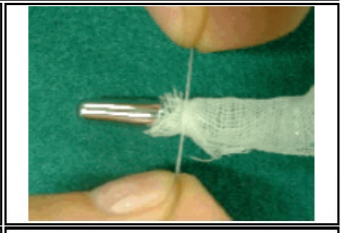
First, remove deposits from the wet bulb with a brush. A thin, tight white cotton cloth with no print is used to cover the wet bulb. Boil the cloth before replacement, then wash it with high-quality soap and rinse thoroughly to remove oily matter. Cut the cloth to an appropriate size. The bulb should be wetted with distilled or clean soft water. To prolong the life of the wet sleeve, distilled water is recommended.



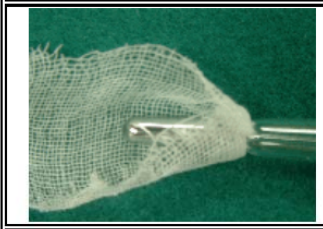
1. White cotton cloth and thread are prepared.



2. Moisten the cloth with clean water.Thread is rolled in the upper part of a bulb.



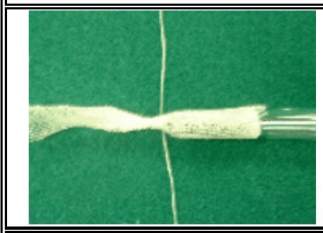
3. Thread is bound in the hollow of a bulb.



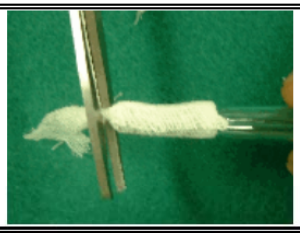
4. Cloth is turned over and bulb is wrapped in cloth.

5. About 1 time and a half roll a bulb with cloth, and excessive cloth is cut off.

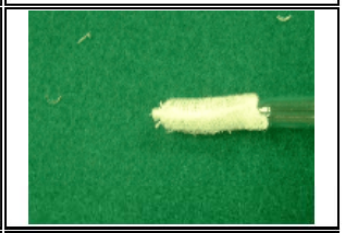
6. Cloth is twisted lightly.



7. Thread is bound at the tip of a bulb.



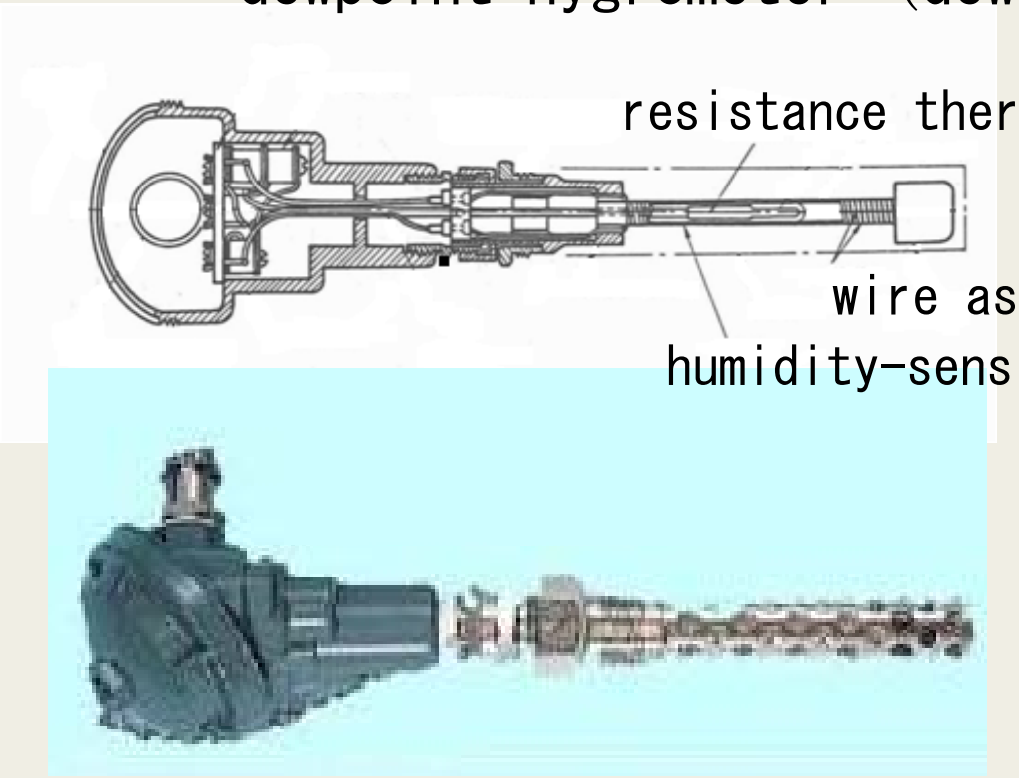
8. Excessive cloth is cut off.



