Specification for

Thermographs (Liquid-filled and vapour pressure types) —

For use within the temperature range – 20 °F to 220 °F (– 30 °C to 105 °C)

Co-operating organizations

The Instrument Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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British Ceramic Research Association
British Clock and Watch Manufacturers' Association
British Electrical and Allied Industries Research Association
British Electrical and Allied Manufacturers' Association*
British Industrial Measuring and Control Apparatus Manufacturers' Association*
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Individual manufacturers and users

This British Standard, having been approved by the Instrument Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on
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Contents

Foreword

This standard makes reference to the following British Standards:

BS 1133, *Packaging code.*

BS 1986, *Dimensional features of measuring and control instruments and panels for industrial purposes.*

BS 2548, *Wood wool for general packaging purposes.*

BS 2770, *Recommendations for the pictorial marking of handling instructions for non-dangerous goods.*

This British Standard is one of a series prepared under the authority of the Instrument Industry Standards Committee at the request of the Temperature Measuring Instruments Sub-committee of the Joint Equipment Standardization Committee. It is intended to cover Service requirements for a distant reading thermograph, either as a wet and dry bulb hygrograph or as a twin (or single) dry bulb thermograph, as well as requirements for certain industrial and marine uses.

For determining the relative humidity of the air the instrument is used as a wet and dry bulb hygrograph and the relative humidity is calculated using the appropriate hygrometric tables[1)] or slide rule[2)]. When used as a hygrograph several precautions must be taken in order to obtain accurate results; these are discussed in Appendix A. These precautions must be taken if the performance of the instrument, as laid down in the body of this specification, is to be attained.

NOTE Where metric equivalents have been given, the figures in British units are to be regarded as the standard. The metric conversions are approximate. More accurate conversions should be based on the tables in BS 350, "*Conversion factors and tables*".

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

[1)] *Meteorological Office booklet M.O.* 265, H.M.S.O., for non-aspirated wet bulbs with ventilation rates 3 to 6 ft/sec (1 to 2 m/sec). *Guide to current practice*, Institution of Heating and Ventilating Engineers, 1959, for aspirated wet bulbs with ventilation rates greater than 15 ft/sec (5 m/sec).
[2)] Meteorological Office humidity slide rule, for °F or °C, conforming to the current Meteorological Office specification.

1 Scope

This British Standard relates to thermographs of the liquid-filled and vapour pressure types, suitable for general and marine use in the measurement of temperatures within the range – 20 °F to 220 °F (– 30 °C to 105 °C).

The instrument comprises a single or twin-pen recorder with one or two capillary tubes and bulbs respectively. When one bulb is used as a wet bulb, a container for distilled water is provided. A louvred screen may be used to house the bulbs, but the screen is not specified in this British Standard.

2 Materials

The instrument shall be constructed of materials which have been selected so as to avoid the possibility of electrolysis and corrosion.

The capillary tube shall be adequately protected against mechanical damage and corrosion by a sheath or sheaths of suitable material, the outer one of which may be of a plastics material.

When the instrument is used as a hygrograph, the wick shall be capable of conducting from the reservoir a supply of distilled water sufficient to keep the surface of the wet bulb moist under all normal conditions.

3 Design and construction

The thermograph shall preferably use one of the types of drum and chart described in BS 1986[3)], the preferred size of the drum being 126 mm in diameter and 154 mm high. If provision is made for a single drum to carry two charts, however, the drum height may be increased to 308 mm. The fixed spindle type of clock is preferred for drum chart recorders, with one of the rates of rotation given in BS 1986.

Alternatively, the thermograph shall be fitted with a circular chart in accordance with BS 1986.

When the twin-pen instrument is used as a hygrograph, the wet bulb pen shall record "low", or have a time lag, so that it does not foul the dry bulb pen. Similar precautions shall be introduced when the twin-pen instrument is used to record two separate temperature readings. Suitable devices shall be incorporated to prevent damage to the mechanism within extremes of temperature stated by the manufacturer as safe, or those agreed between the manufacturer and purchaser.

The recorder shall be provided with a suitable cover, either with windows on at least the three sides which embrace the drum or with a single window of greater diameter than the circular chart, so arranged as to provide free access for removal and replacement of charts. These windows shall be of permanently transparent non-flammable material. A mechanism for withdrawing the pens from the chart shall also be fitted, operated from outside the cover.

The instrument may be supplied with flexible capillary tubes up to 150 ft (50 m) in length as agreed between manufacturer and purchaser.

