

Indian Standard

**CODE OF PRACTICE FOR
INSTALLATION AND OBSERVATION OF
INSTRUMENTS FOR TEMPERATURE
MEASUREMENTS INSIDE DAMS : RESISTANCE
TYPE THERMOMETERS**

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CODE OF PRACTICE FOR INSTALLATION AND OBSERVATION OF INSTRUMENTS FOR TEMPERATURE MEASUREMENTS INSIDE DAMS: RESISTANCE TYPE THERMOMETERS

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0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 25 February 1972, after the draft finalized by the Instrumentation Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Volume change and stress occur in concrete dams due to temperature changes also. The temperature changes arise from both external and internal causes. The temperature effect may be of two general types in mass concrete, namely:

- a) The effect due to the chemical reaction of cement combining with water, and
- b) The effect due to climatic conditions.

0.3 The temperatures of the faces of a dam are affected by radiant heating, evaporation of water on the face of the dam, reservoir water, etc. The surface temperature is important because generally cracking begins at a surface.

0.4 The surface temperature is important to study the effect of ambient temperature on the surface of the structures and the temperature gradient through the dam. The external heating and cooling is as important as the heating from within caused by the chemical reaction of the cement combining with water. Most of the internal heating occurs during the first few weeks after casting, but it continues for many years after the dam is completed. Thus, in order to determine the effect of temperature on the stress and volume change in a dam, temperature should be measured at a number of points within the dam, as well as at the boundaries. However, it is not necessary to determine the detailed temperature history of every portion of dam.

0.5 This standard contains clauses which require the user to specify certain technical requirements at the time of placing orders for thermometers. The relevant clauses are 4.2.1 and 4.2.2.

0.6 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS:2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the details of installation and observation of resistance type thermometers of the embedded type for measuring the temperature in the interior of a concrete dam and such other structures.

2. TEMPERATURE MEASURING INSTRUMENT

2.1 Resistance Thermometers

2.1.1 The operating principle is based on the variations of resistance as a function of temperature. Resistance thermometers are designed and constructed for embedment in mass concrete for measurement of internal temperatures. A typical resistance thermometer which is designed to be embedded permanently and directly in the mass concrete is shown in Fig. 1.

2.1.2 The coils of resistance thermometers are wound with suitable platinum or enamelled copper wire wound non-inductively on an insulating core so as to have a definite resistance at predetermined temperature. The thermometers shall have a fixed resistance change over the temperature change of 0 to 100°C. The entire resistance element shall be encased in a soldered brass case to prevent entrance of moisture and the element shall be further protected by filling the inside of the case with joint sealing compound to ensure thermal contact between the coil and the casing.

*Rules for rounding off numerical values (*revised*).

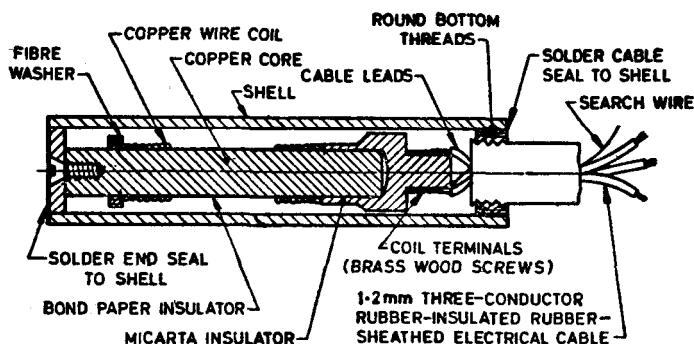


FIG. 1 EMBEDDED TYPE RESISTANCE THERMOMETER

2.2 Measuring Circuits—The measuring circuits shall be in accordance with IS:2806-1964* or any suitable instruments.

3. NUMBER AND LOCATION

3.1 Apart from the externally imposed load and deformation conditions the greatest single factor in causing stresses in massive concrete structures is temperature change. Thus, it is imperative that temperature be measured accurately at many points in the structures.

