Bimetal Disc Thermostat
APPLICATION NOTES

Operating Principle

Bimetal disc thermostats are thermally actuated switches. When the bimetal disc is exposed to its predetermined calibration temperature, it snaps and either opens or closes a set of contacts. This breaks or completes the electrical circuit that has been applied to the thermostat.

There are three basic types of thermostat switch actions:

- **Automatic Reset:** This type of control can be built to either open or close its electrical contacts as the temperature increases. Once the temperature of the bimetal disc has returned to the specified reset temperature, the contacts will automatically return to their original state.
- **Manual Reset:** This type of control is available only with electrical contacts that open as the temperature increases. The contacts may be reset by manually pushing on the reset button after the control has cooled below the open temperature calibration.
- **Single Operation:** This type of control is available only with electrical contacts that open as the temperature increases. Once the electrical contacts have opened, they will not automatically reclose unless the ambient that the disc senses drops to a temperature well below room temperature (typically below -31°F).

Temperature Sensing & Response

Many factors can affect how a thermostat senses and responds to temperature changes in an application. Typical factors include, but are not limited to, the following:

- Mass of the thermostat
- Switch head ambient temperature. The “switch head” is the plastic or ceramic body and terminal area of the thermostat. It does not include the sensing area.

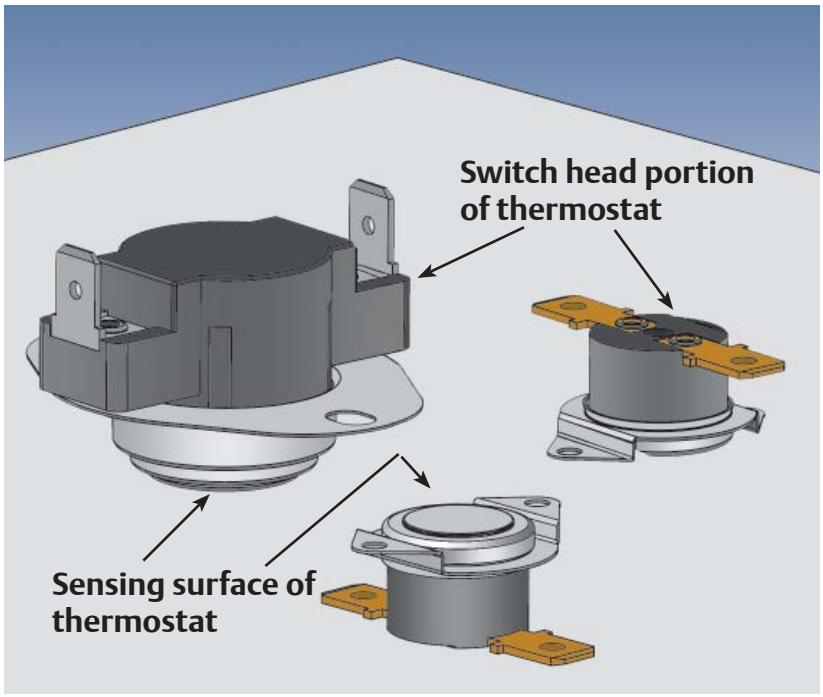


Figure 1 – *Thermostat Construction*

- Air flow across the sensing surface or sensing area. The “sensing surface” (or area) consists of the bimetal disc and metal disc housing
- Air flow across the switch head of the thermostat

- Internal heating from carrying the application electrical load
- Disc cup or housing type (i.e. enclosed, as on left in picture below, or exposed, as on right)

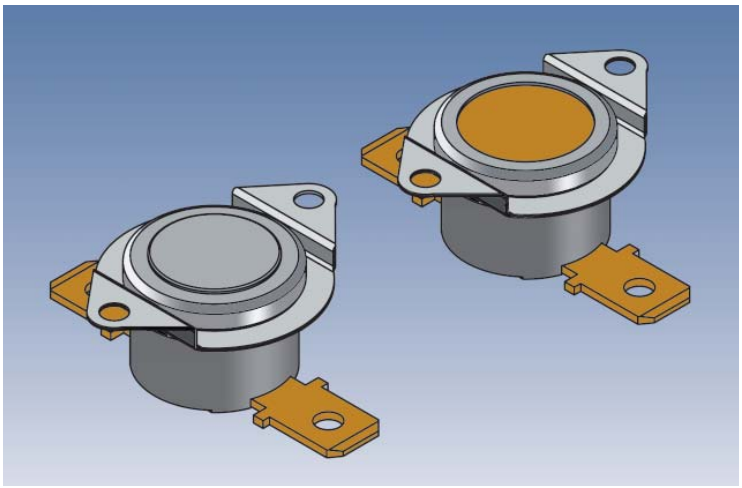


Figure 2 – *Enclosed vs. Exposed Disc Cup*

- Rate of temperature rise and fall in the application
- Intimacy of contact between the thermostat sensing surface and the surface it is mounted on
- Heat transfer by conduction, convection or radiation

