Calibration of barometers
(Lecture and Training)

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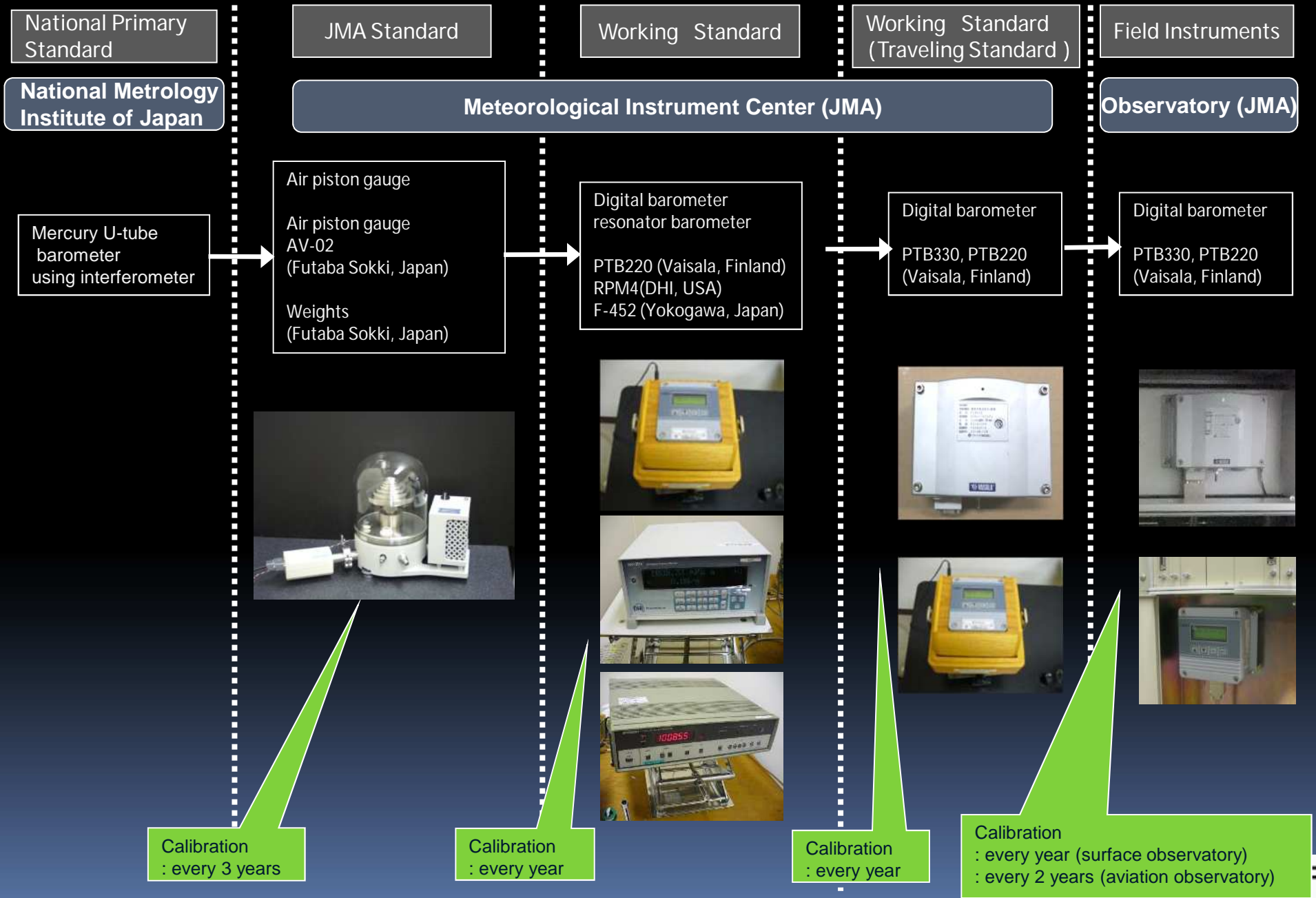*Observing Division, Observing Department*