3.2 It is often sufficient to select those portions of the dam for measurement which are typical, on the one hand, and those which are most severe on the other hand and to concentrate the measurements in such locations.

3.3 Since strain meters and stress meters installed in dams for strain and stress measurements provide an accurate measurement of temperature together with their other indications, there is no need of duplicate instruments for this information at these main points of measurement. However, sufficient resistance thermometers should be embedded at intermediate points to give a complete picture of the temperature in the body of the structure.

3.4 A typical scheme would be to place a thermometer in 15×15 m grid horizontally and vertically in a minimum of one block in the spillway portion, a minimum of one block in the non-overflow portion of the dam and in other portions depending upon the data required for detailed study of the structural behaviour of the dam.

*Methods of temperature measurement by electrical resistance thermometers.

3.5 A few thermometers should be placed near and in the downstream face to evaluate the rapid daily fluctuations in temperature. Thermometers placed in the upstream face as a continuation of the main thermometer grid will serve to evaluate lake temperatures close to the dam.

3.6 In order to better define the steep thermal gradients which may be more prominent near the upstream and the downstream faces of the dam, it is desirable to place thermometers at 15 cm, 1 m, 2 m and 3 m from both the downstream faces of the dam in addition to those in the grid.

3.7 For measurement of foundation temperature, thermometers should be placed near the base of the dam and also in holes drilled into the foundation at desired locations.

3.8 In order to study the effect of operating penstocks and river outlets, on the temperature of surrounding concrete mass, one line of thermometers should be installed, spacing of thermometers from the outside of penstock or outlet pipe being 15 cm, 1 m, 2 m and further as required.

4. INSTALLATION

4.1 In the embedment of a resistance thermometer orientation is not critical and the meter is very rugged. Prior to embedment of resistance thermometers in newly placed concrete, each instrument should be thoroughly checked for meter resistance and lead resistance to assure that all units are in proper operation condition. Immediately after embedment of the thermometer, the location may be covered either with a wooden plank or any temporary protecting device, to protect the thermometer from any damage that is likely to occur during further concreting operations. Identification tags should also be attached to each thermometer and careful record maintained about the location where each instrument is laid.

4.2 Some preparation is necessary prior to embedment. This varies with the type of embedment.

4.2.1 For embedment in the middle of a lift, it has been found helpful to give each thermometer a quick dip in sealing compound as specified by the user, and tape with one layer of friction type tape for additional shock resistance and additional water-proofing insurance during embedment.

4.2.2 Where resistance thermometers are to be embedded at the upstream face to measure water temperatures, additional water-proofing, against hydrostatic pressure is furnished by encasing the thermometer in a suitable length of grout tubing which is then completely filled with sealing compound as specified by the user.

4.2.2.1 For fixing the thermometer at the upstream or downstream face the method shown in Fig. 2 is recommended. As an alternative the thermometer may be held by hand against the form while concrete is back filled around it. It is perhaps better, however, to tie the thermometer

to the form with light wires and provide anchors onto the meter case and back into the concrete so that the thermometer will not be pulled out of the weak concrete, when the form is stripped. Trenches are formed in the fresh concrete for routing the cables from the thermometer to the terminal board location, or if the latter is located in a gallery of the dam below the thermometer location, the cables are routed to a conduit leading from the gallery. Frequently the cable trench is made by vibrating a length of 20×20 cm timber into the fresh concrete after the individual thermometers have been arranged. The timber is then removed from the trench, the lead cables placed in the depression and the depression backfilled with concrete by hand to cover the cables.