9. Finished

1.3 Heated salt-solution method

lithium chloride heated condensation dewpoint hygrometer (dew cell)

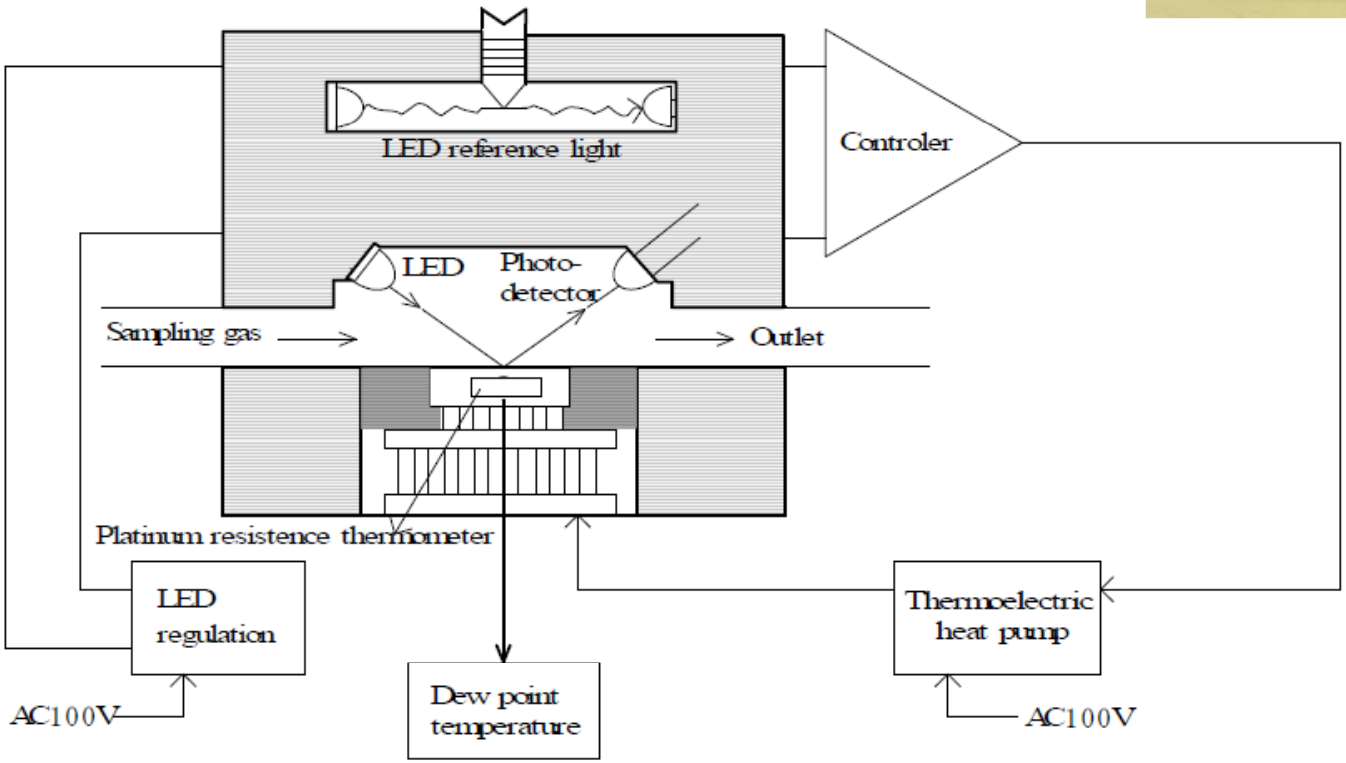


・An operational equilibrium temperature exists for the instrument, depending upon the ambient water-vapour pressure. At the equilibrium temperature, neither evaporation nor condensation occurs because the equilibrium vapour pressure and the ambient vapour pressure are equal.

1.4 Condensation methods

chilled-mirror dewpoint hygrometer

- measurement of Td or Tf .
- small polished-metal reflecting surface cooled electrically by using a Peltier-effect device sense condensation with an optical detector.



