

Testing of the Advanced Stirling Radioisotope Generator Engineering Unit at NASA Glenn Research Center

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August 1, 2012

Purpose

- Advanced Stirling Radioisotope Generator (ASRG) engineering unit (EU) has been on test at NASA GRC for almost 4 years and has accumulated over 27,000 hours of operation
- How has the ASRG EU been operated and tested?
- What have we learned?
- Future plans



Outline

- Advanced Stirling Radioisotope Generator Engineering Unit (ASRG EU) Background
- Test facility
- ASRG EU and ASRG Flight Unit
- Overview of ASRG EU testing
- How the ASRG EU was controlled
- Tests conducted under AC bus control
- Tests conducted under ASC Controller Unit (ACU) control
- Test data
- Conclusion

ASRG EU Background

- ASRG system integration contractor Lockheed Martin, under contract to the Department of Energy, designed and built the ASRG EU
- ASRG Engineering Unit (EU) designed and fabricated by LM, then underwent system-level tests to qualification level

Thermal balance - thermal model validation

Thermal performance - in thermal vacuum chamber, tested beyond allowable flight temperatures

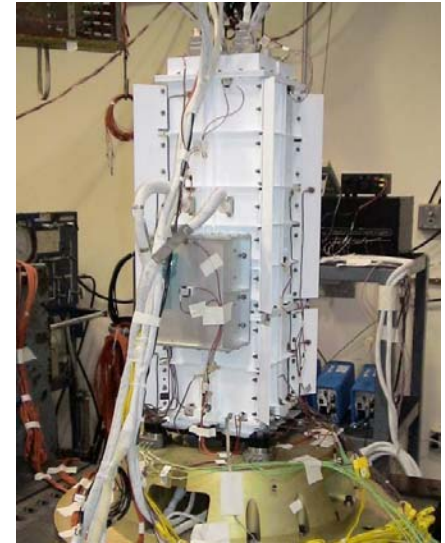
Sine transient – verify ASRG response to 5 to 80 Hz range to qualification level in two axes

Random vibration – to qualification level in three axes

Simulated pyrotechnic shock – to qualification level in two planes

Electromagnetic interference (EMI) – conducted and radiated emissions and susceptibility

- Delivered to NASA Glenn Research Center on August 28, 2008 to begin extended operation



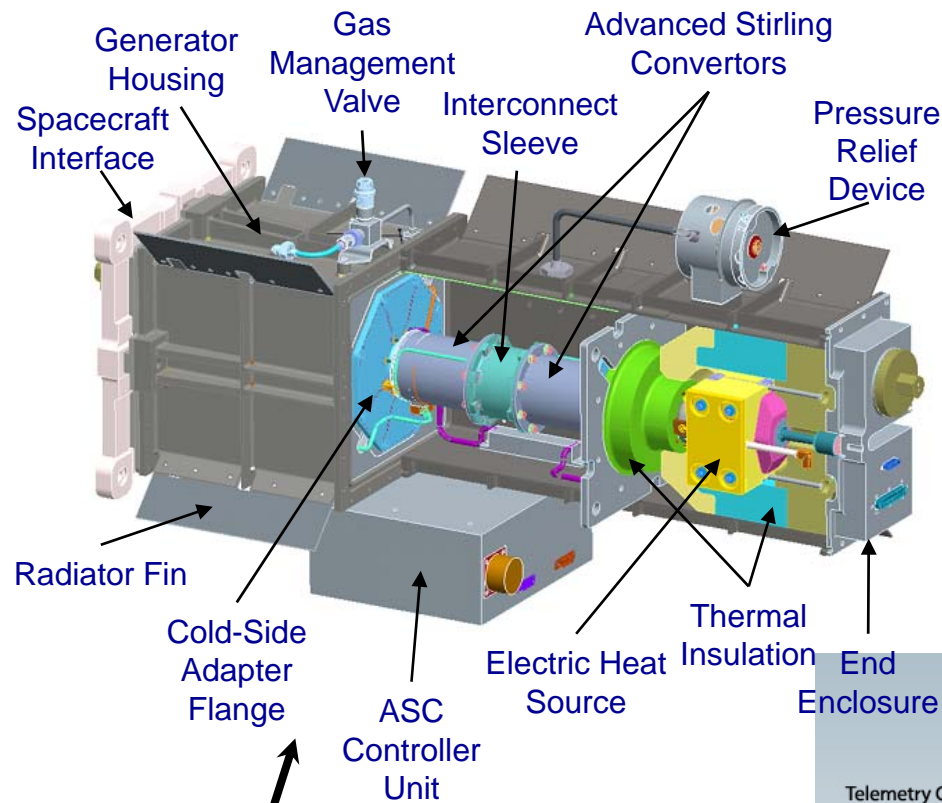
ASRG Flight Unit, courtesy of Lockheed Martin