4 Temperature range

The instrument shall have one or more of the following nominal ranges (or the nearest convenient equivalent in °C):

– 20 to 100 °F
0 to 120 °F
20 to 140 °F
80 to 200 °F
100 to 220 °F

A liquid-filled instrument shall be provided with a zero adjustment having a range of ± 10 degF. A vapour pressure instrument shall be provided with a zero adjustment appropriate to the range.

5 Accuracy

With the instrument set to read correctly at one point, preferably at 32 °F, the error at any other point on the scale shall not exceed ± 1 degF in any one range of 120 degF.

When the temperature of the bulb is changed over any part of the range, the recorded difference in temperature shall not be in error by more than ± 1 per cent of the interval tested or ± $^1/_2$ degF, whichever is the greater.

When so ordered, the two systems of a twin-pen recorder shall be matched so that the difference in reading between them shall not exceed ± $^1/_2$ per cent of the range, the recorder remaining at room temperature. This accuracy of range shall normally be achieved when the height of the bulb(s) differs from that of the recorder by ± 25 ft, unless any other datum is agreed between the manufacturer and purchaser.

Instruments provided with a zero shift adjustment shall also comply with these requirements in regard to both range and height variation.

[3)] BS 1986, "*Dimensional features of measuring and control instruments and panels for industrial processes*".

6 Compensation

a) *Capillary tube*. For normal use, compensation for temperature of the capillary tube shall be such that if the bulb temperature is maintained constant and the temperature of the capillary tube is changed by ± 30 degF over its whole length, then the change in the reading of the instrument shall not exceed ± $^1/_2$ degF for the 30 degF change. The compensation for special conditions of use shall be the subject of agreement between manufacturer and purchaser.

b) *Recorder*. With the bulb(s) and capillary tube(s) at a uniform temperature a change of temperature of the whole recorder by 30 degF shall not produce a perceptible change in reading.

7 Lag

With the thermometer bulb at equilibrium room temperature, the bulb shall be plunged into a well-stirred water bath differing in temperature by at least 30 degF. The instrument shall take up at least two-thirds of the difference in temperature within 15 seconds.

8 Testing

Certification of thermographs shall normally be carried out by a recognized testing station, but periodic checks on performance and examination for general compliance with this specification may be conducted in the manner described in Appendix B.

9 Marking

The following shall be permanently marked on the upper surface of the base plate, e.g. as in Figure 1:

a) The manufacturer's name or trade mark.

b) A serial number.

c) The number of this British Standard, i.e. "BS 3166'.

d) The nominal range of the instrument.

e) The "safe" temperature limits.

f) The chart reference number.

g) The designed difference in height between the bulb(s) and recorder.

The mark "BS 3166" on a product is an indication by the manufacturer that it purports to comply with the requirements of this British Standard.

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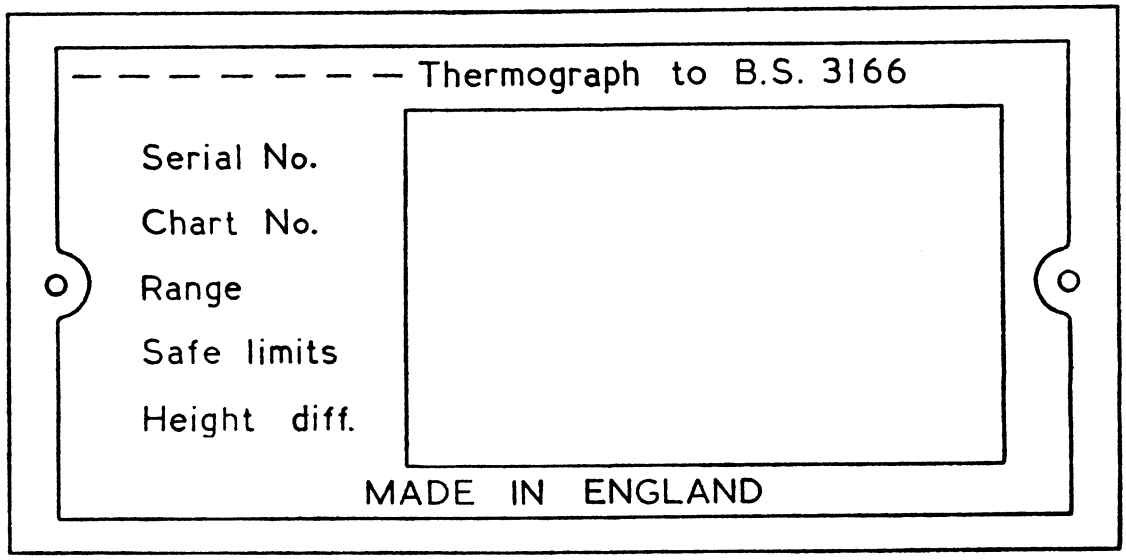

Figure 1 — Typical identification plate

10 Packaging

The instrument shall be packed for transit in such a manner as to minimize the possibility of accidental damage[4)]. Detailed recommendations are given in Appendix C.