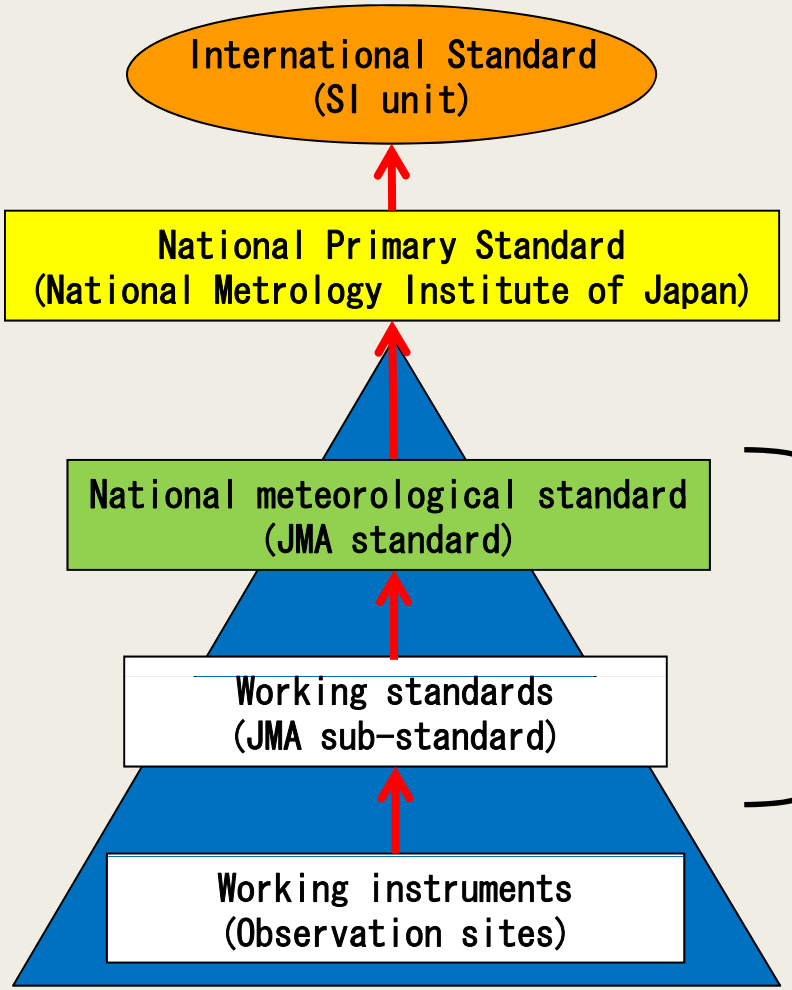
JMA Standard

2.Traceability and calibration methods in JMA

Temperature,
Humidity,
Pressure, ・・・

(Without radiation)

Traceability chart of JMA



JMA

MIC(RIC)

Traceability of Humidity (JMA)

Feb. 2012 by JMA

National Primary Standard

National Metrology Institute of Japan

JMA Standard

Working Standard

Field Instruments

Meteorological Instruments Center

Observatory

Standard humidity generator set

Calibration : every year

Chilled-mirror dewpoint hygrometer
Hygrometer (display)
DewStar S-1M-O
(Shinyei technology, Japan)
Hygrometer (sensor)
DewStar S-2S-OK
(Shinyei technology, Japan)

Calibration : every year

Chilled-mirror dewpoint hygrometer
Hygrometer (controller)
Hygro M2
(General Eastern, USA)
Hygrometer (sensor)
D2
(General Eastern, USA)

Electronic hygrometer

Filter change: Every 6 months

Check:
・every 3 months (manned observatory)
・every year (automatic weather station)

Tolerable range: ±4%

Aspirated psychrometer

Check: at the time of installation

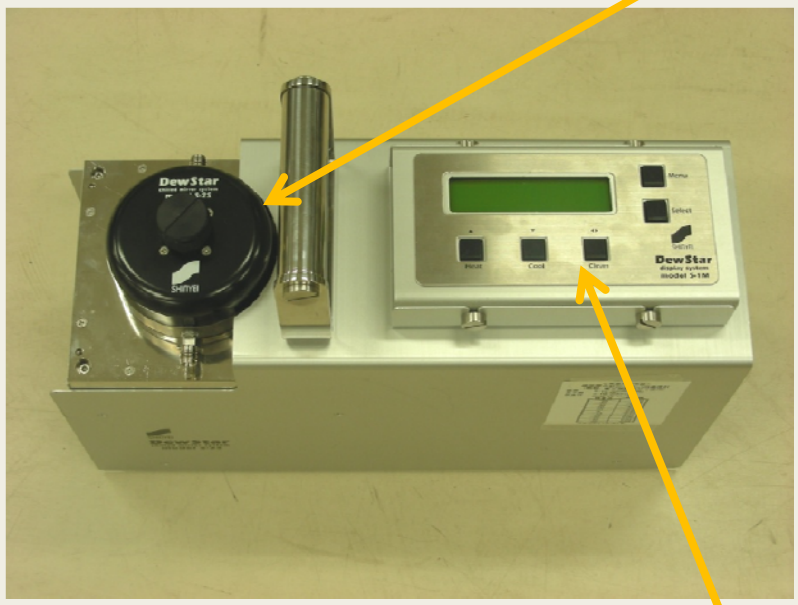
Lithium chloride dewpoint hygrometer

Mercury-in-glass thermometer (Assuman type psychrometer)