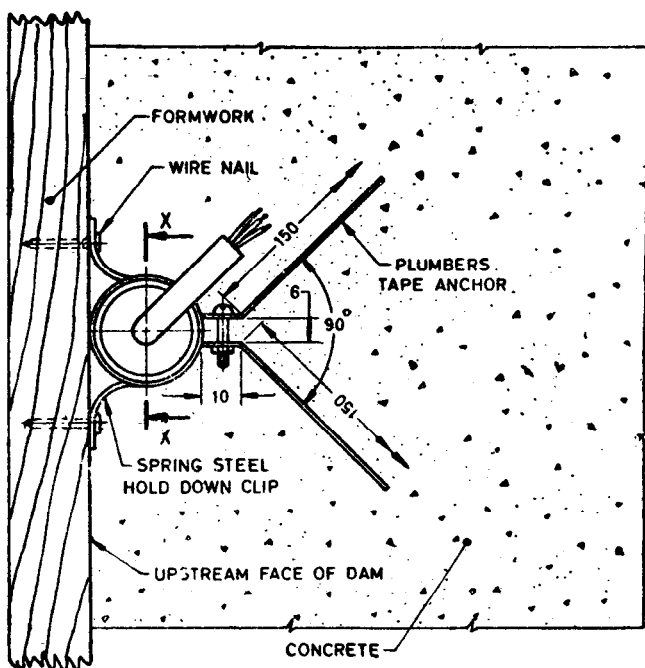
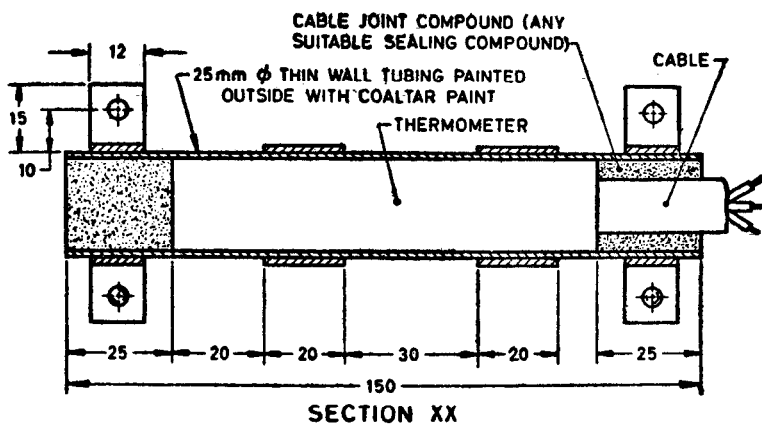
4.2.3 For embedment at the base of a lift, it is best to tie down some wires to the concrete of the previous lift or between two cooling pipes. The thermometer may then be wired or taped securely, to hold down the thermometer so that the pressure of the mass concrete will not dislodge it.

4.2.4 For an installation at the top of a lift, a small hole may be dug and the thermometer inserted and covered immediately, using the foot, or a vibrator, to puddle the concrete around the instrument. For accurate spacing at various heights in a lift, the thermometers have sometimes been taped to a wood pole carefully maintained in vertical position.

4.3 Cables and Conduits

4.3.1 Rubber-insulated, rubber-covered stranded copper cables have proved tough and resilient enough to give good service during the shocks of embedment, and during its long exposure to the alkaline solutions of the hydrating concrete. In general, cables run from the instrument to the nearest gallery for their terminal locations; horizontally directly in the concrete without conduit, and in downward and upward directions in conduit. The conduit may be of almost any material which will not collapse in the fresh concrete. The size of the conduit may easily be chosen by drawing circles of the diameter of the cable. In order to allow for pulling friction and cable crosses, provide for one and half times the number of cables where the conduit run is short, up to twice the number of circles as there are cables where the runs are long or there are many bends. Circumscribe these circles with a larger one to find the inside diameter of the conduit.

4.3.2 If the cable leads are to cross expansion or contraction joints in the structure a slack cable recess should be provided at the crossing point. This may consist of a wooden box block out, forming a recess into which the cable is run. During placement of concrete in the adjacent block a 30 cm loop of slack cable is left in the unfilled block out and the remaining length of cable laid in the usual manner.



All dimensions in millimetres.