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Outline

1. How to maintain observation accuracy of atmospheric pressure in JMA
2. How to calibrate the mercury barometers
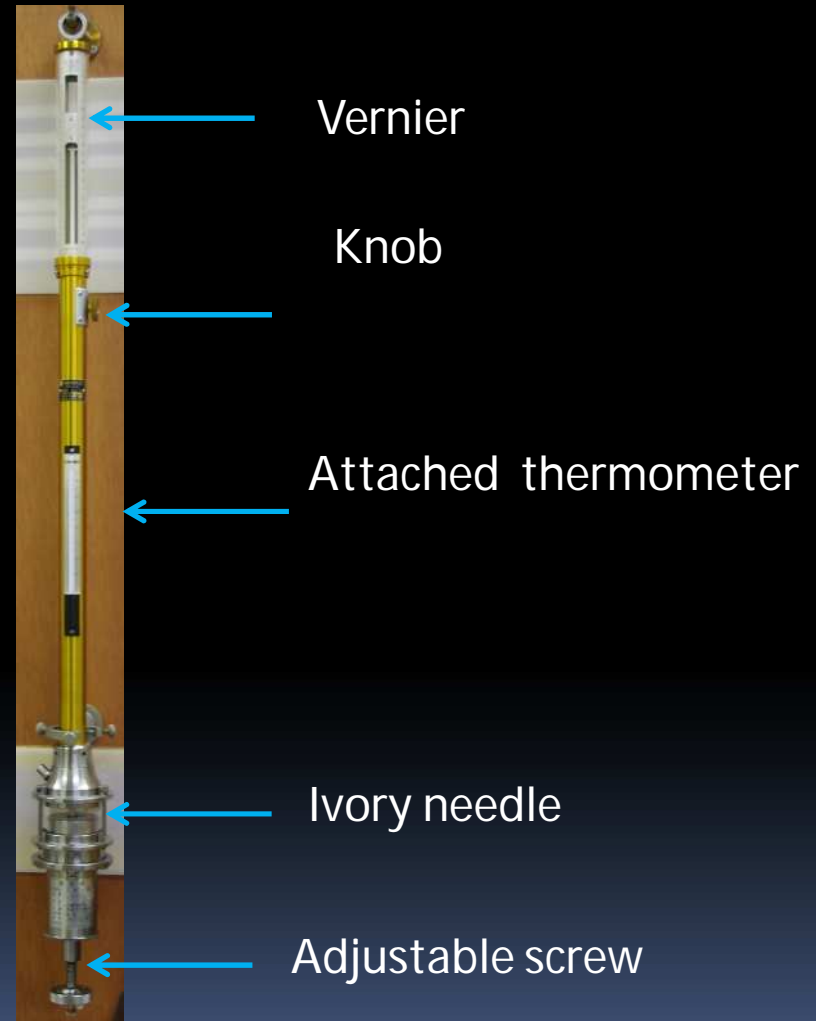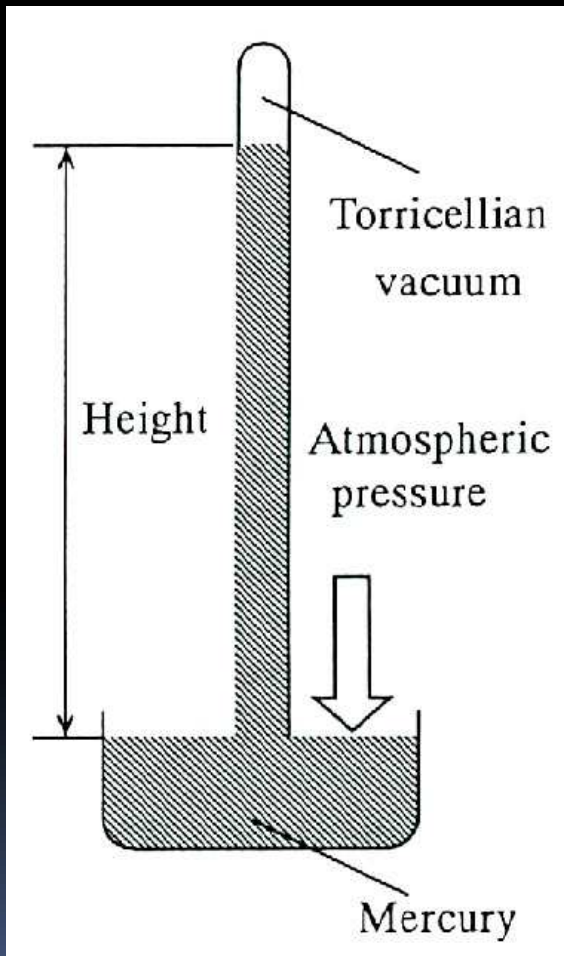3. How to calibrate the electric barometers