JMA Standard of thermometer

JMA Standard →Working Standard

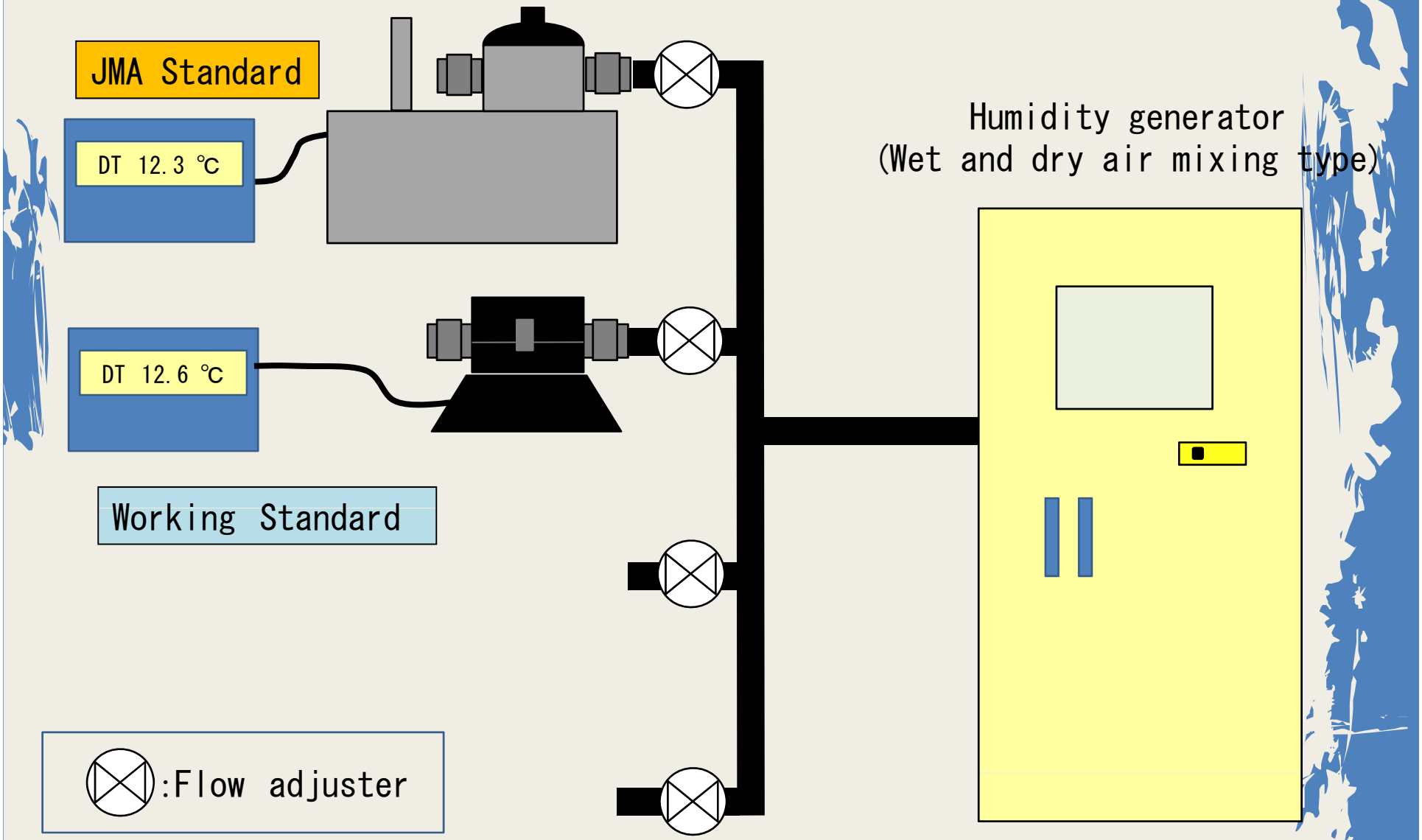
Sensor unit



Monitor

Chilled-mirror dewpoint hygrometer

JMA Standard →Working Standard



JMA Standard →Working Standard

Traceability of Humidity (JMA)

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(Shinyei technology, Japan)
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Electronic hygrometer

