Passive Heat Dissipation of Tritium Lights in Vacuum for Cryo Application

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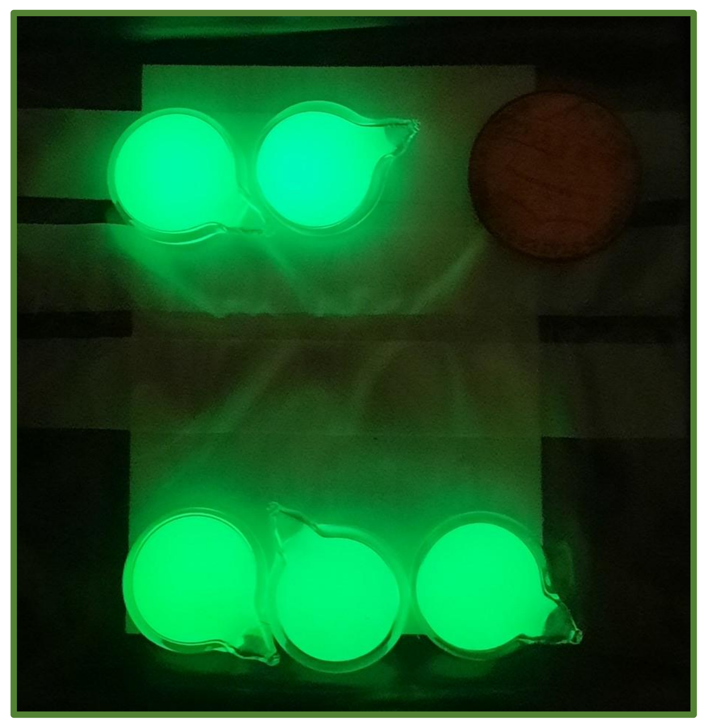
INTRODUCTION

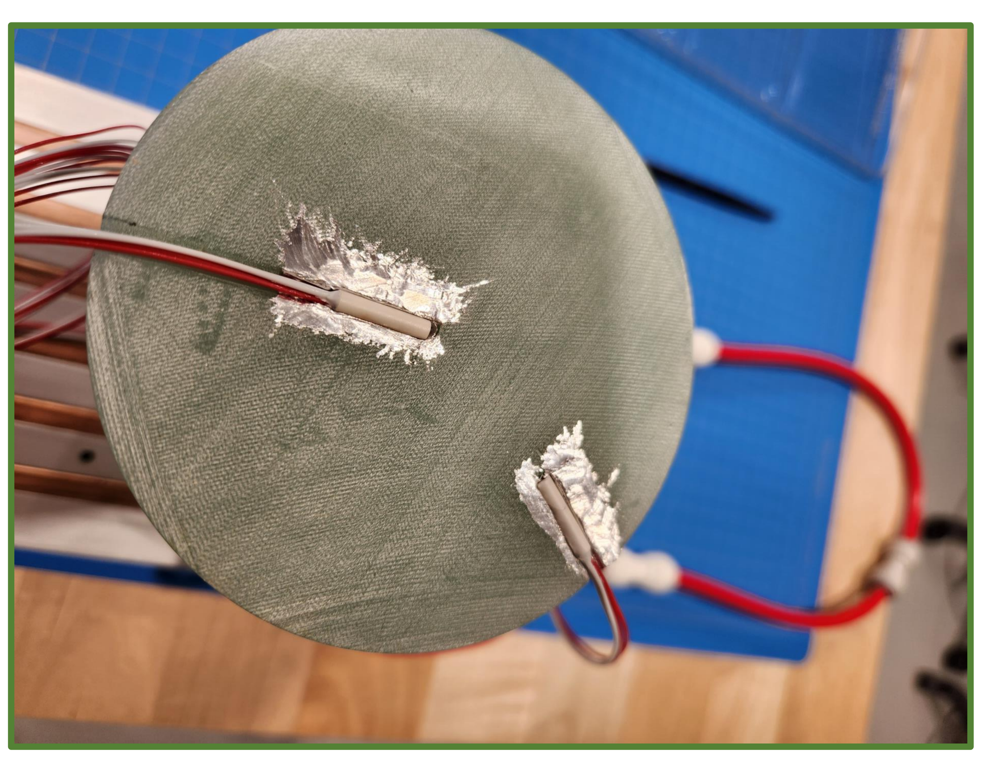
Video guidance systems in space need alternative light sources which can provide enough radiometric power while reducing the conductive waste energy. The EM41 CIF has developed tests to characterize how gaseous Tritium light sources could meet these requirements while significantly reducing the waste heat compared to traditional LEDs. The EV34 team in conjunction with EM41, developed a vacuum test to characterize the conductive waste heat off the Tritium lights in the Hi-TTEMP Thermal laboratory.