It is important to understand that the temperature of the thermostat will typically change more slowly than or lag the temperature it is trying to sense. The impact of the factors mentioned in the previous paragraph will determine the magnitude of the thermal lag. Thermal lag will directly affect determination of thermostat calibration to regulate or limit temperature for a particular application. Reference the “Determining Calibration” section for how to use a thermocouple “dummy” thermostat to establish thermostat calibration.

Control Location

The location of the temperature sensor (controlling thermostat, limit thermostat) should be carefully selected.

Adequate time should be used to determine the temperatures in the various locations within the product to assure the location of the sensor can best measure and control the performance of the product.

Various methods may be employed to measure these temperatures such as infrared thermography, multiple thermocouples, etc. Locations that provide the largest differences between switching on and off will generally allow for the best control.

Determining Calibration

A thermocouple “dummy” thermostat is typically used as a key indication of what the calibration temperature of a thermostat should be for a particular application *(see figure 3)*. The thermocouple is ideally attached internally to the control on the bimetal disc for optimum results since the bimetal disc is the component that senses the temperature in a bimetal thermostat. The “dummy” control has the same thermal response as a functional thermostat but the contacts will not open.

Once a preliminary calibration temperature has been determined with the thermocouple “dummy” control, a functional control calibrated at the desired temperature must be tested in the application to verify that the calibration is appropriate. T-O-D provides thermocouple “dummy” samples upon request. Type J, Type K, and Type T thermocouples are common.

