

Bimetallic Thermometers

A bimetallic thermometer is a temperature-measuring instrument that works on the principle of unequal thermal expansion of two different metals rigidly joined together. When the temperature changes, the two metals expand or contract by different amounts, causing the bimetallic element to bend. This mechanical movement is used to indicate the temperature.

Principle

The working principle of a bimetallic thermometer is based on the difference between the coefficients of thermal expansion of two dissimilar metals. When two metals having different coefficients of linear expansion are firmly bonded together and subjected to a temperature change, one metal expands or contracts more than the other. Since the two metals cannot separate, the difference in expansion produces bending of the combined strip.

For a metal undergoing linear thermal expansion:

$$\Delta L = \alpha L_0 \Delta T$$

where ΔL is the change in length, α is the coefficient of linear expansion, L_0 is the original length, and ΔT is the change in temperature.

For two metals having different coefficients of expansion, α_1 and α_2 , the changes in length are different for the same temperature change. This difference causes the bimetallic strip to bend.

Construction

A bimetallic thermometer consists of two dissimilar metals joined firmly together to form a bimetallic strip. The two metals are selected so that they have significantly different coefficients of thermal expansion. The bimetallic element is generally formed into a spiral or helical coil to obtain a larger mechanical movement from a small temperature change.

One end of the bimetallic element is fixed, while the other end is free to move. The free end is connected to a spindle and pointer mechanism. A graduated temperature scale is provided in front of the pointer. The complete assembly is usually enclosed in a protective case.

Working

When the temperature surrounding the bimetallic element increases, the two metals expand by

different amounts. The metal having the higher coefficient of thermal expansion attempts to expand more than the metal having the lower coefficient of expansion. Since the two metals are firmly joined, this unequal expansion causes the bimetallic strip to bend.

In a spiral or helical arrangement, the bending produces rotation of the free end of the element. This rotation is transferred through the spindle to the pointer. The pointer moves over the calibrated scale and indicates the corresponding temperature.

When the temperature decreases, the two metals contract by different amounts and the bimetallic element bends in the opposite direction. The pointer therefore moves back toward a lower temperature indication.

Temperature change → Unequal thermal expansion → Bending of bimetallic element → Rotation of free end → Pointer movement → Temperature reading

Types of Bimetallic Elements

1. Straight Bimetallic Strip

In a straight bimetallic element, two dissimilar metal strips are bonded together in the form of a flat strip. Temperature change causes the strip to bend. This arrangement is simple and is commonly used where a small mechanical movement is sufficient.

2. Spiral Bimetallic Element

In a spiral bimetallic element, the bonded strip is wound into a spiral. When temperature changes, the unequal expansion of the two metals causes the spiral to rotate. The rotation can be directly coupled to a pointer and therefore provides greater angular movement than a straight strip.

3. Helical Bimetallic Element

In a helical bimetallic element, the strip is formed into a helix. Temperature changes produce rotation or twisting of the helical element. This arrangement provides substantial angular movement and is commonly used in industrial temperature indicators.

Advantages

- Simple construction.
- Rugged and mechanically strong.
- Inexpensive.
- No external electrical power is required.
- Suitable for direct temperature indication.
- Suitable for industrial environments.
- Can be used for automatic switching and temperature control when combined with suitable contacts.

Limitations

- Accuracy is lower than that of precision resistance thermometers.
- Mechanical movement may introduce errors.
- Response is relatively slow because the bimetallic element must undergo physical heating or cooling.
- Calibration may change with repeated thermal cycling.
- Not suitable where very high precision is required.
- Ambient temperature effects can influence the indication.

Applications

- Industrial temperature indicators.
- Ovens and furnaces.
- Heating systems.
- Refrigeration equipment.
- Thermostats.
- Temperature-controlled switches.
- Boilers and process equipment.