[4)] General guidance on methods of packaging and packaging materials is given in BS 1133, "*Packaging code*".

Appendix A Precautions to be taken when the twin-pen instrument is to be used as a wet and dry bulb hygrograph

The principal errors in humidity determinations which occur when this instrument is used as a hygrograph arise from the use of an incorrect value for the wet bulb temperature and therefore, in general, of the wet bulb depression. Common causes of error in the wet bulb temperature are inadequate ventilation or an imperfect wet bulb.

Inadequate ventilation is most likely to be a source of error when the instrument is used indoors, or outdoors on a calm sunny day. It cannot be overstressed that for good results adequate ventilation is essential, and wherever possible it is recommended that the bulbs be artificially ventilated. This may be achieved by *drawing* a stream of air over them, care being taken that the direction of air flow is not from the wet to the dry bulb. For naturally ventilated bulbs exposed in a louvred screen the ventilation rate is assumed to be 3 to 6 ft/sec (1 to 2 m/sec), while for artificially ventilated bulbs the ventilation rate should be more than 15 ft/sec (5 m/sec). Aspirated or non-aspirated hygrometric tables should be used as appropriate. The tables should state the speed for which they are applicable; the slide rule can be used for either case.

Coupled with the errors arising from inadequate ventilation are those caused by conduction along the wet bulb capillary to the wet bulb. Errors due to this cause are greater when the wet bulb depression is large and they also depend on ventilation; they can be reduced to negligible proportions by extending the wet bulb covering for a short distance along the capillary.

The errors due to an imperfect wet bulb arise from many different causes; some of the commonly occurring ones are listed below. It should be remembered that this list is not exhaustive and great care should be taken when planning any installation that all foreseeable sources of error are circumvented, e.g. fortuitous radiation or unrepresentative exposure.

a) **Faulty irrigation of the wet bulb.**

i) Dressing in the wick — the wick should be clean and free from oil or starch and should be changed frequently.

ii) Bacteriological action on the wick — this is particularly prevalent at ambient temperatures above about 95 °F; it can be inhibited without affecting the wet bulb temperature by adding $^1/_2$ per cent by volume of saturated mercuric chloride solution to the water supply.

iii) High ambient temperature (coupled with low humidity) and/or high gas flow rate — met with in some industrial applications or in hot, arid climates; special precautions must be taken to ensure adequate irrigation of the wet bulb, e.g. by drip feed as well as by wick or by control of water temperature.

b) **Contamination.**

i) Pure distilled water should be used; where condensed steam is used as the water supply, boiler water softening compounds may distil over and contaminate the wet bulb.

ii) In many industrial applications fumes, dust or other impurities peculiar to the particular process may condense or settle on the wet bulb— frequent washing and changing of the wick will reduce errors due to this cause.

iii) In marine and coastal installations, there is grave danger of contamination with salt — drip feed may be advisable in view of the frequent washing and changing of the wick which is otherwise necessary.

Table 1 below gives values of the *maximum* error which can occur in the computed relative humidity for a given error in the wet bulb depression at various dry bulb temperatures. The table illustrates the humidity errors which can occur if the precautions outlined above are not taken.
With a good installation the instrument will give a humidity correct to about 5 per cent r.h., except at low temperatures, when difficulty may be experienced in maintaining a continuous ice film in contact with the bulb.

Table 1 — Maximum error in computed per cent relative humidity

Error in wet bulb depression	Temperature of dry bulb				
	20 °F	30 °F	50 °F	70 °F	90 °F
0.5 degF	8	6	5	4	2
1.0 degF	16	12	8	5	4
2.0 degF	27	23	15	10	7

Appendix B Testing of thermographs

1 General

This appendix does not purport to cover in detail the testing of thermographs to the accuracy limits specified, but rather to outline the general procedure to be adopted; the detailed requirements of each particular test are self-evident in the specification.

