TWO-PHASE THERMAL SWITCH FOR LUNAR NIGHT SURVIVAL. N. Van Velson[1], R. Kumar[1], J. Diebold[1], C. Tarau[1], and W. G. Anderson[1], [1]Advancced Cooling Technologies, Inc., 1046 New Holland Ave, Lancaster, PA 17601

Introduction: The lunar night poses a significant challenge for the thermal management of future lunar landers and rovers. To survive the lunar night and enable long-duration lunar missions, the on-board electronics The heat generating components may be mounted directly to the underside of the radiator. While this is effective for heat rejection during the lunar day, this configuration would not allow the rover to survive the lunar night. must be maintained above their minimal survival temperature. Surviving the lunar night without the use of electric power for heating, which would involve significant additional mass, will require advanced passive thermal management technologies.

Thermal switches are among the passive thermal control devices that can be utilized in lunar lander and rover thermal management systems. Thermal switches are designed to minimize heat transfer when "Off" and maximize heat transfer when "On". The actuation of the thermal switch often happens at a specified transition temperature. Most passive thermal switches are based on the expansion and contraction of a volume to make and break contact between two surfaces.

Two-Phase Thermal Switch: A new concept for a passive thermal switch has been developed. This thermal switch design utilizes a sealed metal bellows that contains a saturated working fluid. One end of the bellows is fixed to the heat source, while the other is free to extend axially, and is offset from a heat sink surface. At low temperatures, the vapor pressure of the fluid within the bellows is low, and the bellows is not extended to the point of contact with the heat sink. At higher temperatures, the vapor pressure increases, causing the bellows to expand until in comes into contact with the heat sink, allowing heat to be transferred by evaporation and condensation of the working fluid. The vapor pressure, and thus vapor temperature, at which the bellows initially contacts the sink is determined by the balance of forces between the vapor pressure, the bellows restoring force, and any external pressure. An internal capillary wick structure can be incorporated to enable gravity- and orientation-independent operation.

A thermal-mechanical model has been developed to understand the dynamic performance of the two-phase thermal switch, and to estimate its thermal conductances. Several thermal switch devices were fabricated for concept demonstration and model validation. These devices were built with bellows with a range of spring constants and filled with different working fluids in order to characterize different scenarios. The effects of contact pressure and thermal interface resistance were also investigated.

Small Rover Thermal Switch: A thermal switch design for implementation in a small lunar rover is being developed. In the baseline design, heat is rejected during the lunar day by a radiator that forms the top surface of the rover. The heat generating components may be mounted directly to the underside of the radiator. While this is effective for heat rejection during the lunar day, this configuration would not allow the rover to survive the lunar night. To implement the thermal switch for lunar night survival, a new radiator panel is located above the current frame, separated by low thermal conductivity standoffs. One or more two-phase thermal switches would be placed in the space between the heat collector plate and the radiator panel, with the bellows designed to come into contact with the radiator at a specified temperature corresponding to the survival temperature of the electronics.

Preliminary thermal analysis was done to estimate the On/Off conductance ratio and component temperatures. Two prototype devices are being developed and fabricated for vacuum testing to demonstrate the feasibility of utilizing the two-phase thermal switch for small rover thermal management and lunar night survival.