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Every 6 months

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Aspirated psychrometer

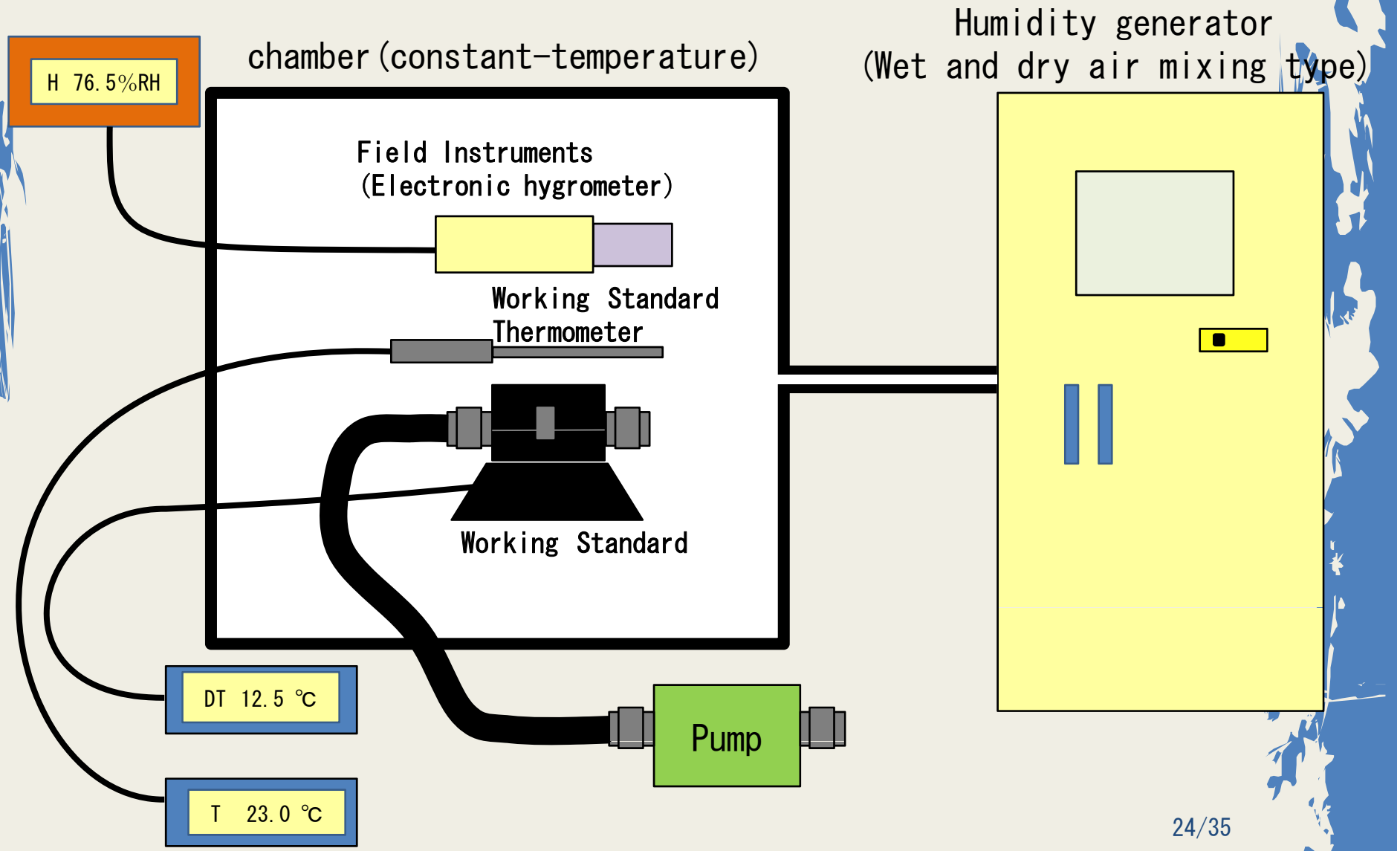
Check:
at the time of installation

Lithium chloride dewpoint hygrometer

Mercury-in-glass thermometer (Assuman type psychrometer)

JMA Standard of thermometer

Working Standard →Field Instrument



Traceability of Humidity (JMA)

Feb. 2012 by JMA

National Primary Standard

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JMA Standard

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Check: at the time of installation

