

Specification for
Dial-type expansion
thermometers

压力式温度计

仅用于学习交流使用



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Foreword

This British Standard has been prepared under the authority of the Industrial Process Measurement and Control Industry Standards Committee. It is complementary to BS 1780 'Bourdon tube pressure and vacuum gauges', Part 2 'Metric units', and, where pressure gauges are panel mounted together with dial-type expansion thermometers, the two types of instrument can present a matched appearance. This standard is intended to promote interchangeability by specifying limits of performance and dimensions.

The dial-type expansion thermometers specified in this standard are suitable primarily for industrial and marine use. They may be suitable for other applications, for example in laboratories and in the medical field.

This standard does not apply to mercury-in-glass thermometers, which are the subject of BS 1041 'Code for temperature measurement', Part 2 'Expansion thermometers', Section 2.1 'Liquid-in-glass expansion thermometers'.

This standard does not apply to thermometers intended for use as approximate indicators.

British Standard Specification for Dial-type expansion thermometers

1. Scope

This British Standard specifies requirements for general purpose liquid, gas or vapour filled dial-type expansion thermometers. It specifies performance, dimensions, tests, materials, markings and packaging requirements. Appendix A gives details of information required for tendering and ordering.

Expansion thermometers for specialized use (e.g. for laboratory or medical use) may be the subject of additional requirements. All temperatures referred to in this standard are temperatures measured on the IPTS-68 Scale or its successor.

2. References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3. Definitions

For the purposes of this British Standard the following definitions apply.

3.1 dial-type expansion thermometer. An instrument which indicates continuously the temperature sensed by the sensitive portion. This is achieved by the change in volume or pressure of a fluid in relation to temperature.

For the purposes of this standard, a dial-type expansion thermometer is taken as consisting of a detecting element, a gauge and a fine bore capillary tube connecting them.

3.2 rigid stem mounting thermometer. A thermometer the gauge of which is supported on the detecting element by a rigid stem which may be straight or bent.

3.3 flush mounting thermometer. A thermometer the gauge of which is intended for mounting in a panel, so that the front of the gauge, when mounted, is virtually flush with the panel.

3.4 surface mounting thermometer. A thermometer the gauge of which is intended for mounting on a surface.

3.5 bracket mounting thermometer. A thermometer the gauge of which is intended for mounting on a bracket and which may be able to swivel to a limited extent.

3.6 detecting element. That part of the thermometer which supports and includes the sensitive portion.

3.7 sensitive portion. That part of the detecting element which contains the major portion of the thermometric sensitive fluid.

3.8 range. The temperature interval over which the thermometer is designed to operate.

3.9 case. The outer casing of the gauge.

NOTE. Customarily, the term 'case' does not include the bezel ring and spacer, the window or the back plate, if this is removable.

3.10 pointer. The index by the position of which, in relation to the scale, the value of the measured temperature is indicated.

3.11 dial. The part of the gauge on which the scale is marked.

3.12 scale. An array of marks together with any associated figuring in relation to which the position of the pointer is observed.

3.13 scale mark. A line or other mark on the dial corresponding to one defined value of temperature.

3.14 scale numbering. The set of numbers marked on a scale corresponding to the values of temperature defined by the scale marks.

3.15 minimum scale value. The value of the temperature corresponding to the minimum scale mark.

3.16 maximum scale value. The value of the temperature corresponding to the maximum scale mark.

3.17 scale range. The temperature zone between the minimum and maximum scale values.

3.18 effective scale range. That part of the scale range over which the specified limits of error are maintained.

3.19 reference conditions. The conditions under which the errors of the thermometer are determined.

3.20 response time. The time interval between the application of a specified change in temperature and the indication of 63 % of the amplitude of the change.

3.21 error. The difference between the indicated value of temperature and the true value.

3.22 permissible limits of error. The specified maximum permissible values of the error.

4. Dimensions

4.1 Detecting element. The dimensions and related tolerances of the detecting element shall be as specified in BS 2765.

4.2 Capillary tubing

4.2.1 The length of the capillary tube shall be as specified by the purchaser.

NOTE. If unusually long tubing is required, the purchaser should consult the manufacturer.

