CUBESAT DEVELOPERS WORKSHOP

HOME

Adaptation of Thermal Vacuum System for vacuum thermal shock testing of Nanosats

Joshua H. Gurian

PRESIDENT

Rydberg Vacuum Sciences, Inc.

jgurian@rydberg-vs.com

Boris Yendler

CEO AND PRINCIPAL CONSULTANT

YSPM, LLC

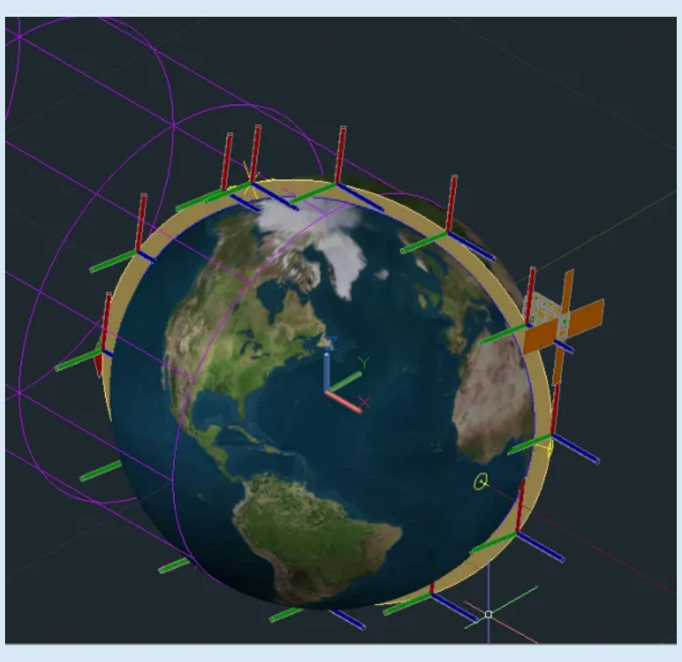
byendler@yspm.net

Abstract

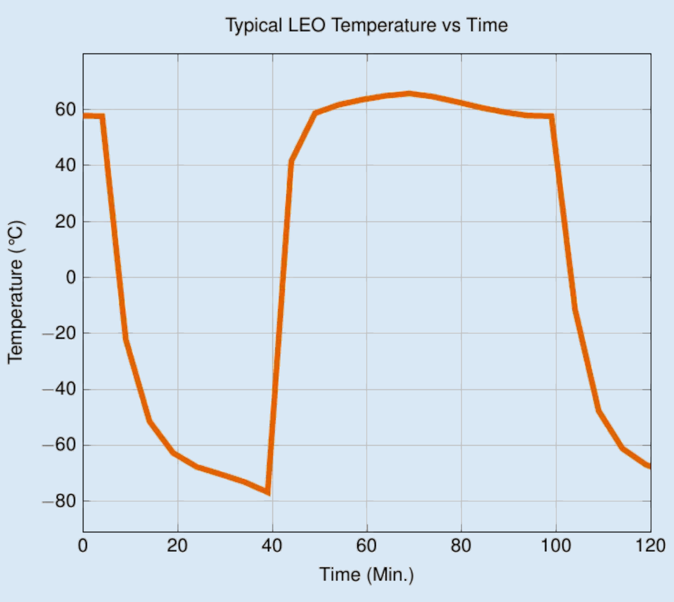
Spacecraft at low Earth orbit spacecraft typically experience rapid transitions between hot (solar irradiance) and cold (Earth shadow) environments during their sub-100 minute orbital period. Smallsats and subcomponents undergo rapid temperature changes, sometimes in excess of 30°C/min. These thermal ramp rates are unachievable by typical thermal vacuum test systems.

Here we present a novel shroud insert to achieve rapid transitions between hot and cold orbital environments in a standard thermal vacuum systems. This insert is simple, inexpensive, and easy to install. This approach allows for using existing thermal vacuum systems to accommodate thermal vacuum shock testing of nanosatellites and subcomponents and significantly reduce overall thermal vacuum test duration.