The ASRG EU Test Facility

- Mounted vertically
- Two control options: AC bus control and ASC Controller Unit (ACU)
- Heat rejection through forced convection
- Full data set recorded every 2 seconds
- Data includes:
 - Temperatures
 - Heater power
 - Alternator voltage, current, power
 - DC bus voltage, current, power
 - Piston amplitude
 - Interface force and acceleration
 - ACU telemetry
 - Other parameters



The ASRG EU and the ASRG Flight Unit

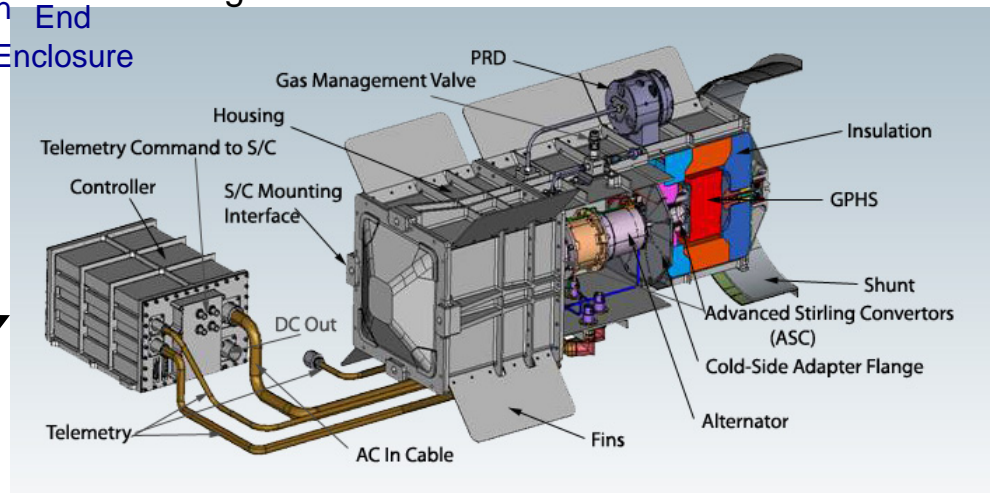


Engineering Unit

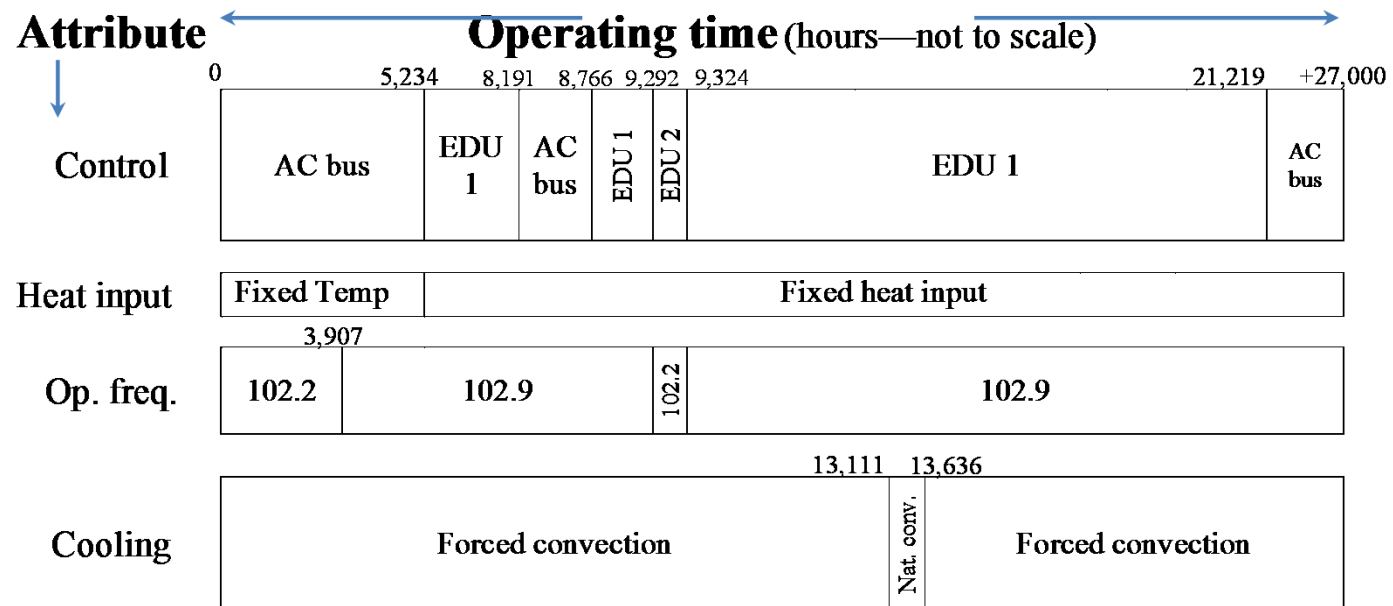
Flight Unit

Differences between the ASRG EU and ASRG Flight Unit

- Flight controller remotely mounted
- Longer flight radiator fins
- Increased flight convertor hot-end temperature
- Flight generator operating temperature range increased
- Flight convertor alternator voltage increased
- Electrical shunts moved from inside the generator to outboard end of the flight generator

