Standard Reference Materials 933 and 934: The National Bureau of Standards’ Precision Thermometers for the Clinical Laboratory

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Because many facets of clinical laboratory work, such as enzymatic reactions, pH measurements, and blood-gas analysis, are highly sensitive to temperature, there is a need to measure temperature accurately and closely control it. To help satisfy these needs and to aid in getting a usable temperature scale into the clinical laboratory, the National Bureau of Standards has developed SRM 933 and SRM 934. These precision thermometers are calibrated at 0, 25, 30, and 37 °C. Their value to the clinical laboratory is described.

Apart from its use in monitoring the temperature of patients in hospital wards, during surgery, and in intensive-care units, temperature measurement and its control are of critical importance in many aspects of the clinical laboratory and in the hospital generally. The temperatures at which enzyme rate analyses are conducted, for example, are very important because of their high temperature sensitivity (1–5). It is well known that the rates of enzyme reactions change by about 10% per degree Celsius change in temperature (6). Hence, for reproducible results within a given clinical laboratory and for meaningful intercomparison among laboratories, the temperature not only must be carefully controlled but must be known absolutely. Recognizing this situation, the Expert Panel on Enzymes, which was created by the International Federation of Clinical Chemistry Committee on Standards, has recommended (7) in their Proposal for I.F.C.C. Reference Methods for Enzymes, that the set point in degrees Celsius of the reaction temperature is to be assigned as a part of the method, that the temperature accuracy must be assured to ±0.05 °C by calibration against the International Practical Temperature Scale of 1968 (8), that the temperature variation of the reaction mixture should be held within the open interval −0.05 and +0.05 °C of the set point, and that the choice of reaction temperature for an IFCC reference method should be 25.00, 30.00, or 37.00 °C. Of course, enzymatic reactions are not unique in being sensitive to the temperature; pH and blood-gas analysis are two others of a long list that could be mentioned (9, 10).

Because of these needs and in order to assist in getting a usable temperature scale into the clinical laboratories (and hospitals generally) and, further, because there is not commercially available a precision thermometer of very limited range especially suitable for the clinical laboratory, NBS is providing precision laboratory thermometers, Standard Reference Material (SRM) 933 and SRM 934,1 designed specifically for use in the clinical laboratory. These SRM’s are available through the Office of Standard Reference Materials and they were produced in cooperation with the Medical Thermometry Program of the Temperature Section in the Heat Division. Many specifications, such as short overall length, partial immersion, limited temperature range, provision for checking calibration, and an uncertainty of calibration of less than ±0.05 °C, requested by clinical laboratory personnel concerned with accurate temperature measurements have been incorporated in the design.

The three thermometers comprising SRM 933 are shown in Figure 1 and the linear dimensions of the thermometers are as indicated. These are solid-stem mercury-in-glass type instruments. The stems have a plain front, enameled back, and are of lead-glass thermometer tubing 7 mm in diameter. The bulbs are also 7 mm in diameter. Nitrogen gas fills the space above the mercury. Special markings consist of a serial number, the manufacturer’s name or trade mark, and a 95-mm immersion line. Each thermometer has an auxiliary scale from −0.20 to +0.20 °C, with 0.05 °C subdivisions. The main scale of the thermometer on the left of Figure 1 is 24.00 to 26.00 °C, with 0.05 °C subdivisions; that for the thermom-

1 SRM 933 and SRM 934 are currently available through the Office of Standard Reference Materials, National Bureau of Standards, Washington, D. C. 20234. The price of SRM 933 and of SRM 934 is approximately $175.
ometer in the middle is 29.00 to 31.00 °C, with 0.05 °C subdivisions; and that for the thermometer on the right of Figure 1 is 36.00 to 38.00 °C, with 0.05 °C subdivisions. The graduations have longer lines at intervals of 0.10 and 0.50 °C. In addition, there are numbers every 1 °C. These three thermometers come packaged in one box.

SRM 934 consists of the one thermometer shown in Figure 2 and its linear dimensions are as indicated. Except for the main scale—which is 24.00 to 38.00 °C, with 0.05 °C subdivisions—and its overall length, the specifications of this thermometer are the same as those for SRM 933.