4.2.2 The overall outside diameter of the tubing

connecting the detecting element to the gauge shall

Table 1. Clamp fixing and three-hole fixing dimensions for circular flush mounting gauges

All dimensions in millimetres

Nominal size of gauge	Panel cut out diameter	Flange diameter (max.)	Dimensions for three-hole fixing	
			Pitch circle	Holes to clear screws of size
63	70	90	78	M4
80	87	105	94	M5
100	112	134	121	
150	165	188	175	
200	215	240	225	

4.3 Gauges

4.3.1 The dimensions of the gauges shall be such as to allow the method of mounting specified in clause 5.

4.3.2 The nominal sizes of gauges shall correspond to those specified in BS 1780: Part 2 and shall be one of the following:

63 mm, 80 mm, 100 mm, 150 mm, 200 mm.

NOTE. These correspond to nominal sizes from BS 1780: Part 2. They do not apply to any specified dimension on the gauge. All essential dimensions are specified in this standard.

of them is at the top centre of the gauge.

No precise diameters for the hole in the flange are specified in table 2 nor is any tolerance specified on the pitch circle diameter, but the holes shall be of a sufficient diameter and so located that the flange will pass over the shanks of three screws of the dimensions specified in table 2, which are accurately spaced at 120° apart on the pitch circle the diameter of which is also specified in table 2.

Table 2. Fixing dimensions for circular surface mounting gauges

All dimensions in millimetres

Nominal size of gauge	Pitch circle diameter for surface mounting gauges	Holes to clear screws of size
63	76	M4
80	91	M5
100	116	
150	168	
200	221	

5.4 Bracket mounting. Any bracket upon which the gauge is mounted in the absence of a convenient vertical mounting, shall be formed so as to maintain the gauge in a vertical position.

6. Temperature ranges

NOTE. A pictorial representation of the specified ranges is given in figure 5.

6.1 Liquid and gas filled thermometers. The scale range of liquid and gas filled thermometers shall be selected from those specified in table 3.

5. Gauge mounting

NOTE. Examples of typical gauge mountings are shown in figures 1, 2, 3 and 4.

5.1 Rigid stem mounting. The stem shall be sufficiently rigid to allow installation by means of a clamp or union attachment.

NOTE. Attention should be paid to heat conduction by short rigid stems which might, if unchecked, cause the temperature of the gauge to exceed that specified by the manufacturer.

5.2 Flush mounting. The dimensions for clamp fixing and for three-hole fixing are specified in table 1. The holes of a three-hole flange fixing shall be so disposed that one of them is at the top centre of the gauge. The dimensions of the clamp shall be such that no part of the clamp extends beyond the flange diameter. No precise diameters for the holes in the flange are specified in table 1 nor is any tolerance specified on the pitch circle diameter, but the holes shall be of a sufficient diameter and so located that the flange will pass over the shanks of three screws of the dimensions specified in table 1, which are accurately spaced at 120° apart on the pitch circle the diameter of which is also specified in table 1.

5.3 Surface mounting. The fixing dimensions for circular surface mounting gauges are specified in table 2. The fixing holes shall be so disposed that one

Table 3. Scale ranges for liquid and gas fill thermometers

Scale range	Scale range
-160 °C to +30 °C*	0 °C to +160 °C
-100 °C to +20 °C*	0 °C to +250 °C
-30 °C to +70 °C	0 °C to +400 °C
0 °C to +100 °C	50 °C to +650 °C
+20 °C to +120 °C	

*These scale ranges apply only to gas filled instruments.

For liquid and gas filled thermometers, the scale range and the effective scale range are coincident.

6.2 Vapour pressure thermometers. The effective scale range for vapour pressure thermometers shall be selected from those specified in table 4.

The physical principles governing vapour pressure thermometers result in non-linearity of the scales. Thus, the scale interval at the lower end of the scale is such that the thermometers cannot be read within the specified limits of error. Table 4 therefore gives the preferred scale range for each specified effective scale range. The specified limits of error are obtained over the effective scale range only.