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How to maintain observation accuracy of atmospheric pressure in JMA

Traceability of pressure

National Primary Standard	JMA Standard	Working Standard	Working Standard Traveling Standard	Field Instruments
National Metrology Institute of Japan	**Meteorological Instrument Center (JMA)**			**Observatory (JMA)**

Mercury U-tube barometer using interferometer

Air piston gauge

Air piston gauge AV-02 (Futaba Sokki, Japan)

Weights (Futaba Sokki, Japan)

Digital barometer resonator barometer

PTB220 (Vaisala, Finland)
RPM4(DHI, USA)
F-452 (Yokogawa, Japan)

Digital barometer

PTB330, PTB220 (Vaisala, Finland)

Digital barometer

PTB330, PTB220 (Vaisala, Finland)

Calibration : every 3 years

Calibration : every year

Calibration : every year

Calibration
: every year (surface observatory)
: every 2 years (aviation observatory)

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How to calibrate the mercury barometers

The principle of mercury barometer

Torricellian vacuum

Height

Atmospheric pressure

Mercury

Vernier

Knob

Attached thermometer

Ivory needle

Adjustable screw

How to calibrate the mercury barometers ?

(a) Installation

(b) Calibration
Calibration of the mercury barometers against the electric barometer (standard barometer)

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(a) Installation

Standard barometer

Barometer to be calibrated
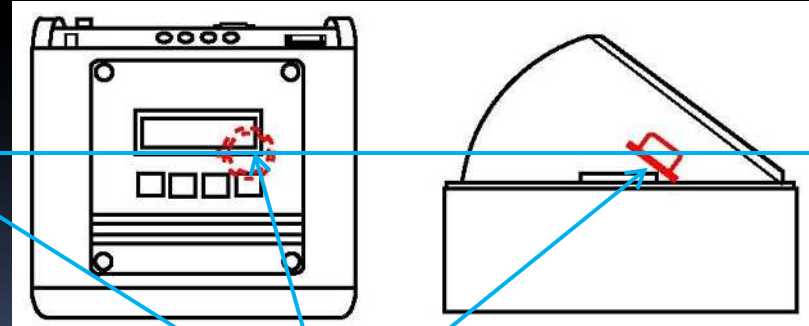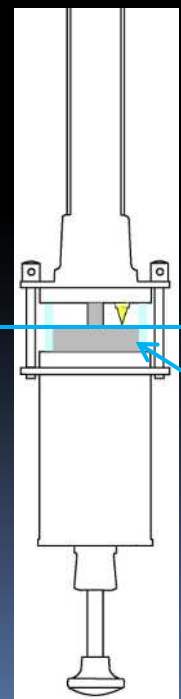
Align the heights of the ivory needle and the sensor inside the electric barometer.

(b) Calibration

How to read a mercury barometer
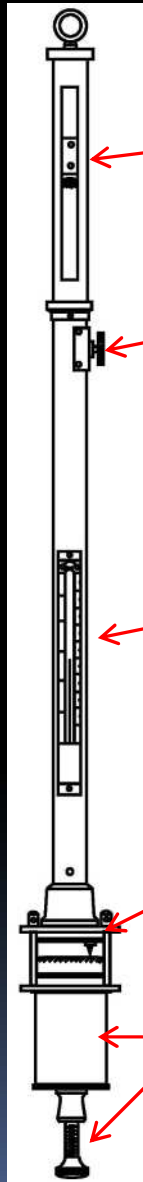
(5) Check again whether the top of mercury column is aligned with the zero line of the vernier, read the value of pressure.

(3) Tap the mercury barometer a couple of times gently and turn the vernier adjustment screw, and align the top of the mercury column with the zero line of the vernier. Never turn the adjustment screw any more.

(1) Read the value of the attached thermometer as quickly as possible

(4) Check again whether the tip of the ivory pointer contacts a mercury surface slightly.