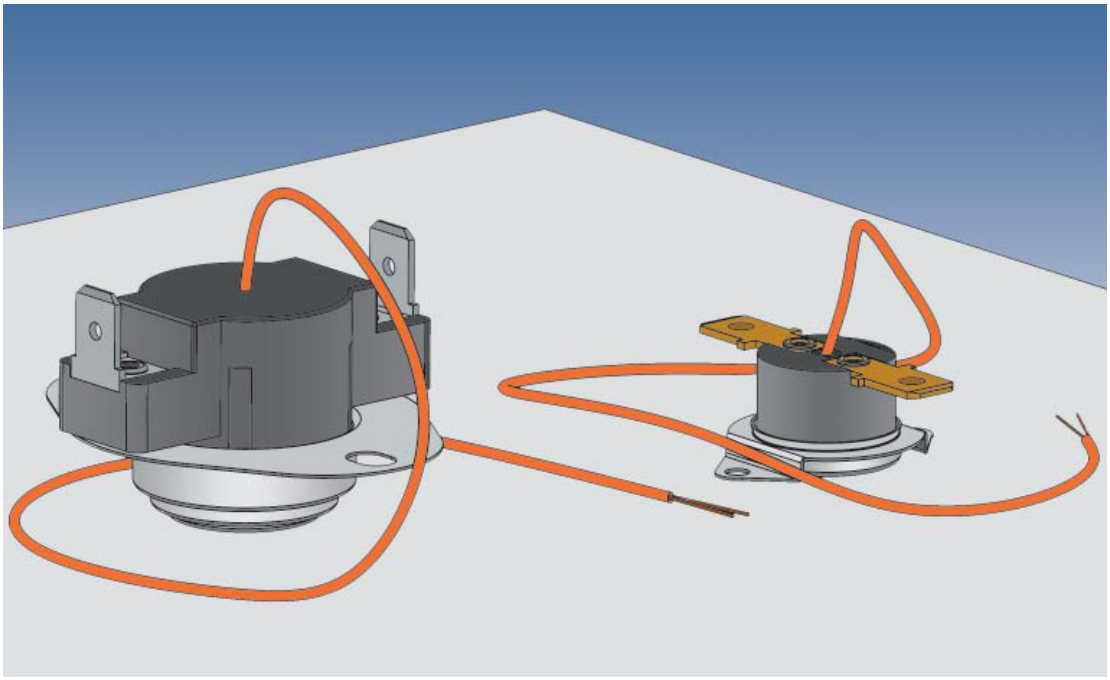


Figure 3 – *Thermocouple “Dummy” Controls*

A thermocouple may be placed externally on a thermostat in place of a “dummy” *(see figures 4 and 5)*. The preferable location would be on the metal disc “cup” / mounting bracket at a point closest to the sensing surface. The sensing surface is the flat area of the “cup” or bimetal housing for thermostats with enclosed bimetal discs. Those with exposed bimetal discs should have the thermocouple positioned as close to the disc as is practical. Care should be taken to assure that the thermocouple wires do not contact one another except at the sensing junction.

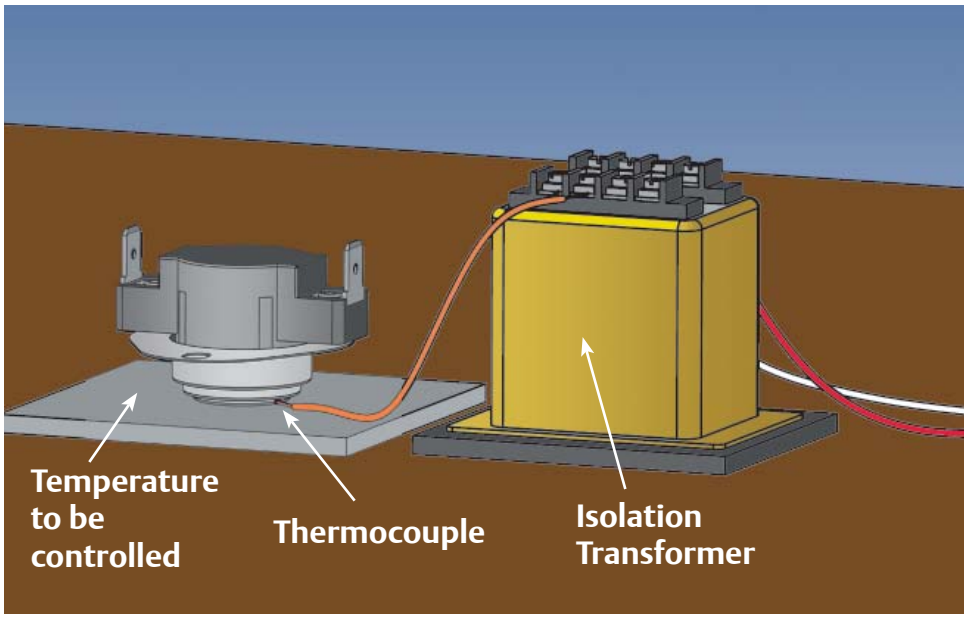


Figure 4 – *Thermocouple placed externally to thermostat*

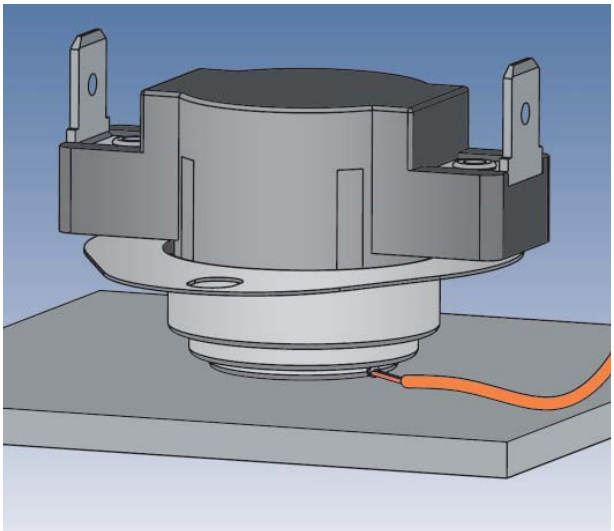


Figure 5 – *Close-up of Thermocouple Placement*

Thermostats are used to both regulate and to limit temperatures. A thermostat that regulates temperature is exposed to temperatures of normal operating conditions of a particular application, plus an overshoot temperature. A thermostat that limits temperature is exposed to temperatures of abnormal operating conditions, plus an overshoot temperature. It is important to determine both the normal and abnormal operating temperatures as well as the respective temperature overshoots in each application in order to specify the appropriate thermostat calibration.