Table 4. Scale ranges for vapour pressure thermometers

Preferred scale range	Effective scale range
-70 °C to +30 °C	-30 °C to +30 °C
10 °C to +50 °C	+10 °C to +50 °C
0 °C to +80 °C	+30 °C to +80 °C
20 °C to +120 °C	+60 °C to +120 °C
+50 °C to +200 °C	+100 °C to +200 °C
+50 °C to +250 °C	+150 °C to +250 °C
+150 °C to +300 °C	+200 °C to +300 °C
+200 °C to +340 °C	+240 °C to +340 °C

7. Materials and construction

7.1 Detecting element. The material to be used for the detecting element and the means by which it is fixed (e.g. union attachment) shall be as agreed between the manufacturer and the purchaser.

Only ferrous materials shall be used in contact with the detecting element.

The surface of the outside of stainless steel shall be as specified in table 5.

7.2 Capillary tubing. The material from which the capillary tubing is made shall be as agreed between the manufacturer and the purchaser. Only ferrous capillary material, which may be sheathed, shall be used for mercury thermometers.

Protection against mechanical damage shall be achieved either by the strength of the capillary tubing itself or by the sheathing of the capillary tubing. The outer surface of the capillary tube or the sheathing, where fitted, shall protect against corrosion.

The minimum bending radius shall be as agreed between the manufacturer and the purchaser.

7.3 Filling. The manufacturer shall make available, if required by the purchaser, particulars of the filling fluid.

7.4 Gauge

7.4.1 Dial. The dial shall be of a suitable metal or plastics material and the finished dial shall be capable of withstanding a dry heat of 85 °C for 10 h and immersion in water at 85 °C for 1 h, without cracking or blistering of the dial or of paint on the dial.

The dial shall be finished matt white with black markings. The scale shall extend over an arc of approximately 270°. The dial shall be clearly marked in degrees Celsius (°C). The marking of abbreviations and quantities on the scale shall be in accordance with BS 1991.

Scale markings shall be in general accordance with BS 3693: Part 2, resolution 0.33 % to 1.25 %, with the exception of those for vapour pressure thermometers, the scales of which are non-linear but should be of a similar style. Examples of acceptable scale markings are shown in figures 6 and 7.

The maximum and minimum scale values shall be at the bottom of the gauge and the scale shall be symmetrically disposed about the vertical centre line of the gauge.

The scale shall not have boundary lines.

7.4.2 Pointer. The pointer shall be of metal or a suitable plastics material. It shall be securely fixed to its spindle and the pointer shall be balanced about its centre of rotation.

In order to reduce parallax errors, the tip of the pointer shall be as near as practicable to the dial. The tip of the pointer shall be of such a width that the gauge may be read to a value within the permissible limits of error.

The end of the pointer shall lie within the maximum and minimum diameters of the scale.

The minimum length (centre to tip) of the pointer shall be as specified in table 5.

The pointer shall move clockwise for increase in temperature.

7.4.3 Case. The case shall be manufactured from material which gives adequate protection against environmental conditions including shocks which are likely to be encountered during transport, storage, installation, normal operation and maintenance. The case shall be as specified in table 5.

Table 5. Length of pointer

All dimensions in millimetres.

Nominal size of gauge	Minimum length of pointer (centre to tip)
63	23
80	30
100	36
150	57
200	80

7.4.4 Window. The window of the gauge shall be of sheet glass having a uniform thickness of not less than 3 mm and shall be free from defects. Other transparent material shall only be used by agreement between the manufacturer and the purchaser.

7.4.5 Protection against weather and atmospheric conditions. Gauges for indoor use shall be designed and constructed so as to be proof against ingress of dust and mist spray.

Gauges for outdoor use shall give adequate protection against atmospheric conditions which are likely to be encountered during normal operation.

Where abnormal environmental conditions occur, special protection shall be provided by agreement between the manufacturer and the purchaser.

8. Performance

8.1 Errors

8.1.1 Maximum permissible errors under reference conditions. Under reference conditions, the maximum permissible errors shall not exceed:

- (a) $\pm 1\%$ of the difference between the maximum and minimum values of the effective scale range for liquid or gas filled thermometers;
- (b) $\pm 1.5\%$ of the difference between the maximum and minimum values of the effective scale range for vapour pressure thermometers.

8.1.2 Effect of ambient temperature. The error per °C change in the ambient temperature surrounding the gauge and capillary tube shall not exceed:

- (a) $\pm 0.03\%$ of the difference between the maximum and minimum values of the effective scale range for liquid or gas filled thermometers;
- (b) $\pm 0.05\%$ of the difference between the maximum and minimum values of the effective scale range for vapour pressure thermometers.