(2) Tap the vessel of mercury a couple of times gently and turn the adjustment screw slowly to raise mercury surface until it contacts the tip of an ivory pointer slightly.
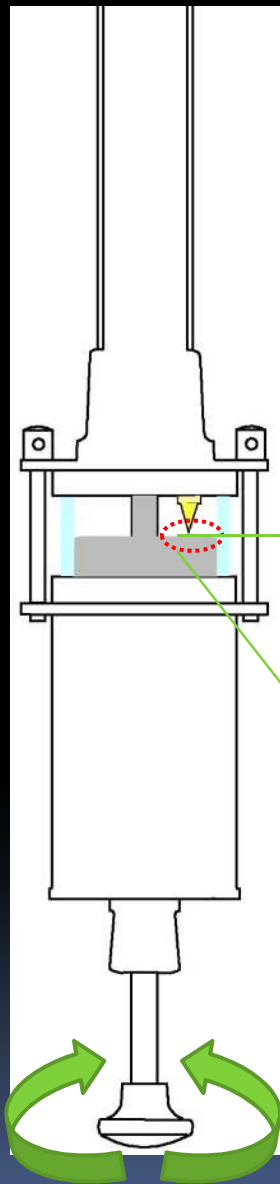
Notes for (2)
Check the position of the tip of the ivory pointer carefully to avoid parallax errors.
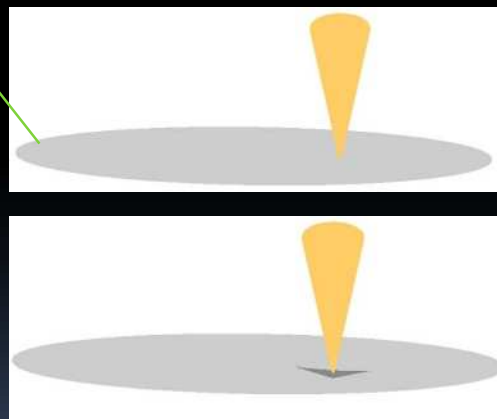
Keep a pit being made onto the surface. In this case, turn an adjustment screw left and lower the mercury surface.

Right turn is to raise mercury surface.

Left turn is to lower the mercury surface.
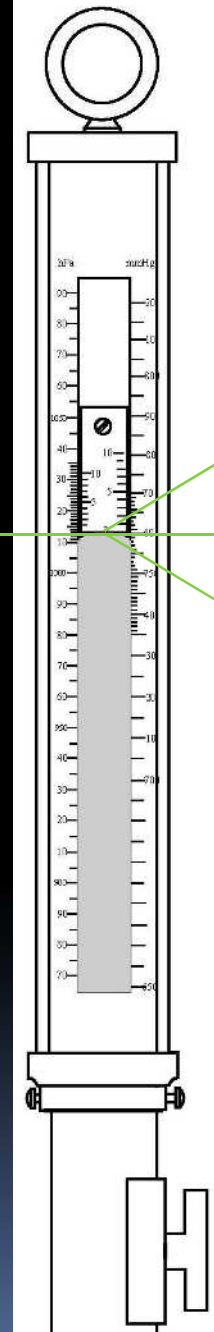
Notes for (5)
Keep an eye on the vernier coming into contact with the top of mercury column !!
Check the position of vernier carefully by making visual identification in a vertical direction.

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How to read the electronic barometer
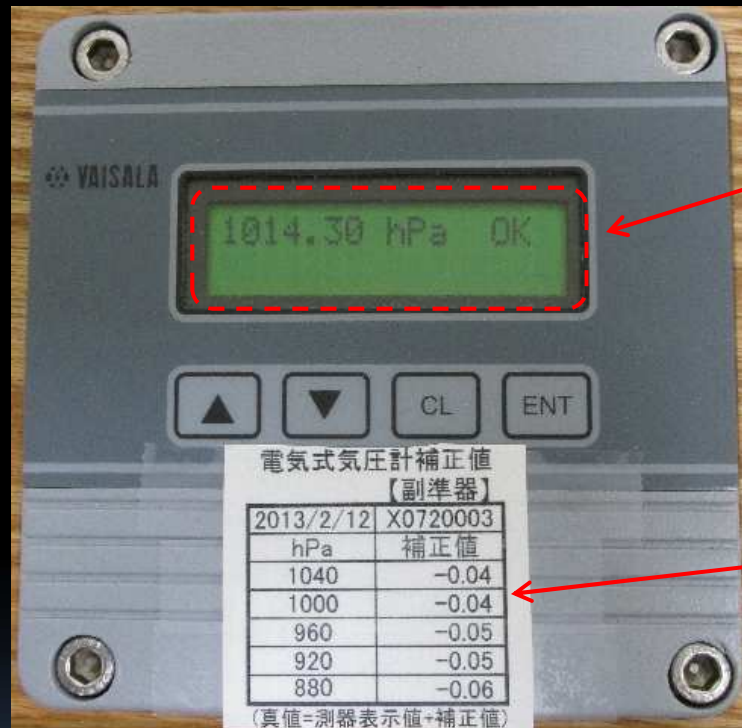
(1) Read the pressure value on the display and write it down in the calibration sheet.