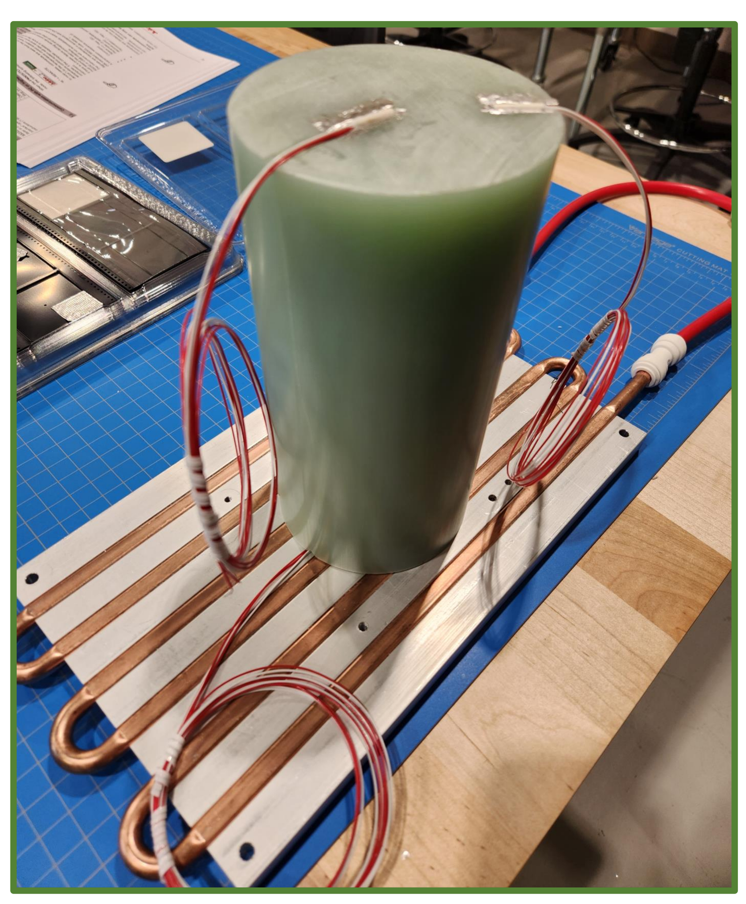
Glowing Tritium Lights

THERMAL TEST CONCEPT

The designed thermal vacuum test measured the temperature difference across a G10 cylinder to determine the waste heat produced by ten small, gaseous tritium lights. Resistance Temperature Detectors (RTDs) were installed at the top and bottom of the G10 cylinder to measure the temperature difference.