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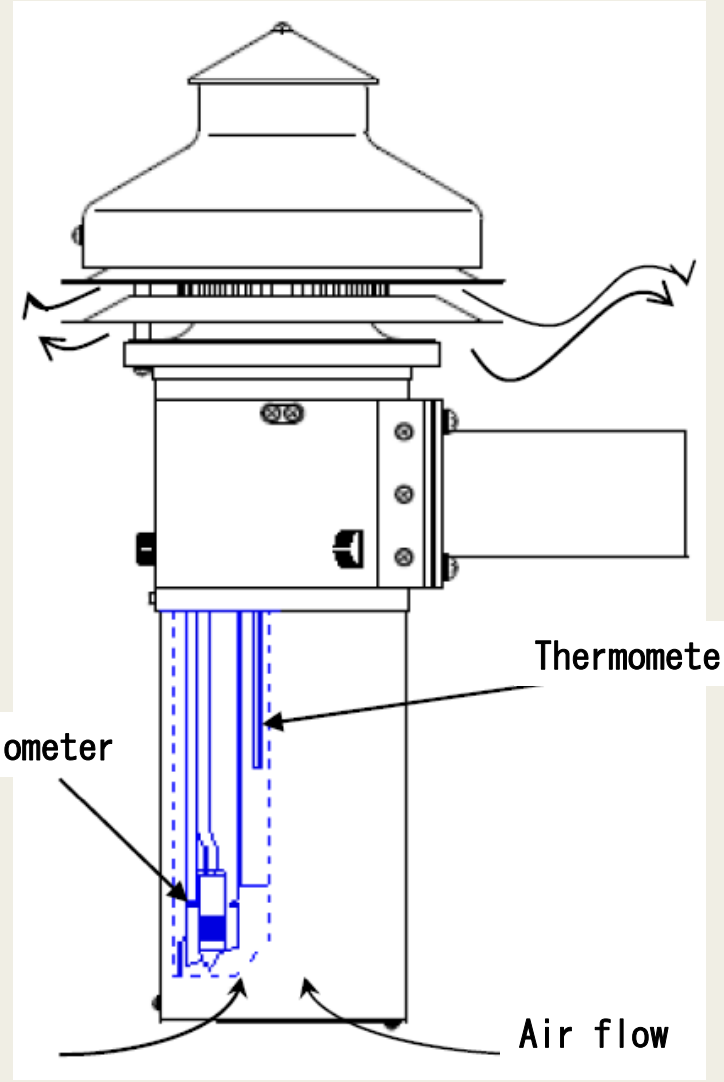
JMA Standard of thermometer

Check of Field Instruments

Field instruments in the shelter

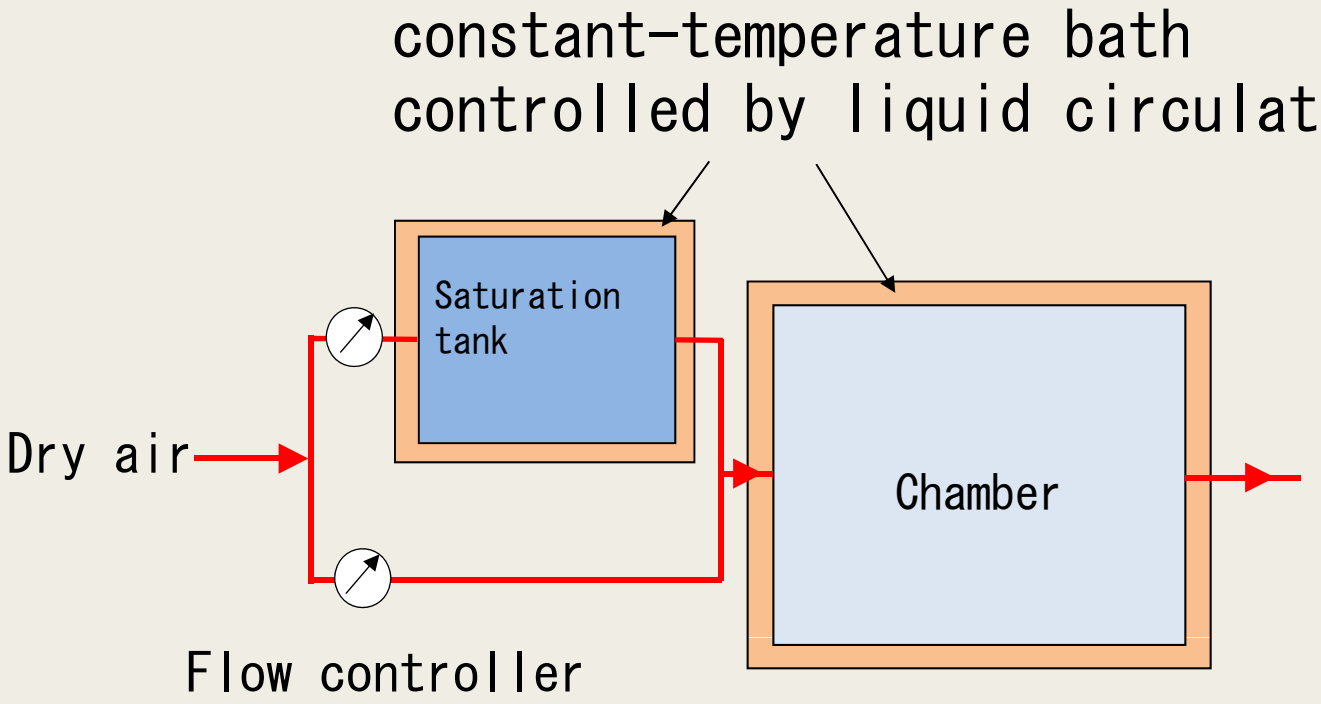


3.Calibration of Hygrometer (*practice*)