(2) Write down a correction value corresponding for a calibration point nearest from the measured value in the calibration sheet.

Real pressure value
= The pressure value on the display + the correction value

The calibration sheet of Mercury barometer

Barometer to be calibrated
Manufacturer's name
Serial number
Date of manufacture

Serial number of standard barometer

Number of times	Month Day	Hour, minute	Temperature reading of thermometer	Tendency of atmospheric pressure	standard barometer			Barometer to be calibrated (Mercury barometer)				Index errer
					Reading	Correction value	Pressure value	Reading	Temperature correction value	Gravity correction value	Pressure value	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

Correction value _____ hPa

Average	
Standard deviation	
Maximum value	
Minimum value	
Very difference	

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How to calibrate the electric barometer

Principle of Atmospheric Pressure Measurement (Electronic Barometer)

Z0620008

PTB220B

2012年3月校正済

Measurement of electrostatic capacity

Atmospheric pressure

Silicon diaphragm

Electrode I

Vacuum gap

Electrode interval

Glass substrate

Electrode II

Silicon substrate

Atmospheric pressure : small

Electrostatic capacity : small

Vacuum gap

Atmospheric pressure : Large

Electrostatic capacity : large
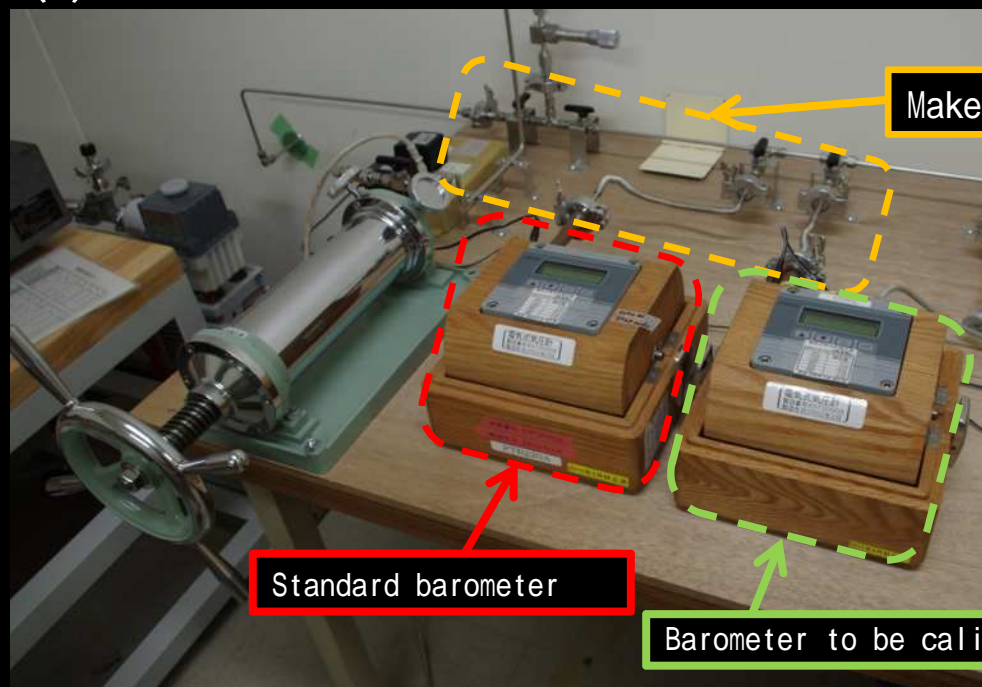
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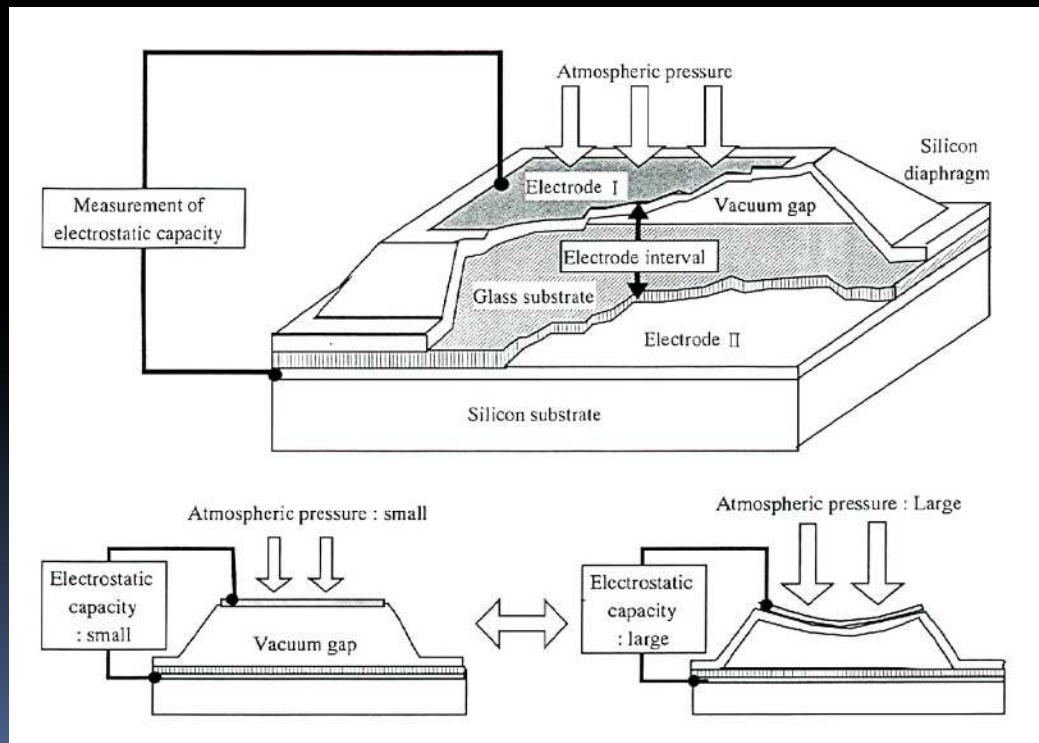
How to calibrate the electric barometers

(a) Installation

(b) Calibration

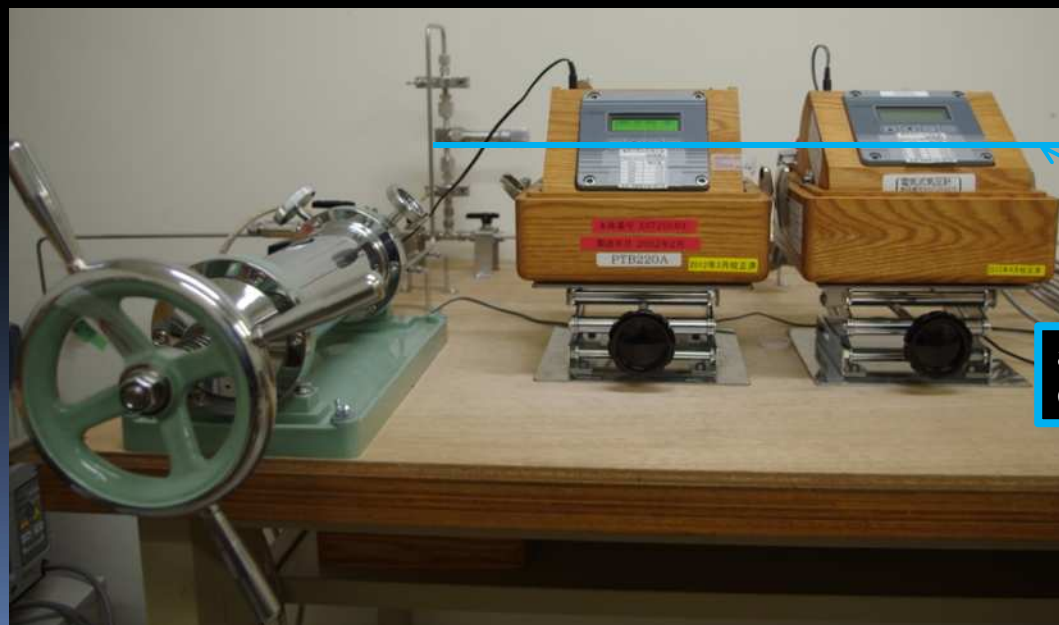Calibration of the electric barometers against the electric barometer (standard barometer)