Since most applications include both regulating and limiting thermostats, it is essential to prevent nuisance tripping of the limit by fully understanding the temperature overshoots. It is important to know what the maximum exposure temperature is to assure that components and complete units do not exceed their respective rated temperatures. The maximum exposure temperature is the combined result of the maximum ambient temperature added to the temperature increase due to the application plus the overshoot.

Test Guideline

Install the “dummy” thermostat in the appropriate location (see earlier section named “Control Location”) using both the same mounting and electrical connections as will be used in the application. The thermocouple lead should be connected to a device that will monitor and record the output from the thermocouple. Only personnel properly trained in the safe use of electrical equipment should perform testing. Caution must be exercised to assure that line voltage, if present, must not injure personnel or damage equipment. Use of an isolation transformer is recommended if there is any chance that the thermocouple wires may see line voltage.

CAUTION . . . To avoid a false reading of the unit under test, thermocouple wires must not make contact with each other except at the temperature sensing junction.

CAUTION . . . Ensure that the thermocouple wire insulation will provide isolation against short-circuiting and shock hazards.

CAUTION . . . The terminal of the temperature measuring instrument, to which the thermocouple is attached, will be the same potential as the connecting circuit wire. This instrument must be electrically isolated and considerable caution must be exercised in its use, since one of the thermocouple terminals is frequently grounded to the instrument chassis

It will likely be necessary to conduct several trials with varying ambient temperature, air flow rate and/or volume, rate of temperature rise or fall, etc. to identify normal and abnormal operation. Normal manufacturing and assembly variation between units and any applicable approval agency requirements or industry standards must also be considered.

Monitor the temperatures under normal operating conditions using the “dummy” thermostat. Repeat using conditions for abnormal operating conditions. Conduct as many trials as are necessary to understand all the potential fault conditions and to assure that the rated temperature of components (including the thermostat) and the test units are not exceeded.

The test may be set up to be able to manually open the electrical circuit when the “dummy” thermostat reaches a particular target temperature (as determined from testing described above). Continuing to monitor the temperature of the “dummy” after the circuit is manually opened, and determining the maximum temperature excursion beyond the “open” temperature can determine the temperature overshoot. This can be conducted for both regulating and limiting thermostats.

Once the preliminary calibration value for the thermostat has been determined, by taking into account normal and abnormal operating conditions, product and test variation and overshoots, it is necessary to repeat testing with functional thermostats. It may be necessary to try thermostats calibrated both higher and lower than the targeted temperature to better optimize the calibration temperature. This will also provide useful information for specifying the calibration tolerance.

Important Notice

Users must determine the suitability of the control for their application, including the level of reliability required, and are solely responsible for the function of the end-use product.

These controls contain exposed electrical components and are not intended to withstand exposure to water or other environmental contaminants which can compromise insulating components. Such exposure may result in insulation breakdown and accompanying localized electrical heating.

A control may remain permanently closed or open as a result of exposure to excessive mechanical, electrical, thermal or environmental conditions or at normal end-of-life. If failure of the control to operate could result in personal injury or property damage, the user should incorporate supplemental system control features to achieve the desired level of reliability and safety. For example, backup controls have been incorporated in a number of applications for this reason.

GLOSSARY OF TERMS

Ambient – The typical environmental temperature at which a product is exposed.

Approval Agencies – Agencies created to verify the safety and/or functionality of electrical and gas household products. Therm-O-Disc products are typically recognized at the major global agencies, including UL, CUL, CSA, IEC, VDE, BEAB and METI.

Arm Force – The force required to operate the switching contacts, measured at the bumper centerline.

Automatic Reset – A type of thermostat that will reset itself at a specific temperature (set point minus differential = reset temperature).

Biased-Closed Control – A control designed with a contact arm that normally holds the contacts closed until the sensing mechanism pushes them open.

Biased-Open Control – A control designed with a contact arm that normally holds the contacts open until the sensing mechanism pushes them closed.

Bimetal – Metallic strip material made by bonding two different materials together with different thermal expansion rates.

Bumper – An actuating pin that transmits motion from the sensing mechanism to an actuating arm.

Castellation – Posts affixed to a thermostat switchcase that serve to align a mounting bracket.

Contacts – Term for components used in all electrical-type products that physically make and break electrical circuits.

