Chase Research Cryogenics

World leaders in sub-Kelvin cryogenics

PERFORMANCE NOTES FOR CRC CRYOGENIC HEAT SWITCHES

Cryogenic heat switches are used for thermal management over large temperature ranges. CRC heat switches are filled with Helium gas, which can be either absorbed or desorbed from a charcoal-filled gas absorber. The heat switch is 'ON' when the helium is present in the switch, and the switch turns 'OFF' when the gas is absent from the switch. The absorption of helium onto charcoal is temperature dependent; helium becomes maximally absorbed at temperatures below ~4K. For this reason, a CRC heat switch can only turn OFF in cryogenic systems operating at 4K and below. Heat switches filled with 4He gas are used at temperatures down to 4K, and switches filled with 3He gas can be used at temperatures below 4K.

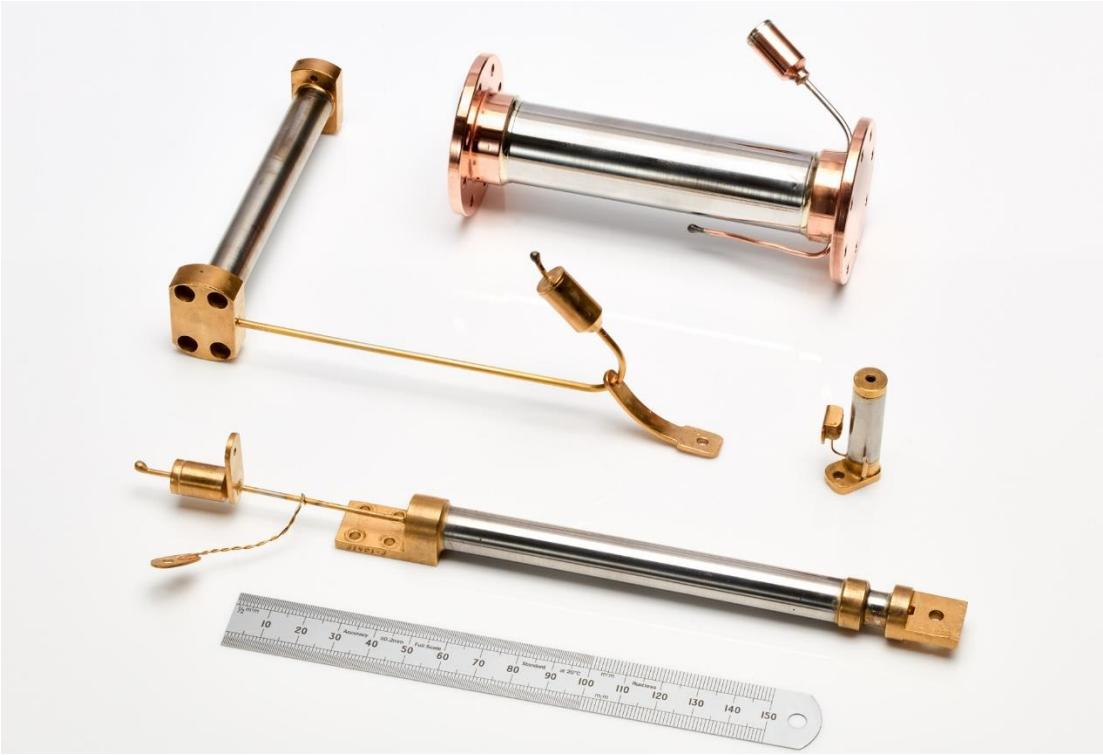

Figure 1: A Selection of Active heat switches.

CRC makes many types (and sizes) of heat switch, including bespoke switches optimised to meet specific customer requirements. Ideally a heat switch will have a high 'ON' state thermal conductance and a low 'OFF' state conductance. However in practice it may be impossible to achieve both of these goals and compromises are often necessary. The thermal conductance of the switch in its ON and OFF states depend on material properties of the gas, on the materials used to make the heat switch, on the physical dimensions of the switch and on the temperatures at the 'hot' and 'cold' ends. CRC has developed mathematical models of heat switches to assist with the design process, these models allow us to explore options and help to identify the best solution for a specific application.

CRC also makes standard heat switches, many of which are incorporated into our sorption cooler products. Our standard active heat switch (right) has a small external gas adsorber pod connected by a gas tube to the foot of the switch. Gas is released into the switch (turning it 'ON') by electrically heating the pod to 15-20K under user control. In the ON state the thermal conductance is relatively large (around 100mW/K at 4K). The residual thermal conductance in the 'OFF' state is strongly temperature dependent. Total heat flux through the OFF switch is typically less than 0.1mW when the ends of the switch are thermally anchored at 4K and 1K respectively.

Figure 2: A Selection of Passive heat switches.

A passive heat switch contains an internal gas absorber and operates automatically; it turns ON and remains fully ON while the 'hot' end temperature is greater than around 15-20K. In the ON state the thermal conductance is relatively large (around 100mW/K at 4K). When the 'hot' end temperature drops below around 10K the switch will start to turn OFF, though it will not be fully OFF until the 'hot' end temperature is below ~4K. When the switch is OFF it has a residual thermal conductance dictated by the material properties and dimensions of the switch shell.

A convective switch is an active heat switch with a larger gas absorber pod, releasing gas into a convective loop between the hot and cold ends of the switch. The large gas pod allows greater user control over the amount of gas released, enabling the switch to be operated in a 'partially ON' state by heating the gas pod from ~4K (OFF) up to ~50K (ON). A convective switch typically has a lower ON-state conductance than a gas-gap switch, however the switch is optimised for different purposes, for example fine user control of the temperature of a cold table.

Please contact Chase Research Cryogenics to discuss your heat switch requirements with us.