8.1.3 Effect of head. Vapour pressure instruments are more prone than the other two types to errors due to the effect of the head of liquid if the detecting element and gauge are at different levels. This can, in some instances, be taken into account in calibration. Special care should also be taken to avoid reversals of the system resulting from measurements in the region of the ambient temperature or under extreme temperature outside the operating range of the

8.1.4 Mounting attitude. Where the gauge will not be mounted upright in the vertical plane, the instrument shall be calibrated accordingly.

8.2 Long term stability. The errors shall not exceed those specified in 8.1.1 and 8.1.2 after the thermometer has operated continuously for 1000 h under the operating conditions specified by the manufacturer.

8.3 Over-temperature stability

8.3.1 Liquid and gas filled thermometers shall comply with the requirements of 8.1.1 after the sensitive portion has been subjected for at least 5 min to a temperature which exceeds the maximum scale value by 10 % of the difference between the maximum and minimum scale values.

8.3.2 The characteristics of vapour pressure thermometers (increased rate of rise of pressure/temperature at high temperatures) render them especially susceptible to damage by over-temperature, unless the system has been arranged to 'boil-dry' just beyond maximum indicated temperature, thus providing some protection. The manufacturer shall specify on request the over-temperature stability of vapour pressure thermometers.

8.4 Response time. By agreement between the manufacturer and the purchaser the manufacturer shall state the response time of thermometers. It shall be determined by a sudden increase or decrease of temperature by a value corresponding to approximately 50 % of the difference between the maximum and minimum scale values. This temperature excursion shall be entirely within the effective scale range.

9. Determination of errors

9.1 Reference conditions. The reference conditions shall be as specified in this subclause unless otherwise agreed between the manufacturer and the purchaser.

9.1.1 Mounting attitude. The errors shall be determined with the gauge mounted upright in a vertical plane by the method specified by the manufacturer.

9.1.2 Ambient temperature. The ambient temperature of the gauge shall be $20 \pm 5^\circ\text{C}$.

9.1.3 Effect of head. The difference in levels between the detecting element and the gauge shall not exceed 1 m, except for rigid stem thermometers.

9.1.4 Temperature test equipment. The detecting element shall be placed in a constant temperature enclosure, of large thermal mass, the temperature of which shall be measured by a suitable thermometer. The introduction of the thermometer under test shall not affect the temperature of the enclosure. If a liquid bath is used as the constant temperature enclosure, the liquid used shall not damage the detecting element and the liquid shall be stirred continuously.

The temperature of the constant temperature enclosure shall be measured by a method such that the maximum permissible error not greater than one quarter of the maximum permissible error of the

9.2 Test

9.2.1 The shall be the temp the mini thermom reading the cons after the

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9.2.2 T decrease

9.2 Test method

9.2.1 The detecting element of the thermometer shall be placed in the constant temperature enclosure, the temperature of which is near to but not less than the minimum value of the effective scale range of the thermometer under test. The difference between the reading of the thermometer and the temperature of the constant temperature enclosure shall be noted after the thermometer has reached a steady reading.

For values of increasing temperature, the procedure shall be repeated so that at least two further readings are obtained, the highest value being near to but not greater than the maximum value of the effective scale range of the thermometer under test.

9.2.2 This procedure shall then be repeated for decreasing values of temperature.

9.2.3 The increasing and decreasing values of temperature may be obtained by means of several constant temperature enclosures or by a single enclosure whose temperature may be varied. If the latter method is used, care should be taken to ensure that the temperature of the enclosure is stable before readings are taken.

9.3 Test results. The differences obtained at each temperature value in 9.2.1 and 9.2.2 are the errors of the thermometer.

10. Packaging

The manufacturer shall pack the thermometer so that normal transit risks of damage are minimized.

NOTE. Attention is drawn to BS 1133 which gives guidance on packaging and packaging materials.

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Appendix A

Information to be supplied by the purchaser

The purchaser shall state the following in his enquiry and order.

A.1 Temperature to be measured

- (a) The maximum and minimum temperatures to which the detecting element is likely to be subjected both in normal service and in case of malfunction.
- (b) The expected temperature cycle and cycle times if known.

