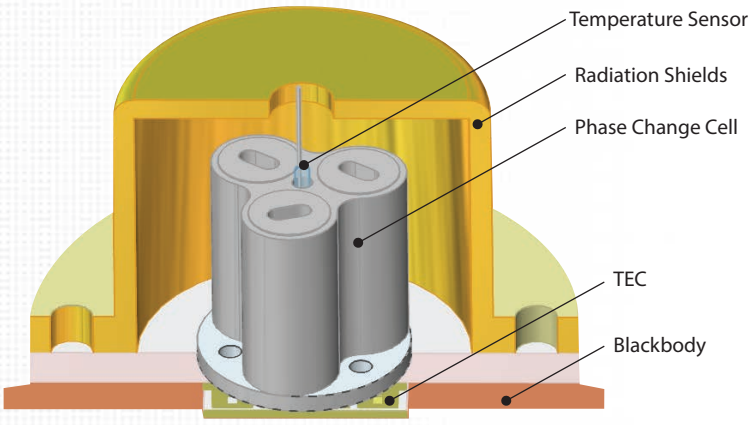
SDL/11-248D

MOTR

MINIATURE ORBITAL TEMPERATURE REFERENCES

Patent # US 2009/0312976 A1

MOTR is a Space Dynamics Laboratory (SDL) effort to miniaturize and ruggedize traditional fixed-point cells used for ground thermometry calibration sources to make them practical as references to extend calibration knowledge of orbital temperature sensors. The external attachment design of MOTR enables it to be easily integrated into existing blackbodies and other equipment. Internal temperature sensors and Peltier thermoelectric cooling devices (TECs) enables phase change materials (PCM) to be melted and monitored independent of the device they are attached to. Following the phase transition measurement, the TEC is disabled, and the recalibrated MOTR temperature sensor will reach thermal equilibrium with the blackbody it is attached to, permitting comparison of the blackbody temperature measurements and the MOTR sensor.



MOTR FEATURES

- Realistic solution for automated orbital sensor self-calibration system
- Excellent countermeasure for unavoidable temperature sensor drifts
- Phase transition measurements repeatable to better than 3 mK
- Quick drift verification melts can be performed within 30 min
- Vaccuum tight stainless steel containment of PCMs achieved using laser welds
- Several PCMs available including metal eutectics with temperature reference points between -40˚ and 30˚ C
- Tested phase change cell on the International Space Station (ISS) in 2014
- Small size, working designs can fit inside a 1" cube and weigh less than 15 g
- The TEC requires around <5 W to freeze and melt the Ga-based PCMs at blackbody temperatures from 0 to 20 C

Size Comparison

Phase Transition Temperatures or Eutectic Alloys & Pure Metals

PCM	Temp. (K)
In	429.75
Ga	302.9146
GaZn	298.5
GaSn	293.61
GaIn	288.78
H_2O	273.150
Hg	234.326

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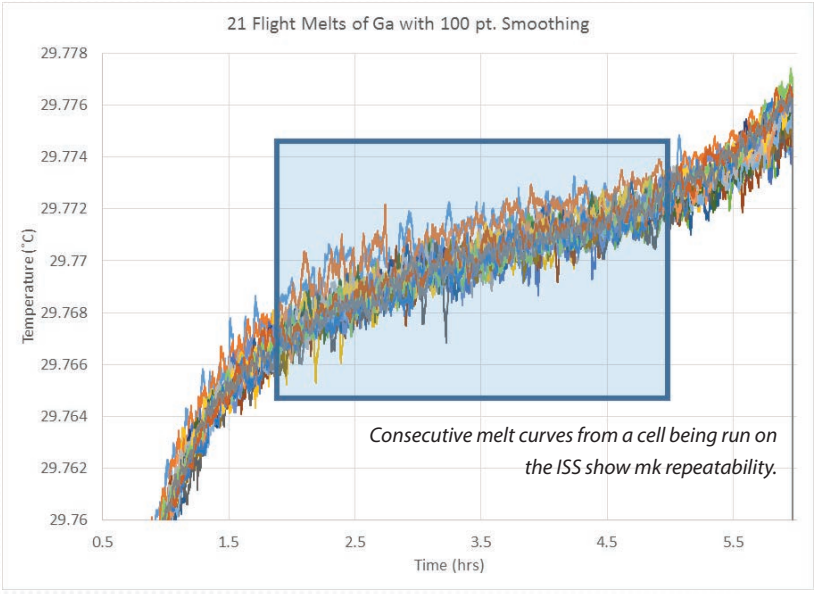
Triple point of water cell used on the ground for ITS-90 calibrations

FIXED-POINT STANDARDS OF THERMOMETRY

Phase changes have been used for centuries as reliable temperature references. They make up the fixed points of the international standard in thermometry measurements, the ITS-90 scale. NIST-traceable calibrations done on the ground originate with some phase transition apparatus such as the triple point of water cell shown here. Many of these fixed points are repeatable to sub mK levels.



Consecutive melt curves from a cell being run on the ISS show mk repeatability.

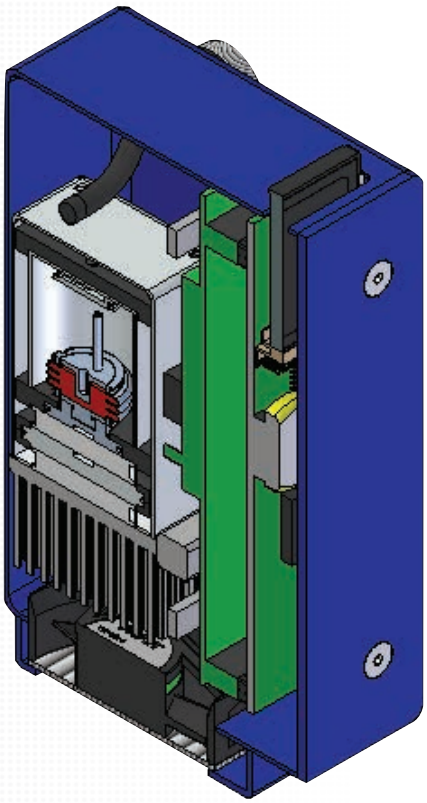
TEST RESULTS

Tests performed over a period of eight years with different PCM cells have demonstrated cell performance. Melt curves are repeatable to 1-2 mK and a phase change attached to a blackbody simulator matches the simulator temperature to a few mK in a vacuum when the TEC is unpowered. The plot (at right) shows 21 consecutive melts of gallium from a cell being tested on the International Space Station.

Actual flight phase change experiment hardware for microgravity testing on the ISS

FLIGHT TESTING

Through contacts that SDL has developed over two decades with the Institute for Biomedical Problems (IBMP) in Moscow, Russia, orbital experimental testing of two PCM cell designs took place on the ISS during 2014. These tests demonstrated that over a four year period the phase change cell remained stable to a few mK and the melt point of gallium did not change in microgravity by more than a few mK. The tests verify the utility of PCMs in orbital applications, such as satellites monitoring global climate change.



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