What is necessary for the calibration

- Comparisons against a reference instrument
  - Standard Calibration
    - Relative humidity
      ex) 20[%],40[%] ,60[%] ,80[%] ,95[%]
      at 23[℃]±3[℃]
    - Dew point temperature
      ex) -5[℃] ,0[℃] ,5[℃] ,10[℃] ,15[℃] ,20[℃] ,25[℃]
- under suitable steady conditions
  - Humidity chamber
    - Dynamic two-pressure humidity generator
    - Wet and dry air mixed-flow generator (**MIC using**)
    - etc.
  - Saturated salt solutions

Calibration chamber for hygrometers (Wet and dry air mixing type)



[diagram of system]

Saturated salt solutions

Vessels containing saturated solutions of appropriate salts may be used to calibrate relative humidity sensors.

Barium chloride ($BaCl_2$): 90.3 %

Sodium chloride ($NaCl$): 75.3 %

Magnesium nitrate ($Mg(NO_3)_2$): 52.9 %

Calcium chloride ($CaCl_2$): 29.0 %

Lithium chloride ($LiCl$): 11.1 %

etc.

at 25° C

Saturated salt solutions

ex) Vaisala HMK15

Refer to User Guide

Today's practice

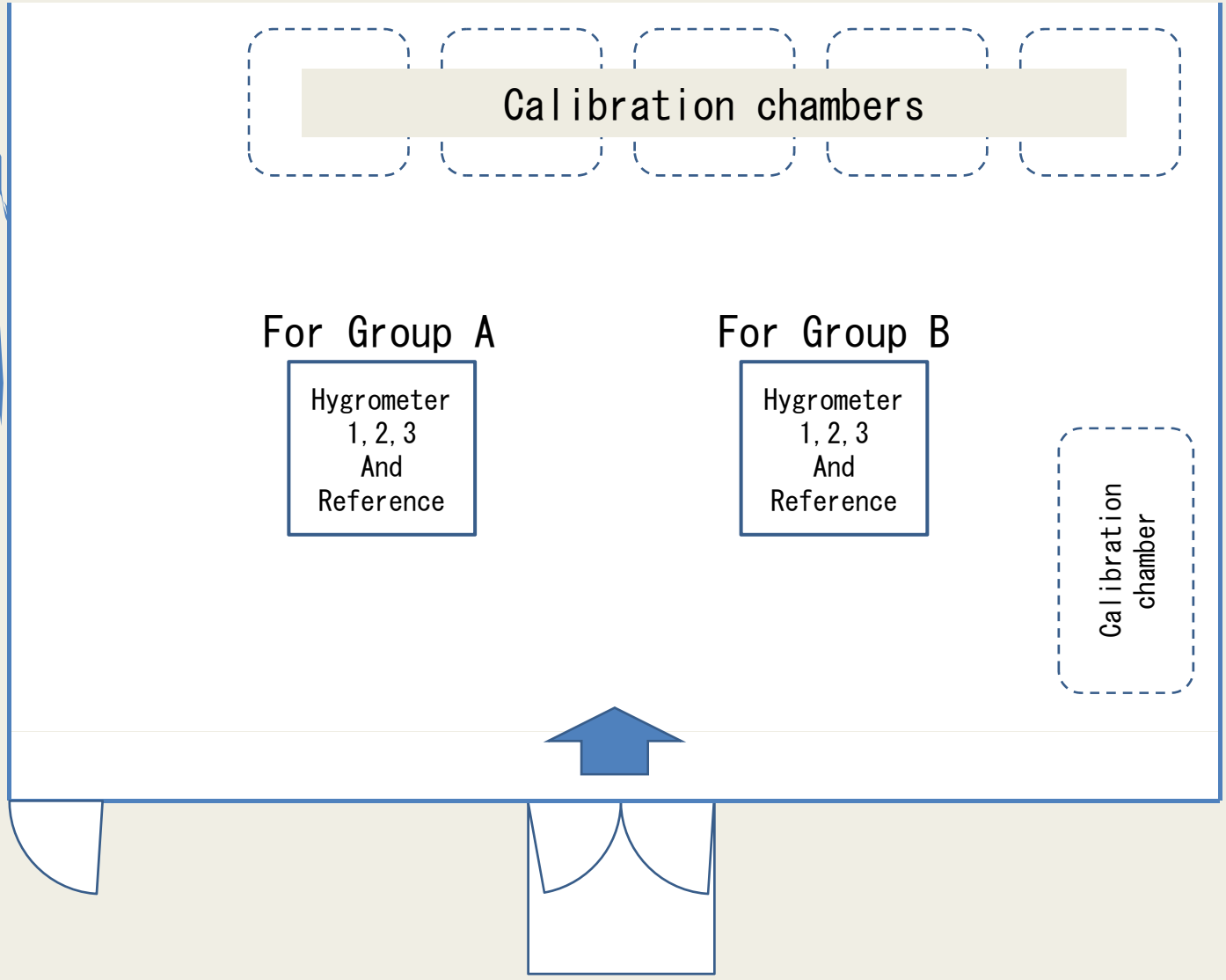
Comparisons against a reference instrument under the room

Purpose: Check the difference between the Hygrometers.