RTDs on Top of G10 Cylinder



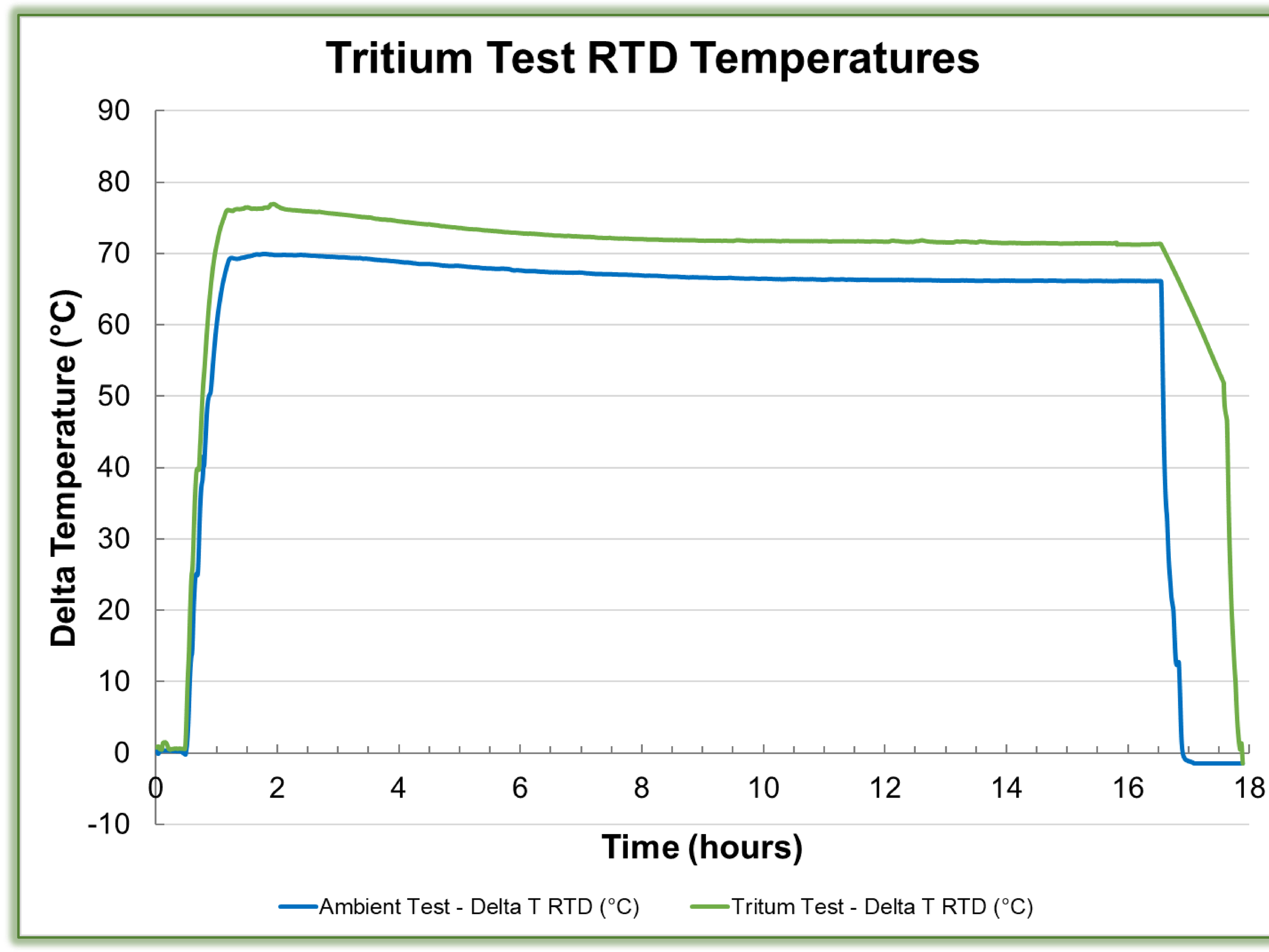
G10 Cylinder with Coldplate

The bottom of the G10 cylinder opposite of the tritium lights was attached to a coldplate held at a constant temperature of -60°C. The RTDs measured the temperature difference across the G10 cylinder between the isothermal bottom held at the coldplate temperature and the top of the cylinder where the tritium lights were placed. An “ambient” test was conducted without tritium lights in order to provide an accurate comparison inside the vacuum chamber and to account for the radiative losses in the chamber. For both the ambient test and tritium test, all of the temperature sensors were allowed to reach steady-state in vacuum.

Left to Right: Ambient Test Setup, Raised Top to expose Tritium Light, Final Tritium Test Setup

TEST RESULTS

The RTDs measured the temperature difference between the top and bottom of the G10 cylinder. That delta temperature (°C) is shown for both the ambient and tritium tests. The Tritium lights held the G10 cylinder ~5°C warmer than the ambient test during the steady-state portion of the test between 6 and 16 hours.