In making a test, the temperature of the capillaries must be known and variable in relation to that of the bulbs. It is advised that two temperature baths be used; one large enough to contain the capillaries still attached to the mounting board and the other for the bulbs. The bath for regulating the capillary temperature does not need fine control; it should be capable of maintaining the capillary temperature uniform to within 2 degF. The bath required for regulating and determining the bulb temperature is necessarily more precisely controlled since the bulb temperature must be known to 0.2 degF if the instrument is to be tested to the limits specified.

2 Thermographs operating within the range – 20 °F to 140 °F

Both baths should be lagged and the liquid continuously agitated to achieve uniform temperature distribution throughout.
Bath temperatures should be measured with N.P.L. certified thermometers capable of being read to the limits quoted above in this appendix.

For the twin-pen recorder, testing should be done with both bulbs (and capillaries) together so that the requirement on matching (Clause **5**, Paragraph 3) will be checked throughout the range over which the thermograph is tested.

3 Thermographs operating within the range 80 °F to 220 °F

When testing a thermograph operating in the range 80 °F to 220 °F, hot water may be employed under similar conditions to those described above in this appendix. Up to 212 °F it is less convenient to determine a fixed point, but in the neighbourhood of that temperature boiling water can be used in one of two ways:

a) employ a standard thermometer and proceed as previously described, or

b) apply the correction necessitated by atmospheric pressure to the nominal value of 212 °F.

When the water is agitated by a stirrer, compressed air or other means, it can be brought to a gentle boil, but in the absence of such means of agitation it should be boiled vigorously.

The correction to the boiling point of water due to variations of atmospheric pressure is made by the addition (subtraction) of 0.49 degF for *each* 10 mb increase (decrease) of pressure above (below) 1013.2 mb to the nominal boiling point of 212 °F.

The above correction should be determined to the nearest 0.1 degF, which implies a measurement of atmospheric pressure at the level of the apparatus to an accuracy of 1 mb. The pressure can be determined by using an aneroid barometer of known accuracy or, preferably, a mercurial barometer of the Fortin or Kew patterns, taking care that the appropriate corrections are applied.

In either case, the recorder should be operating in its normal manner. The bulb is then correctly immersed and the instrument allowed to run until the record shows definitely that it is giving a consistent reading and has, therefore, attained the temperature of the bath. This value should then be compared with boiling point as corrected for atmospheric pressure or with the reading of a standard thermometer, and any necessary correction made to the adjustment of the recorder.

Appendix C Recommendations for despatch by manufacturer and subsequent movement by customer from site to site

a) **Packaging.**

1) Allow clock to run down.

2) Remove ink from pen-nib (absorb by blotting paper).

3) If reserve ink is contained within the recorder remove the container and pack separately.

4) Operate pen lifter and fix by tying with thread or by using a rubber band, so that the nib does not hammer the chart drum when in transit.

5) Lock lid or door or failing locking arrangements tie with broad tape, so as to prevent the instrument opening when the package is inverted.

6) Cover windows with plywood, fibreboard or very stout paperboard fixed with adhesive tape, thus transferring padding pressure strains to the instrument case.

7) Fix the instrument case to one end of a stout plank by screwing; or when the design does not permit this, by lashing with strong broad tape.

8) Coil capillary or capillaries and arrange on the plank with bulbs, avoiding sharp bends, especially at junctions with the instrument and bulbs.

9) Fasten capillaries and bulbs firmly to the plank so that all bending strains between capillary and instrument or capillary and bulb are avoided.

b) **Transport.**

1) For local delivery by van, etc., carry on layer of wood wool[5)].

2) For air transport, insert in light case with adequate blocking or other support of minimum weight inside.

3) For train, ship or tropical transport, protect the instrument with suitable wrapping and pack in a strong case using a minimum of 8 in. of wood wool on all sides.

4) It is preferable to pack each instrument in a separate case. Where this is not practicable the second instrument should be rested, by means of its plank, on battens fixed to the sides of the case so that the weight of one instrument cannot be transmitted through the packing to the second instrument.

5) For internal use, provide in English the usual warnings of fragility; but for export purposes use the appropriate international "Fragile" sign[6)].

[5)] See BS 2548, "*Wood wool for general packaging purposes*".
[6)] Attention is drawn to BS 2770, "*Recommendations for the pictorial marking of handling instructions for non-dangerous goods*".

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