(a) Installation
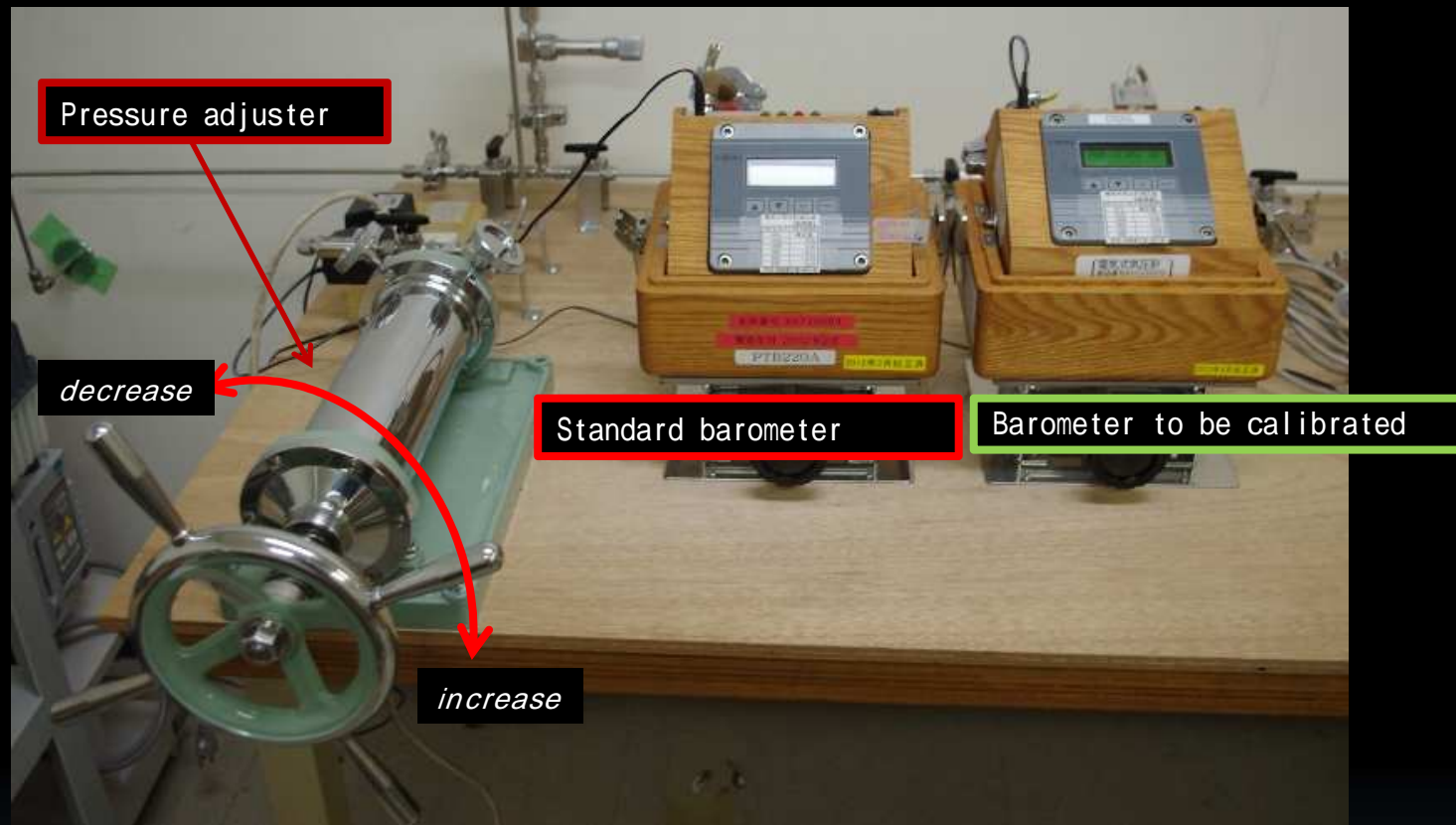

Make sure there are no leaks.