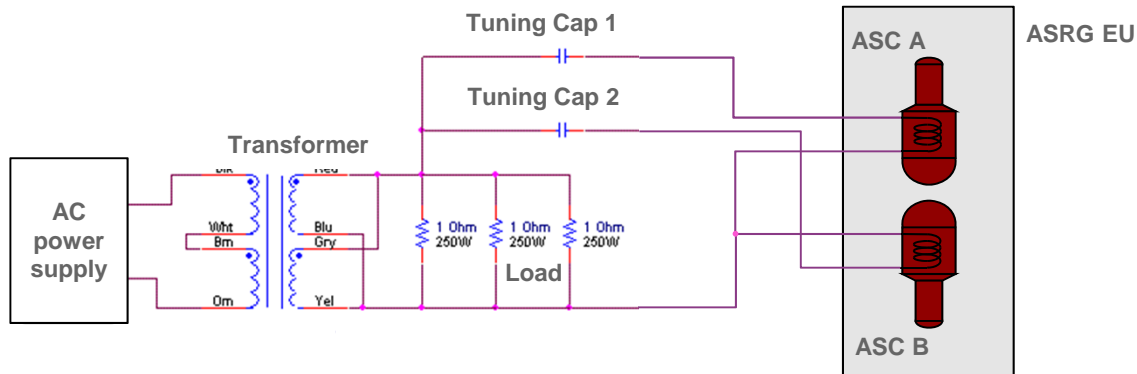


Summary Overview of ASRG EU Testing

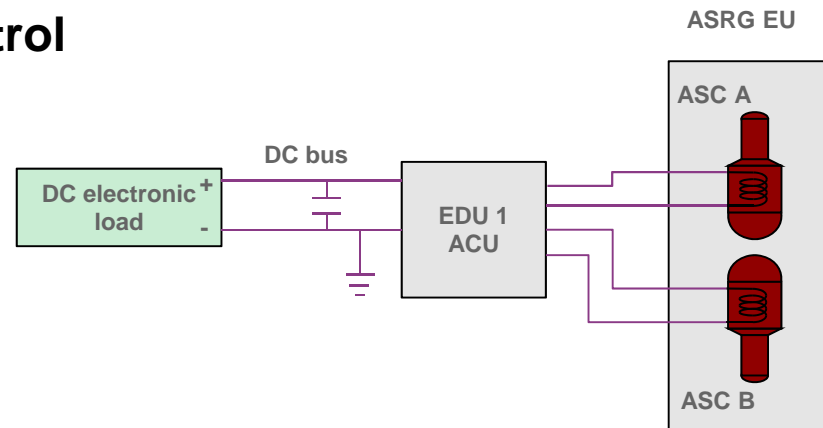


- Over 27,000 hours total operation
- 15,378 hours of operation on EDU 1 ACU

How the ASRG EU was Controlled



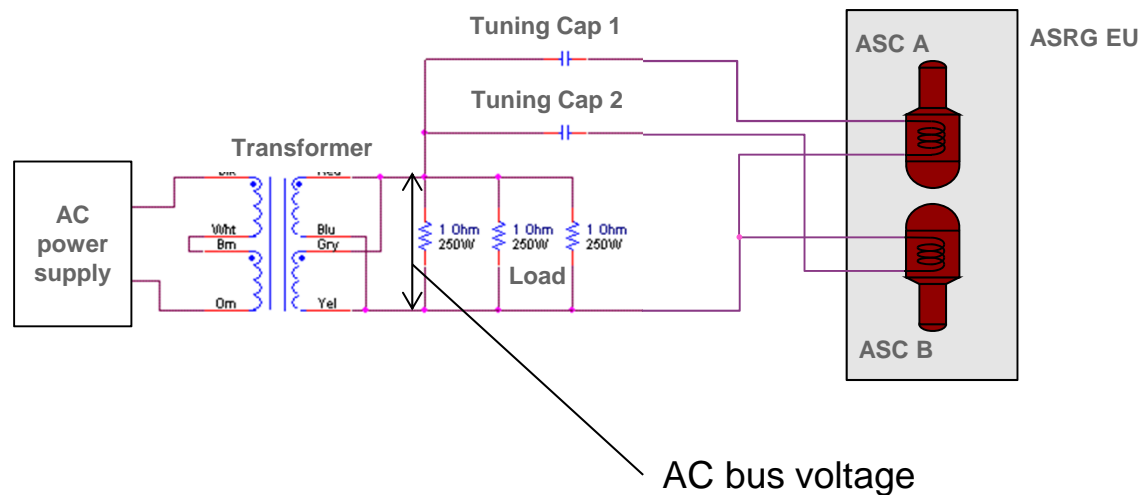
ASRG EU under AC bus control



ASRG EU under EDU 1 ACU control

Tests Conducted under AC Bus Control

- AC bus voltage variation
- Heat input variation
- Cold-end and pressure vessel temperature variation