All thermometers of SRM 933 and 934 have been individually calibrated (11) in a stirred-liquid comparison bath at constant temperature against the International Practical Temperature Scale of 1968 (8). A precision platinum resistance thermometer was used as the interpolating and transfer device (12). Each thermometer has been calibrated at 0.00 °C. In addition, the one of SRM 934 has also been calibrated at 25.00, 30.00, and 37.00 °C. One of SRM 933 has also been calibrated at 25.00 °C, the second one at 30.00 °C, and the third at 37.00 °C. The maximum error at any calibrated point is no greater than 0.03 °C. The report accompanying the thermometers gives typical emergent-stem temperatures for the thermometers immersed in baths at 25, 30, and 37 °C. The emergent stem is defined as the length of mercury column and stem exposed to the ambient temperature. Of course, corrections can be made for emergent stem temperatures different from those listed by using the accepted correction formula given in the report. Some of the thermometers were checked at partial (95 mm) and total immersion to verify the correction formula, and it was confirmed to be accurate.

The auxiliary scale from −0.20 to +0.20 °C is provided so that the user may check the calibration of the thermometers at the ice point. This temperature point is readily available to anyone who has access to distilled water and a freezer, and the check is easily made.2 This check will indicate to the user whether or not the calibration has changed because of changes in bulb volume.3 If the calibration has changed at the ice point, then it has also changed at the other temperatures, and the original calibration is no longer correct. In general, however, any change observed at the ice point can be expected to be reflected in all other points of the scale, including the

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2 To make an ice bath, a Dewar flask may be used as a container, since the insulating properties of the vessel retard the melting of the ice. Ice shaved from clear cakes or from that made with distilled water is mixed with distilled water to form a tightly packed slush. Enough water is used to afford good contact with the thermometers, but not so much as to float the ice. From time to time excess water is siphoned from the bath. Care should be taken to prevent contamination of the ice and water.

3 Because of bulb expansion, a temporary ice point depression will be introduced when the thermometer is heated above room temperature. Because of this depression, the thermometer should never be used at a given temperature shortly after it has been heated beyond that temperature.
calibration points, by the same amount and in the same direction (11).

These SRM's have been produced with the clinical laboratory specifically in mind. The thermometers may be used in constant temperature baths or in instruments to monitor the temperature, especially in those instances where the incubation of reactions or where specific measurements are to be performed at 25, 30, or 37 °C. They may also be used as secondary standards against which other thermometric sensors can be calibrated in the hospital's and clinical laboratory's standardization programs. This may include other liquid-in-glass thermometers, electronic thermometers—both continuously monitoring and maximum reading types—the sensors in thermal dilution catheters, fever thermometers, small temperature-sensors (thermistors, platinum resistance thermometers, thermocouples, etc.) used in temperature-control systems located in enzyme and other type analyzers, spectrophotometers, pH, and blood gas analyzers, etc. In such standardization, however, the bath in which the various thermometers are compared must be well stirred, to achieve uniform temperatures throughout the bath, and one must be aware that the liquid-in-glass thermometers do not respond instantaneously to changes in temperature.

With the introduction and use of these SRM thermometers in the clinical laboratories, there will be a marked improvement in their temperature-measurement capability. The thermometers will provide a means by which the laboratory personnel can evaluate any uncertainty in their testing that is the result of inaccurate temperature measurements and, in many cases, inadequate temperature control. This will assist efforts at improving measurement reproducibility within a given laboratory and intercomparisons among laboratories.

Although these SRM thermometers were designed to fill an existing need and to assist in making an initial effort toward badly needed improvements in the measurement and control of temperature in the clinical laboratory, the major needs as regards temperature sensors are for small, highly sensitive, reproducible, interchangeable, and fast-responding devices. Because of these needs we have begun a study as a part of the Medical Thermometry Program at the National Bureau of Standards to properly characterize thermistors, small platinum resistance thermometers, thin films, and various other small sensors that appear to possess some or all of the above properties and that have not been adequately characterized previously. This all fits into the work toward the goal of marked improvements in the measurement and control of temperature throughout the nation's hospitals and clinical laboratories and, thereby, leading to improved health care.

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References