LEO Orbit



- Orbital period less than 128 min. Typically 90-95 min for nano sats (90 min s/c orbit plotted below)
- Surface temperature ramp rates up to 30°C/min (23°C/min below)



The typical ramp rates observed during flight are not achievable with conventional TVAC systems. With the presented shroud insert, simulating these types of orbits is now achievable and practical. Overall standard ramp/soak thermal vacuum cycling test duration can be reduced by approximately 30% to increase system throughput.

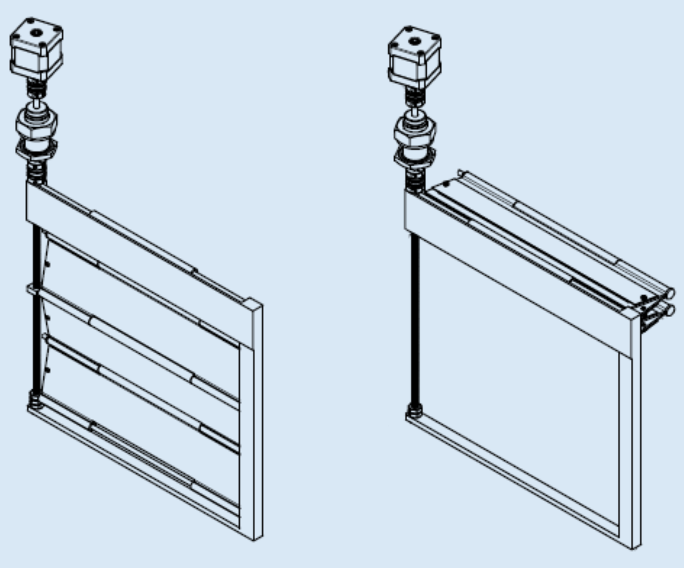
TVAC Testing

Best practices for qualification of spacecraft and subcomponents involves "test as you fly", subjecting spacecraft and subcomponents to pre-flight testing as similar as possible to predicted orbital environmental characteristics.

Typical thermal vacuum systems include a thermally controlled platen and optionally a thermally controlled shroud to control the conductive and radiative environment seen by the test article.

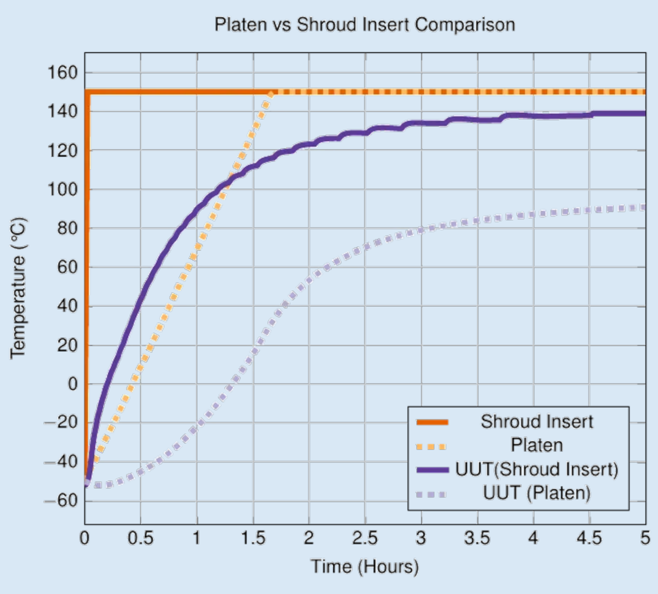
Thermal Shroud Insert

Our shroud insert works by rapidly changing the radiative thermal environment using foldable shrouds with electrical heaters. Our invention is self-contained, scalable, and does not require changing TVC design. It could be installed in almost any existing TVC. It converts any TVC into a thermal-vacuum shock chamber with minimum efforts. An example shroud insert in the hot(deployed configuration, left) and cold (retracted configuration, right) configuration is shown below.



Assigned Provisional Patent #: 63170349

Improved Thermal Response



By rapidly changing the radiative thermal environment, significantly faster test article ramp rates were achievable than with traditional platen and shroud configurations. This difference in ramp times is illustrated in the Figure above.

