Honeywell

FREQUENTLY ASKED QUESTIONS

Thermal Switches

Q: Why use a thermal switch?

A: The fundamental physics recognizing the coefficient of expansion of two dissimilar joined metals cannot be easily stopped from operating. The flat spring used to maintain closed contacts cannot be stopped from operating if the ambient are observed (and even if not). In short, with correct application we do not know when a switch will stop working.

Examples include:

- 1 million cycles, 1ampere, 30VDC, as a creeping (arcing) device
- Thermal cycling room temperature switches to 600ºF
- Thermal cycling room temperature switches to -184ºF
- Random vibration to 83grms
- Pyro-shock to 4000g
- Discs archived for 35 years have shifted less than 2°F

Q: What will shift bimetal and flat springs significantly?

A: The following:

1. Soak the device in LN^2 for 30 minutes
2. Randomly grind the edges of the disc
3. Force assemble the disc in mechanism with the longest possible striker pin that can be assembled
4. Assemble the disc in mechanism with the shortest possible striker pin that can touch a fully deflected disc
5. Clamp the formed disc between metal blocks and then assemble into switch
6. Strike the formed disc with a hammer
7. Strike the formed disc with a rounded pin using a hammer

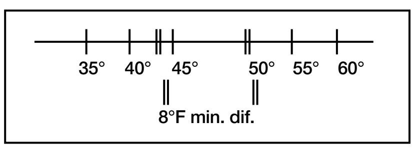
The LN^2 soak had the greatest effect erratically, meaning some discs were unaffected and others shifted 50º, and a few ceased to snap. The exaggerated long striker pin caused a 70º shift. All other abuses had less than 30ºF effect on the mechanism. This is the reason that Voyager 1 and Voyager 2 spacecraft are operating effectively today.

Q: When does a thermal switch turn devices on and off?

A: It is a little like a light switch operated by a bimetallic sensor instead of the hand.

An example of a standard thermal switch can be used to clarify:

- The switch closes at 40°±5°F. The switch opens at 55°±5°F. The switch minimum differential is 8°F.
- This is how this switch operates in the environment.
- All temperatures below 34.9°F will be closed.
- All temperatures above 60.1 will be open.
- As the temperature decreases from 60.1 or above the switch will remain open to between 35° and 45°F.
- As the temperature increases from 34.9 or below the switch will remain closed to between 50° and 60°F.
- The 8°F minimum differential overrides the ± tolerances when an overlap of ± tolerances allows an overlap of less than 8°F.
- A switch closing at 44.5°F and opening at 50.5°F is within the ± tolerances but fails the 8°F minimum differential.
- A number line may assist in visualization.



There are an infinite number of temperature tolerances and differentials.

Q: How are thermal switches most likely to fail?

A: Thermal switches using electrical contacts are most likely to fail when the contacts fail. For example, when using a ½" switch:

- If the voltage and current are low, say 28 VDC at 500 milliamps, the devices have never been tested to the end of life. The greatest risk of failure is a contaminant between the contacts. This would mean the switch closed mechanically but not electrically failing in the open position. A clean switch will work in excess of 1 million cycles.
- If the voltage and current are high, say 28 VDC and 5 amperes, the devices will fail due individually or in combination to contact transfer, dimensional change influencing the contact gap, and annealing of the flat spring as result of fast cycling. Depending on the combination of events the device may fail open or closed. The device will work in excess of 100,000 cycles at 28 VDC, 5 amperes and much longer when de-rating is properly applied.

Q: What is de-rating of a thermal switch? And what is the purpose of de-rating?

A: At the start of space flight, few practices were in place to assure performance in space. Parts designed for aircraft and basic Mil-Spec devices were used much as they would be on earth. This soon proved to be unsatisfactory, and de-rating of all "Electrical, Electronic, and Electro-Mechanical Parts" became a documented practice. MIL-STD-975 was one of the earlier methods imposing requirements for de-rating. This document is now obsolete, however de-rating is still a vital practice. Several documents have superceded MIL-STD-975.

Purpose of de-rating

De-rating is a technique whereby a part is stressed in actual usage at values well below the manufacturer's rating for the part. By decreasing mechanical, thermal, and electrical stresses, the possibility of degradation or catastrophic failure is lessened.

Current Documents:

- MIL-HDBK-1547, Military Specification D-8545B, JPL
- SSP30312, NASA, International Space Station
- MF0004-400, THE BOEING COMPANY

The first two documents are available on the Web.

Discussion

These specifications refer thermal switch users to the relay portion of the specifications for de-rating. The tables in each specification vary in amount of de-rating recommended, however they have a great deal in common. The JPL and NASA specification both use formulas which consider temperature, number of cycles per hour and load factor. The MIL-HDBK-1547 uses a table based on the type of circuit elements: resistive, lamp, etc. The Boeing specification provides a table like MIL-HDBK-1547, a reliability calculation, and specific written guidelines as follows:

- In no case (except for non-repetitive transients) shall the de-rating be less than 25 percent (.75 X rating) for all upper and worst-case specification limits.
- It must be emphasized that the user shall evaluate all thermal switches according to the requirements of the application since the user is responsible for assuring adequate de-rating.
- Worst-case circuit design analysis must consider the possibility of a thermal-vacuum on the circuit and the effect of this environment on the operation and thermal dissipation capability of the device.

Use of these methods and guidance has served the Space industry well. Honeywell endorses the practice of de-rating and encourages users to implement de-rating as appropriate for their application in all instances.

Q: What does the term "differential" mean when it is for a thermal switch?

A: Differential is a term used to define the closing and opening temperature of a thermal switch. The best understood differential is the "nominal differential". The intent is to describe the nominal closing and opening temperatures.

Examples include:

- Let's say we have a switch that closes at 100°F and opens at 110°F. The standard tolerance is ±5 F on close and open. It was simple until the tolerance worst case analysis reveals a close and open simultaneous operation at 105°F. This is unobtainable in a bimetallic snap acting thermal switch. Bimetal works on coefficient of expansion differences between metals. To deal with the overlap a "minimum differential" is applied. In the 700 series that is 8°F. So a switch closing at 104°F and opening at 113°F is a good switch. If the switch opened at 110°F it is a failure because the minimum differential is 8°F. The minimum differential increases snap energy and reduces risks in operating life in space environments.

  Differential is also used as "minimum/maximum" tolerance method. This means that a range is selected by the user for control such that above or below specific temperature the switch is closed or open.

- Let's say we have a switch where the minimum close is 95°F and maximum open is 115°F. This means that a close of 94.9°F is a failure and an open of 115.1°F is also a failure. Like the earlier example, differential between close and open is undefined. The application of the 8°F minimum differential solves the problem of being too narrow. This means an open of 108.1°F is a good switch if the close is 95°F, again using a worst case example.

There are many combinations of ± tolerances, minimum differentials, and maximum differentials used to control tight tolerances while reducing high costs that ± tolerances alone can evoke.

Thermal switches exported from the United States must be done in accordance with the Export Administration Regulations (EAR).

For additional information on Honeywell Thermal Switches, please visit **aerospace.honeywell.com/thermalswitchesandsensors**.

For more information about return material requests, please visit **aerospace.honeywell.com/returns**.

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Honeywell Aerospace
1944 E. Sky Harbor Circle
Phoenix, AZ 85034
aerospace.honeywell.com

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