The heat transfer was calculated using the known values:

- k, thermal conductivity of G10 averaged across the known temperature difference
- A, surface area of the cylinder
- l, length of cylinder
- ΔT, temperature difference across cylinder

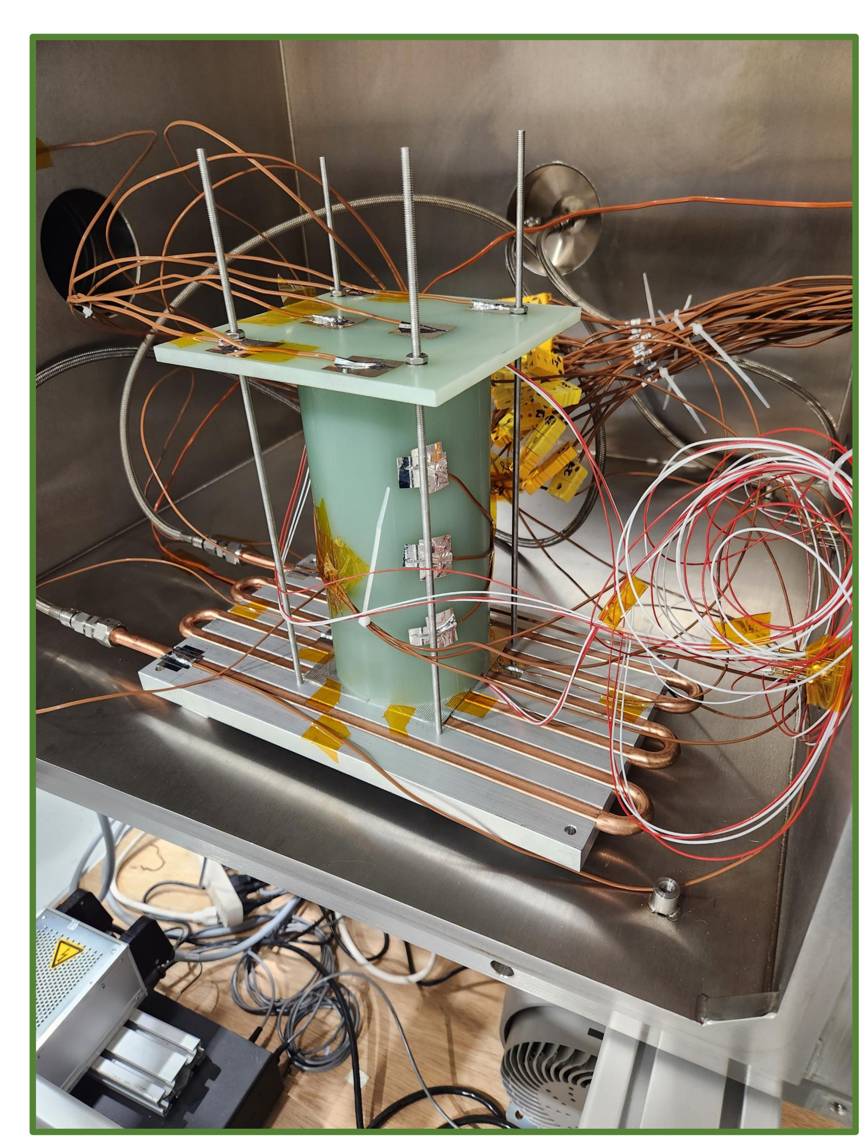
$$Q = \frac{kA}{l}\Delta T$$

Conductive Heat Transfer

Using the measured temperature difference of ~5.3°C between the tritium and ambient tests during steady-state, the total waste heat for all 10 tritium lights was measured to be between 0.317 BTU/hr (0.093 W) and 0.351 BTU/hr (0.103 W) over an area of 81 cm^2.

CONCLUSION

This thermal vacuum test used RTDs to measure the temperature difference between the isothermal bottom of the G10 cylinder and the top of the cylinder. A comparison between steady-state vacuum tests demonstrated that the tritium lights held the G10 cylinder ~5.3°C warmer than the ambient test without tritium lights. The tritium thermal test measured temperature difference of ~5.3°C, resulted in an average waste heat of 0.033 BTU/hr (0.0097 W) from each individual tritium light.



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