RCA Application Note

AN-200

# Techniques for Measuring Electron-Tube Bulb Temperatures

This Note discusses basic techniques essential to accurate measurement of bulb-surface temperature of electron tubes. It points out sources of errors usually associated with such measurements, and indicates precautions that should be taken to avoid them. It also describes a recommended measurement procedure that has excellent repeatability and insures a minimum amount of error.

Bulb-temperature measurements are essential to determine whether the "hot-spot temperature" of a tube operating in a given application is within the published bulb-temperature rating. Because bulb temperature is indicative of the operating plate temperature of a tube, accurate temperature measurements also permit a precise determination of the plate dissipation in a tube operating in a specific application. Bulb temperature is also closely allied, especially in high-voltage types, to electrolysis in the tube glass, a factor directly related to the life expectancy of the tube. Because of the growing demand for tubes having higher and higher ratings, and for operation in small, inadequately ventilated spaces, the ability to determine the exact bulb temperature of a tube is becoming increasingly important.

## Essential Factors of an Accurate Measurement

An approximate indication of bulb temperature may be obtained by application of materials that melt at known temperatures to the bulb surface; a material such as Tempilaq, which can be obtained in various forms from the Tempil Company of New York, is normally used for this purpose. However, this material only isolates the bulb temperature to a particular range of values; if an exact temperature measurement is required, a thermocouple device is used with a calibrated potentiometer indicator that provides readings either directly in degrees or in millivolts.

Two factors are essential for precise measurement of the hot-spot bulb temperature: First, the bulb "hot spot" must be located with the tube operating in its intended application. A simple technique for locating



ELECTRONIC COMPONENTS AND DEVICES
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

11-63

the hot spot is to apply a low-temperature-melting Tempilaq to the entire bulb surface; the point at which this material first begins to melt is the hottest point on the bulb. Second, the thermocouple junction must be properly attached to the bulb surface directly at the hot spot. This operation is critical, and precautions must be taken to insure that accurate results are obtained.

## Sources of Error in Current Measurement Techniques

Several types of error may be introduced when a thermocouple is used to measure the bulb temperature of an electron tube:

1. Inaccurate measurements may be obtained if the wrong type of wire is used for the thermocouple. For example, iron-constantan wire tends to be inhomogeneous, and may introduce appreciable errors, particularly at temperatures below 200° F.* Chromel-alumel thermocouple wire is recommended to eliminate this condition.

2. Precise measurements may not be obtained if the thermocouple wire is too large. The use of small-gauge wire (AWG 26 to 30) is recommended to prevent excessive heat being conducted away from the hot spot by the thermocouple.

3. A poor thermocouple junction may contribute to errors in the measurement. Neither soldering nor high-voltage arcing is recommended for joining the two dissimilar metals to form this junction. Soldered junctions usually become embedded in the solder area and may not make proper contact with the bulb surface; high-voltage arcing creates relatively large junctions and carbonizes the metals. The recommended technique for joining the thermocouple wires is welding. This method insures a durable, uniform junction and has none of the drawbacks of the other two methods. Once the thermocouple wires are joined, the junction area should be thoroughly cleaned with an abrasive material to remove any oxidation or burrs formed during the joining operation.

4. Environmental air currents may cause erroneous readings if they are permitted to affect the temperature of the bulb.

5. The method selected for attaching the thermocouple junction to the bulb surface may prevent a precise measurement of the bulb temperature. The basic features and drawbacks of methods currently being used are as follows:

(a) An excellent indication of the average bulb temperature can be obtained by welding the thermocouple wires to opposite sides of a split phosphor-bronze ring that makes good thermal contact with the bulb. However, this method cannot be used for hot-spot measurements because the thermocouple junction is spread over a large area (i.e., it is not restricted to the "hot spot").

(b) Sauereisen cement can be used to hold the thermocouple junction directly on the hot spot. Although it is difficult to keep the junction against the bulb surface while the cement is drying, this method can be used to obtain a satisfactory indication of bulb

---

* Herzfeld, C.M., Temperature, Its Measurement and Controls in Science and Industry, (AIP) Vol.3, Part 2, page 18, Reinhold Publishing Corporation, New York, 1962.

temperature. However, because of the hardened cement that forms on the junction, the thermocouple cannot be re-used for subsequent measurements.

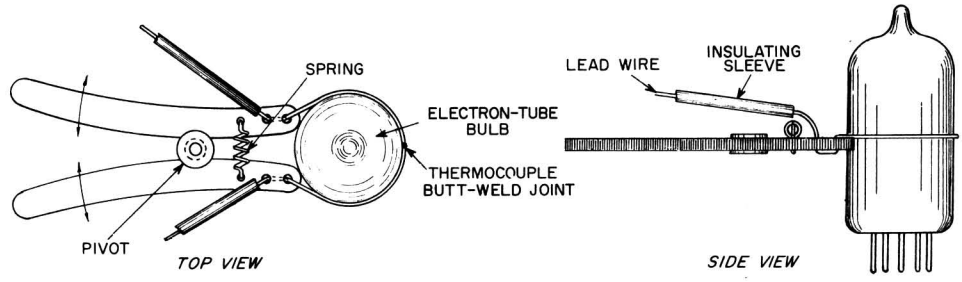
(c) A piece of twine can be used to hold the junction in place. Good results can be obtained with this method at low temperatures; at temperatures greater than 250° C, however, the twine deteriorates and breaks.

(d) Glass tape can also be used to hold the junction. This method is not recommended, however, because the tape becomes slightly detached from the bulb surface at elevated temperatures.

(e) A special thermocouple clamp that is adaptable to any bulb configuration has provided excellent results. This method is explained in detail in the recommended procedure.

## Recommended Procedure

Fig. 1 shows top and side views of the special thermocouple clamp mentioned above. Chromel and alumel wires are threaded through opposing arms of the clamp, and their ends are drawn together to form a loop. The ends of the wires are then welded together to create a thermocouple junction. The size of the loop may be adjusted, by varying the length of wire threaded through the clamp, to fit any bulb configuration. The clamp is made of Transite, which is a very poor conductor of heat, so that no significant amount of heat is conducted away from the bulb surface.




The loop is placed about the bulb and adjusted so that the thermocouple junction coincides exactly with the bulb hot spot, which has been located by the Tempilaq technique. The loop is then clamped tightly against the bulb surface, and the temperature is read on a chromel-alumel potentiometer indicator. This method has demonstrated excellent repeatability, and is especially useful for determining plate dissipation.


RCA