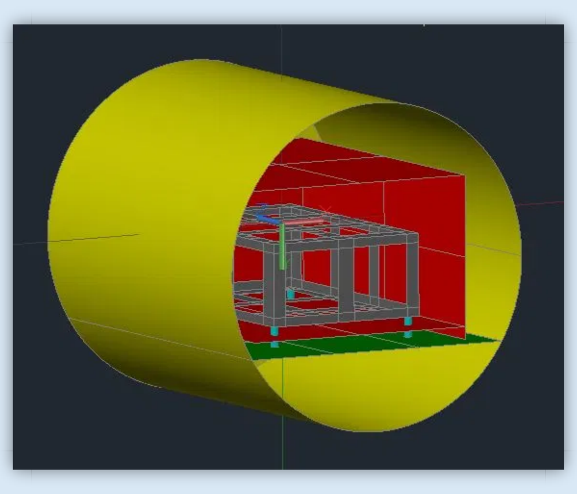
It also significantly reduces overall thermal vacuum test duration.

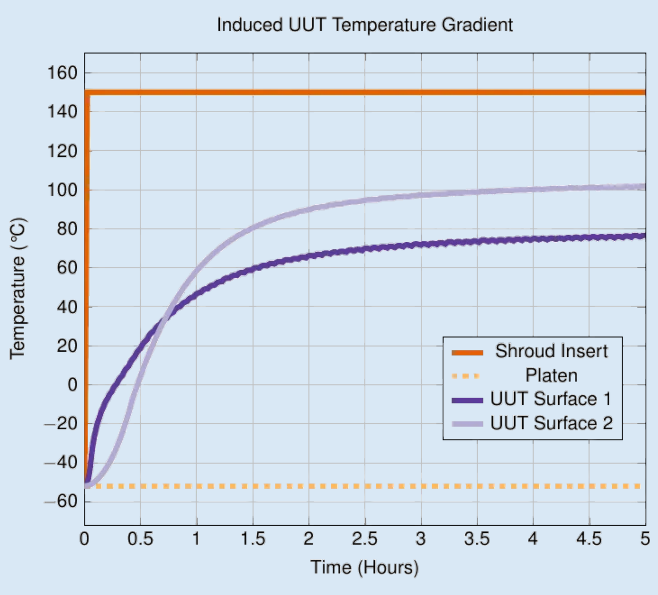
Innovative Testing

Induced Thermal Gradients

By combining our shroud insert with the existing thermally controllable environment in a traditional TVAC system, we can induce consequential thermal gradients across a test article.

Below, we can induce a 22°C gradient across the test article by mounting the test article on thermally conductive standoffs to the cold platen, while encased by six hot shroud inserts. This can help identify workmanship defects such as solder cold joint failure and potting compound creep strain.





Transient Analysis

Because of the fast transition between hot and cold radiative environments, the transition time scale is similar to in-flight conditions. This allows for verification of thermal transient behavior in a TVAC system.

Acknowledgements

RYDBERG VACUUM SCIENCES

YSPM, LLC. Satellite Propellant Management

Established in 2018, Seattle-based RVS has become a leading provider of advanced thermal vacuum test systems for the aerospace industry. We provide exceptional value space simulation systems for flight qualification of small satellites and components. RVS strives to offer solutions for anyone trying to complete a mission to space. Our in-depth knowledge is demonstrated with every completed system, as well as through our comprehensive consulting services and informative virtual courses on vacuum science.

As a small company, we pride ourselves on a personal approach to business. Our talented staff design, program, and support every system we make. RVS is committed to providing exemplary customer service alongside our quality products. Our affordable and advanced systems are an excellent option for small satellite developers, mission managers, educators and institutions, research centers, and private industry customers.

Established in 2011, YSPM offers a wide range of thermal engineering services –from initial concept generation to fully integrated thermal management solution in aerospace industry and beyond (telecommunications, medical equipment, etc.). We save time and avoid costly delays at the end of a project by identifying the correct thermal solution up front. We do a trade study to determine which of multiple potential thermal solutions offers the best performance and value.

Our thermal engineers are fully competent in heat transfer analysis and fluid dynamics. They are fluent in commercial software packages like Thermal Desktop, Sinda/Fluient, etc. Our thermal engineering professionals have done analysis on all levels, from system level like satellites to component level, heat pipes, heat sinks, Multi-Layer Insulation (MLI), thermal storage using Phase Change Materials and Radiation analysis.