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Validation of an Absolute Temperature Calibration Scheme for use in an On-Orbit Absolute Radiance Standard (OARS)

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The next generation of infrared remote sensing satellite instrumentation, including climate benchmark missions will require better absolute measurement accuracy than now available, and will most certainly rely on the emerging capability to fly SI traceable standards that provide irrefutable absolute measurement accuracy. As an example, instrumentation designed to measure spectrally resolved infrared radiances with an absolute brightness temperature error of better than 0.1 K will require high-emissivity (>0.999) calibration blackbodies with emissivity uncertainty of better than 0.06%, and absolute temperature uncertainties of better than 0.045K (k=3). Key elements of an On-Orbit Absolute Radiance Standard (OARS) meeting these stringent requirements have been demonstrated in the laboratory at the University of Wisconsin and are undergoing further refinement under the NASA Instrument Incubator Program (IIP). This work will culminate with an integrated subsystem that can provide on-orbit end-to-end radiometric accuracy validation for infrared remote sensing instruments. We present details of the configuration and the test program conducted to validate the scheme that provides on-orbit absolute calibration of the temperature sensors that are imbedded in the OARS blackbody cavity. The scheme uses the transient melt signatures of small quantities (<1g) of reference materials (gallium, water, and mercury) housed in miniature phase change cells that are also imbedded in the cavity. Absolute temperature calibration of the temperature sensors at the reference material melt points has been demonstrated to better than 10 mK (k=3), both before and after exposure to simulated full life cycle testing. The life testing was designed to simulate the environmental aspects of a 7-year spaceflight mission, and includes deep temperature cycling (freeze/thaw cycles) to mechanically work the phase change cell housings; and warm soaks to simulate the dissolution environment. Detailed melt signature performance was examined both before and after exposure to the full life cycle testing and very little or no change was observed. Another important upcoming test will validate the phase change temperature calibration scheme in microgravity, using the International Space Station (ISS). The small scale of the miniature phase change cells favors surface tension over gravitational forces, so operation in microgravity is expected mimic operation observed on the ground. The University of Wisconsin demonstration will make use of an Experiment Support Package developed by Utah State Space Dynamics Laboratory to continuously run melt cycles on miniature phase change cells containing gallium, a gallium-tin eutectic, and water. The phase change cells will be mounted in a small aluminum block along with a thermistor temperature sensor. A thermoelectric cooler will be used to change the temperature of the block. Melt signatures obtained on orbit will be compared to those recorded on the ground to validate that the melt behavior is unaltered in the microgravity environment.