- Reference Hygrometer:
  "Chilled-mirror dewpoint hygrometer"
  HYGRO M－2
  "Platinum resistance thermometer "
  F-250
  Hygrometer１: "Electronic hygrometer "
  Hygrometer２: "Hair hygrograph "
  Hygrometer３: "Aspirated psychrometer "

Demonstrations:Chilled-mirror dewpoint hygrometer setting
Saturated salt solutions(NaCl) setting

inspection room



※ 1st floor

Group A;
- Bangladesh
- Cambodia
- Lao PDR
- Maldives
- Mongolia
- Myanmar
- Nepal

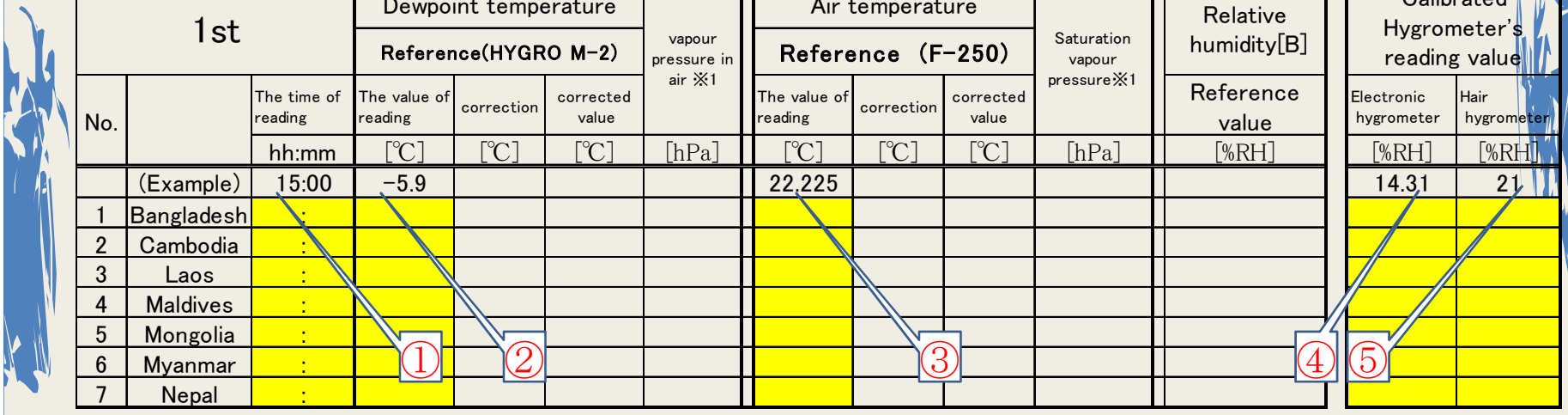
Group B;
- Oman
- Pakistan
- Qatar
- Sri Lanka
- Thailand
- Viet Nam

Commparison form

Example (Group A)

1st			Dewpoint temperature			vapour pressure in air ※1	Air temperature			Saturation vapour pressure※1	Relative humidity[B]	Calibrated Hygrometer's reading value	
			Reference(HYGRO M-2)				Reference (F-250)						
No.		The time of reading	The value of reading	correction	corrected value		The value of reading	correction	corrected value		Reference value	Electronic hygrometer	Hair hygrometer
		hh:mm	[℃]	[℃]	[℃]	[hPa]	[℃]	[℃]	[℃]	[hPa]	[%RH]	[%RH]	[%RH]
	(Example)	15:00	-5.9				22.225					14.31	21
1	Bangladesh	:											
2	Cambodia	:											
3	Laos	:											
4	Maldives	:											
5	Mongolia	:											
6	Myanmar	:											
7	Nepal	:											

			Aspirated psychrometer							Atmospheric pressure	Relative humidity※2
			Wet Bulb			Dry Bulb			T-Tw		
No.			The value of reading	correction	corrected value(T)	The value of reading	correction	corrected value(Tw)			
			[℃]	[℃]	[℃]	[℃]	[℃]	[℃]	[℃]	[hPa]	[%RH]
	(Example)	-	10.9			22.5				1009.80	
1	Bangladesh										
2	Cambodia	-									
3	Laos	-									
4	Maldives	-									
5	Mongolia	-									
6	Myanmar	-									
7	Nepal	-									



Please read twice
(①→⑧
①→⑧)

Please pass the staff after finished.

Thank you for your attention.

See you later