A.2 Conditions of service

- (a) The description of the material the temperature of which is to be measured.
- (b) The description of any other material with which the detecting element is likely to come into contact.
- (c) Whether the gauge will be sited indoors, outdoors or under special conditions (see 7.4.5).
- (d) The expected ambient temperature at the gauge.
- (e) The vertical difference in level between the sites of the detecting element and the gauge, and which of them is higher.
- (f) For vapour pressure thermometers only, the height above sea level of the intended location, if above 1200 m.
- (g) Whether the gauge is likely to be attacked by corrosive agents and, if so, of what nature they are.
- (h) Whether the mounting is subject to vibration.

A.3 Details of instrument required

- (a) *Actuation*. Whether there is any preference for liquid, gas or vapour pressure.
- (b) *Filling*. Whether there are any substances which are not acceptable as filling*.
- (c) *Gauge*
 - (1) The size of gauge (see 4.3).
 - (2) The suggested scale range (selected from those specified in clause 6).
 - (3) The mounting (see clause 5 and figures 1 to 4).
 - (4) The point of capillary entry.
 - (5) The place of mounting if other than vertical.
- (d) *Capillary*
 - (1) The length of capillary.
 - (2) The type of covering.
 - (3) Whether any relative movement is likely between the detecting element and the gauge.
- (e) *Pocket*
 - (1) Whether the purchaser intends to provide a pocket and, if so, relevant details of the pocket†.
 - (2) Whether a pocket is required to be supplied and, if so, relevant details of the pocket†.
- (f) *Detecting element*. In the situation where the detecting element is to be supplied without a pocket:
 - (1) the material of the detecting element;
 - (2) the length;
 - (3) the immersion depth;
 - (4) the preferred diameter;
 - (5) the means of attachment.
- (g) *Any special requirements*.

*For example, mercury is a commonly used filling material, but it is not acceptable in the case of detecting elements which are used for measuring the temperature of foodstuffs.

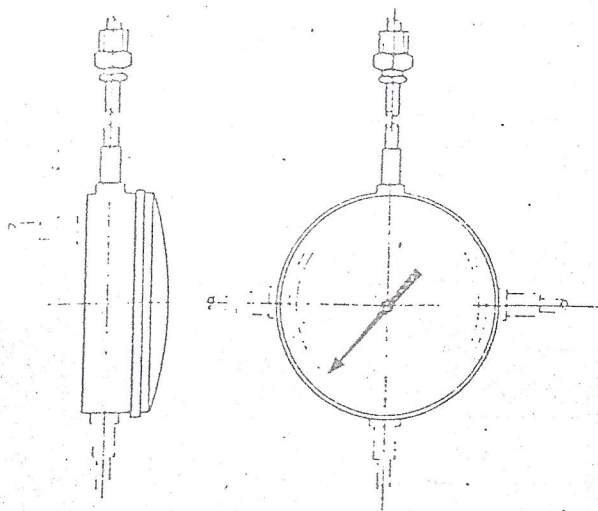
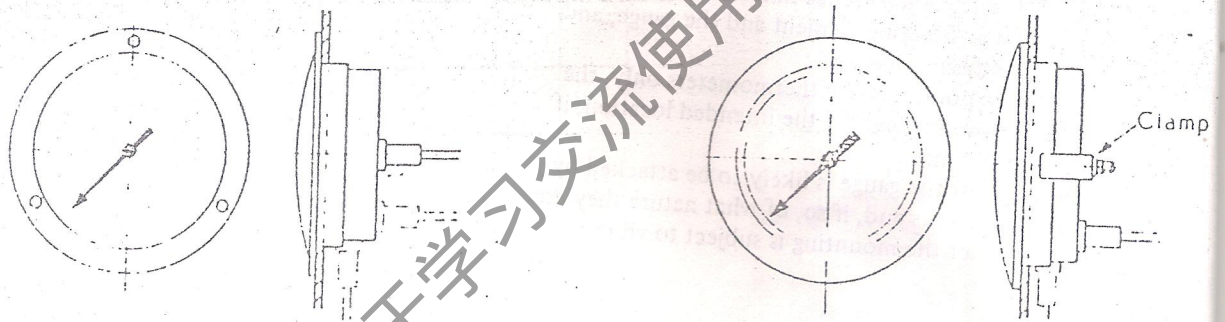