Standard barometer

Barometer to be calibrated

align the heights of both of the sensors inside electric barometers.

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(b) Calibration (Pressure inspection)

Pressure adjuster

decrease

increase

Standard barometer

Barometer to be calibrated

Calibration points   880, 920, 960, 1000, 1040 (hPa

1040→1000 → 960→ 920 →880 (decreasing)
880 →920→ 960 →1000 →1040 (increasing)

3 times

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The calibration sheet of Electric barometer

Barometer to be calibrated
Manufacturer's name
Serial number
Date of manufacture
Measurement range

The date of calibration
Room Temperature
Serial number of standard barometer

Unit: hPa

Calibration point	Standard barometer			Reading of barometer to be calibrated	Difference between standard barometer and calibrated barometer at each calibration point	Average of difference between standard barometer and calibrated barometer at each calibration point (3 times)	Differnce Between adjacent calibration points	Index error	Hysteresis error
	Reading	Correction value	Pressure value						
			(A)	(B)	(C)=(B)-(A)	(C)/3		(D)	
1040						①		(①+⑩)/2 =⑮	
1000						②		(②+⑨)/2 =⑭	
960						③		(③+⑧)/2 =⑬	
920						④		(④+⑦)/2 =⑫	
880						⑤		(⑤+⑥)/2 =⑪	
880						⑥			
920						⑦			
960						⑧			
1000						⑨			
1040						⑩			

Correction value	880	920	980	1000	1040
	=－(⑪)	=－(⑫)	=－(⑬)	=－(⑭)	=－(⑮)

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Appendix: mercury barometer

Corrections for temperature
 The temperature correction means to correct a barometric reading, obtained at a certain temperature, to
a value when mercury and graduation temperatures are 0 °C. The temperature of the attached thermometer
is used for this purpose.
 The height of the mercury column varies with temperature, even the atmospheric pressure is unchanged.
 The graduation of the barometer is engraved so that the correct pressure is indicated when temperature
is 0 °C. In a case that when temperature is above 0 °C, the graduation expands and the measured
value will be smaller than the true value. This effect of temperature must be corrected from these two
aspects collectively. Correction for the expansion and contraction of mercury is much larger than that
for the expansion and contraction of the graduation.
   The correction value for temperature C_t is expressed as follows:

   where:
   H hPa is the barometric reading .
   t °C is the temperature indicated by the attached thermometer.
   μ is the volume expansion coefficient of mercury. ($18.18 \times 10^{-5}(°C)^{-1}$)
   λ is the linear expansion coefficient of the tube. ($1.84 \times 10^{-5}(°C)^{-1}$)
 There is a small difference in absolute values for correction between temperatures below and above
0 °C. The values for correction at temperatures above 0 °C are negative and those below 0 °C are
positive.

 Corrections for gravity
 Gravity affects the height of the mercury column. After the corrections for temperature, the reading
under the local acceleration of gravity has to be reduced to the one under the standard gravity
acceleration. This is called corrections for gravity.
   The gravity value for correction C_g is derived by:

$$C_g = H_0 - H = H \frac{g - g_0}{g_0}$$
   where:
   g_0 is the standard gravity acceleration. ($980.665 cm/s^2$)
   g is the gravity acceleration at a calibration point. (TSUKUBA: $979.949 cm/s^2$)
   H is the barometric reading after the temperature corrections.
   H_0 is the value already corrected for gravitation.
 The gravity acceleration used in corrections for gravity value is calculated to the fifth decimal place,
in m/s^2. When the gravity acceleration at the observing point is larger than the standard gravity
acceleration, the gravity value for correction is positive. Otherwise, the value for correction is
negative.
 To use a barometer for regular observations at a particular location, a synthesis correction table that
summarizes values for correction for index error, temperature and gravity should be used.

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