FIG. 2 TYPICAL LAYOUT OF SURFACE THERMOMETERS

4.3.3 Cables should be threaded individually into the conduit, so that each cable will be required to support only its own weight. At the entrance of the cables into the conduit suitable protection, such as padding with burlap, should be provided around each cable and in the interstices between the cables to prevent sharp bends and to prevent the entrance of concrete and grout into conduit.

4.3.4 Where a group of many cables is to be run horizontally in a lift, they may be taped together at intervals and laid on the top of the next to last layer of concrete in the lift, covered with pads of fresh concrete at several points along their length, and placement of the final concrete lift layer allowed to proceed in the normal manner. Single or pairs of cables leads may be 'walked into' the concrete.

4.3.5 The layout should be planned so that meters and terminal boards are in the same block.

4.3.6 In the general case where a number of cables from widely separated points are collected at one central point and run downward in conduit, a very successful plan is to run the cable in two steps. A collecting box or concrete form is erected around the grouped conduits so that the lift is left about 45 cm low at the conduits. During the placement of the concrete in which the meters are embedded, the cables are brought horizontally to the collection point and there coiled and hung out of the fresh concrete. As soon as the concrete has set sufficiently to bear traffic, the cable coils are taken down the conduit to the terminal boards. The advantages are that it is much easier to sort and run cables when they are not muddled with fresh concrete.

4.4 Terminal Boards — The cables should be terminated in a suitable terminal board.

5. OBSERVATIONS

5.1 The observations of the instruments should begin as soon as the instruments are covered and continue at gradually increased time intervals. As the concrete hydrates, the resulting heat induces volume changes and consequent stress change which vary rapidly during the early days of the concrete and more slowly later. Hence enough observations shall be available to give the complete picture of these changing conditions of temperature. The following sliding schedule that has proved effective is recommended:

- a) An observation as soon as the meters are covered (embedded) and two more that day;
- b) Two observations on the second day;
- c) One reading per day for ten days or until maximum temperature is reached;

- d) Reading every other day for ten more days;
- e) Thereafter, twice weekly for a month; and
- f) Thereafter, weekly until the construction is completed. Usually available help falls off sharply at the end of the construction period and observations should be continued on a twice a month basis, if help can be spared but not less than monthly, if the help situation is critical.

5.2 A recommended *pro forma* for the record of observations in the field and for transfer of observations to a permanent record in the office is given in Appendix A. Suitable data sheets should be printed in advance upon which the observations can be noted as they are taken and for preparation of permanent records.

5.3 Resistance thermometers are based on the fact that the ohmic resistance of a metal wire varies at a practically linear rate with the temperature. The thermometer readings are taken by a test set operating on the Wheatstone Bridge principle.

5.3.1 With the calibration provided for the thermometers (resistance at 0°C and the change of resistance per °C), resistance readings can be converted directly to temperature.

6. SOURCES OF ERROR

6.1 The following are the sources of error in measurement of temperature by resistance thermometers and should be checked frequently:

- a) Low voltage of test set batteries,
- b) Loose connection of cable terminals on terminal panels,
- c) Loose connections in the test set circuit, and
- d) High voltage may cause heating of the wire and thus affect accuracy of the reading.

APPENDIX A

(Clause 52)

THERMOMETER DATA SHEET**Field Record Sheet**

Project: Sheet..... of.....
 Ambient temperature °C Date:
 Reservoir level: Observer:

THERMOMETER No.	TIME OF OBSERVATION	METER RESISTANCE		REMARKS
		Previous Reading with Date	Present Meter Reading	

Temperature Data Permanent Record

Project: Sheet..... of.....
 Thermometer No.

Location: Block..... Chainage..... Station..... Elevation.....

Meter resistance at °C.....

Change in temperature per ohm change in resistance.....°C

DATE	TIME	METER RESISTANCE Ω	TEMPERATURE °C	OBSERVER	REMARKS
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NOTE — Record any observations like overflow of water, etc, which are likely to influence the reading of any thermometer which may deviate from the normal.

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