Figure 1. Rigid stem mounting (back, bottom, side or top capillary entry)



(a) With flange fixing and back or bottom capillary entry

(b) With clamp fixing and back or bottom capillary entry

Figure 2. Flush mountings

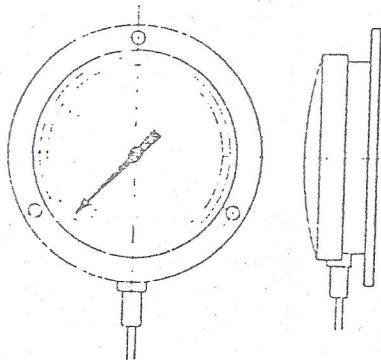


Figure 3. Surface mounting with bottom capillary entry

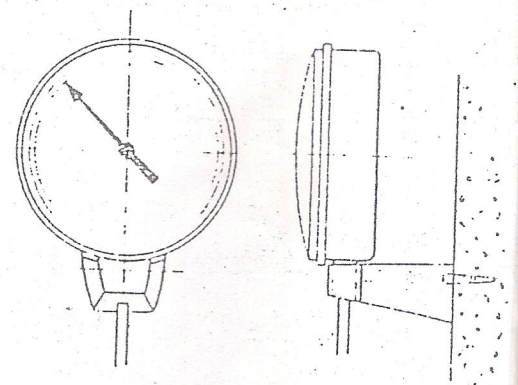


Figure 4. Bracket mounting with bottom capillary entry

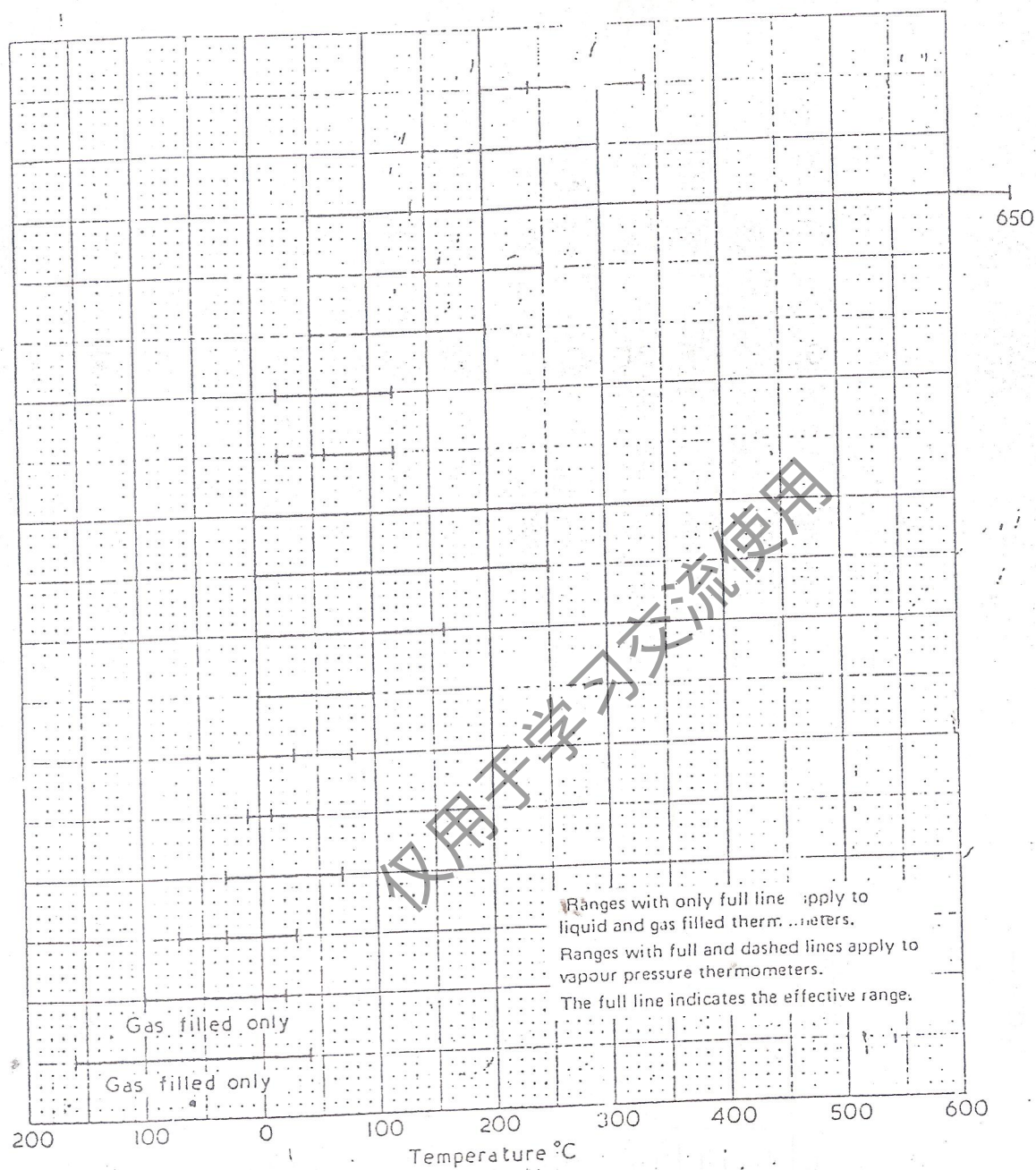


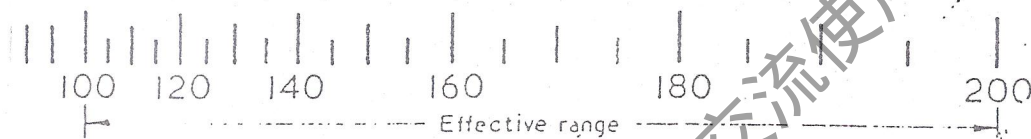