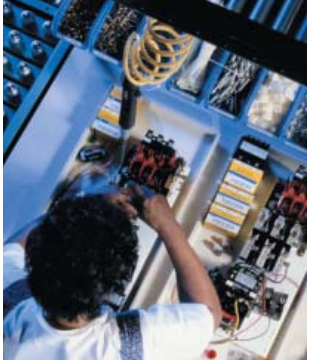
Comparative Tracking Index (CTI) – A measure of material surface electrical tracking (resistance).

Cycle Rating – The agency-recognized number of operations that a control will function, given a specific temperature range and electrical load.

Dielectric Strength – A product's ability to withstand an application of a pre-determined over-voltage for a specified period of time.

Differential – The temperature difference between the opening and closing points of a control.

Disc Cup – A cup that holds a disc in place on a disc-type control.



Disc – A thin, circular bimetallic component.

DPDT (Double Pole, Double Throw) – An electrical term where “pole” is a leg of an electrical circuit and “throw” describes the switch action. Therefore, a DPDT will switch two legs and each leg will open a set of contacts, and close another set (4 sets of contacts).

DPST (Double Pole, Single Throw) – An electrical term where “pole” means a leg of an electrical circuit and “throw” describes the switch action. Therefore, DPST will switch two legs and each leg is switched open or closed by one mechanism.

Fan-Type Control – A thermal control designed such that the contacts close on temperature rise. Also referred to as “close on rise,” or “normally open.”

Fuse-Type Control – A control built to cycle only once.

Limit-Type Control – A thermal control designed such that the contacts open on temperature rise. Also referred to as “open on rise,” or “normally closed.”

M1 – Refers to manual reset devices. If the reset button is held down, the control can cycle thermally.

M2 – Refers to manual reset devices. If the reset button is held down, the control must open mechanically or thermally and will not reset automatically.

Manual Reset (M.R.) – A control that opens automatically, but must be reclosed manually by pressing a button or lever.

NTC (Negative Temperature Coefficient) – A resistor that reduces resistance (ohms) with a temperature increase.

Phenolic – A thermoset plastic material often used as the insulating body of a thermostat.

Pole – The number of completely separate circuits contained in a control.

Prime Differential – The thermal differential between the nominal open temperature and the minimum close temperature.

PTC (Positive Temperature Coefficient) – A resistor that increases resistance (ohms) with temperature increase.

Reference Dimension – A dimension without tolerance used only for information purposes that does not govern production or inspection operations.

Reset Temperature – The temperature at which the contacts return to their normal position.

Response Time – The time for a thermistor to indicate a step change in temperature within a specified amount.

Set Point – Temperature at which normally closed contacts will open, or normally open contacts will close. Also referred to as operating temperature.

Shield – A thermostat component that provides guidance for the actuating system in the control.

SPDT (Single Pole, Double Throw) – An electrical switch term where "pole" means a leg of an electrical circuit and "throw" describes the switch action. Therefore, a SPDT will switch one leg that will open a set of contacts, and close another set.

SPST (Single Pole, Single Throw) – An electrical term describing switch actions. A SPST will switch one leg and open one set of contacts.

Stenciling – The marking on a product identifying the product type, temperature, part number and plant of manufacture.

Switchcase – The component that represents the thermostat "body," made from insulating material that supports switch mechanisms.

Thermal Cutoff (TCO) – A product that functions as a thermal fuse (one time operation). Various operating temperatures are achieved by formulating a pellet that melts at very specific temperatures.

Thermistor – A device that exhibits a large change in electrical resistance with a change in temperature.

Tolerance – The allowable range above or below the set point or reset temperature.

Trip-Free – A term associated with manual reset type controls. When the reset button is depressed it cannot restrict the normal opening of the control.

SAMPLES AND QUOTATIONS

Many variables can affect the operational characteristics of a thermal control. It is for this reason that we recommend that you conduct thorough testing of our products in your specific application. Therm-O-Disc has both functional and thermocoupled samples readily available for determining the desired performance and the correct response in your application. To obtain samples, please go to **www.thermodisc.com** and complete the appropriate request form, or contact your local Therm-O-Disc sales representative directly. To ensure a quick turnaround, please have the following information ready:

- Application description
- Electrical load
- Operating temperature requirements
- Agency recognition(s) required
- Mounting and terminal configurations
- Estimated annual volume

Don't know what product you need? Do you have a general question about our products? Then please visit **www.thermodisc.com** or contact your local Therm-O-Disc Sales Office. Our applications engineers are always available to assist you in answering your questions or in obtaining any samples you may need.