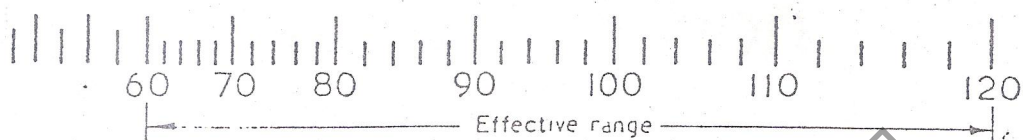
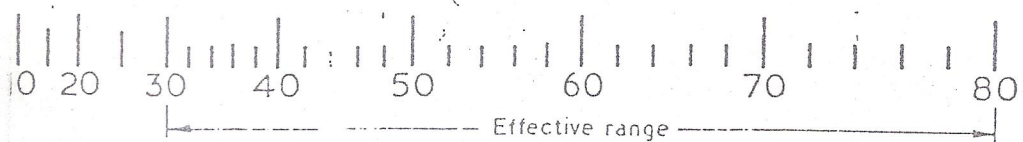
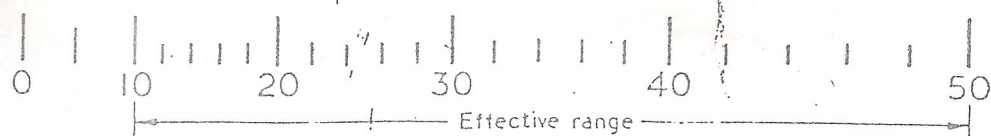
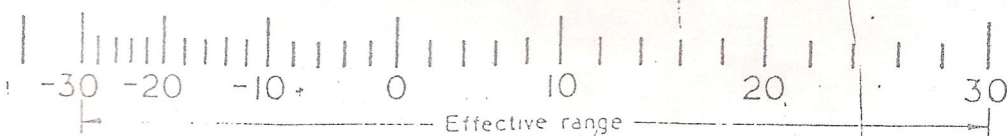
Figure 5. Temperature ranges

Scales (1), (3), (5), (7), (9) are in resolution class 0.67 – 1.25 %
 Scales (2), (4), (8) are in resolution class 0.33 – 0.62 %
 Scale (6) has resolution 0.625 %



Figure 6 Examples of scale markings for liquid and gas filled thermometers

are in resolution class 0.67 — 1.25 %



7. Examples of scale markings for vapour pressure thermometers