Tests Conducted under EDU 1 ACU Control

Controller level tests

- ASC stability under ACU control
- ACU stability and drift
- ASC voltage setpoint command resolution
- Operating frequency command resolution
- Performance under different control modes

Voltage control

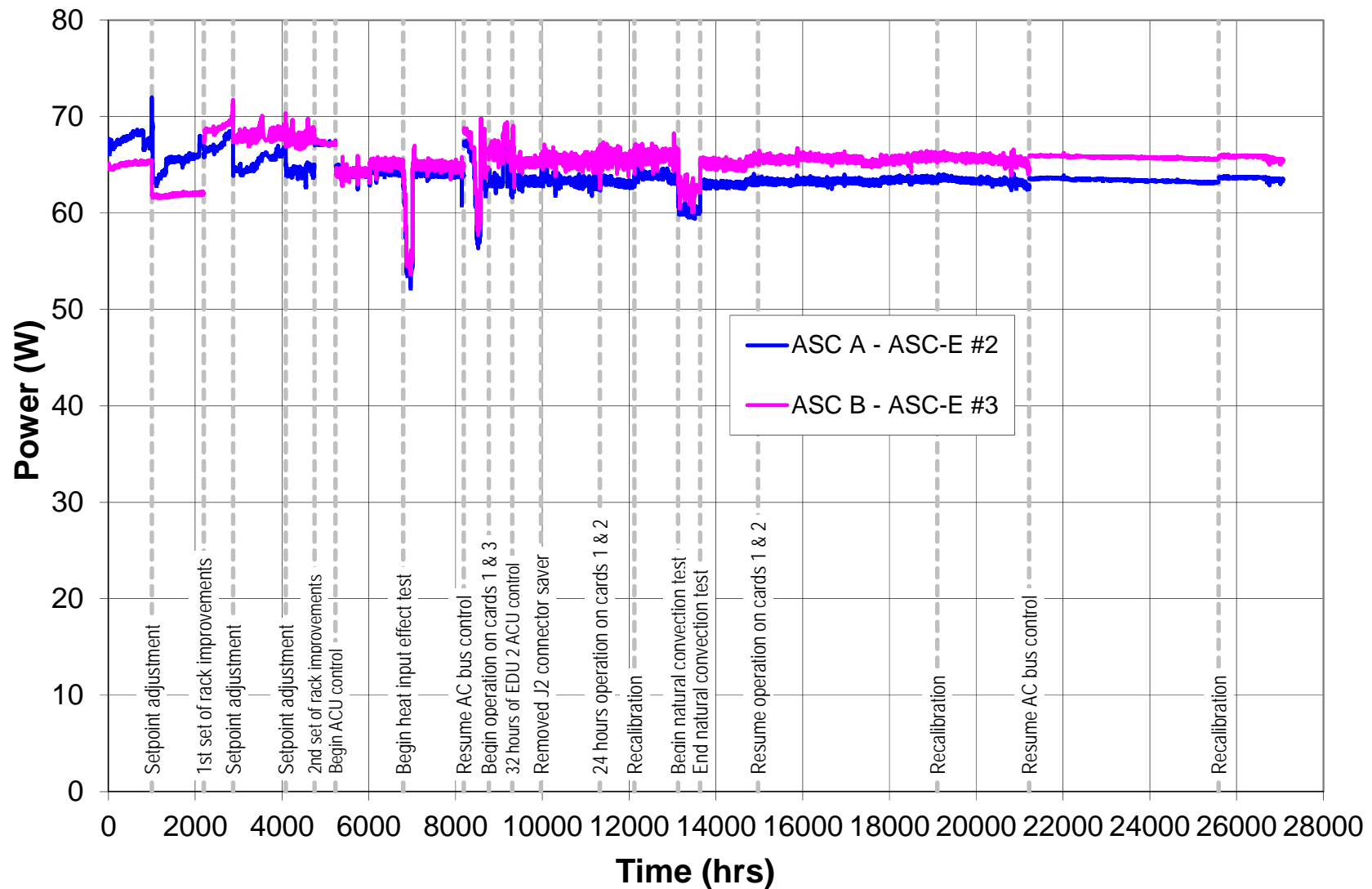
Piston amplitude control

Temperature control

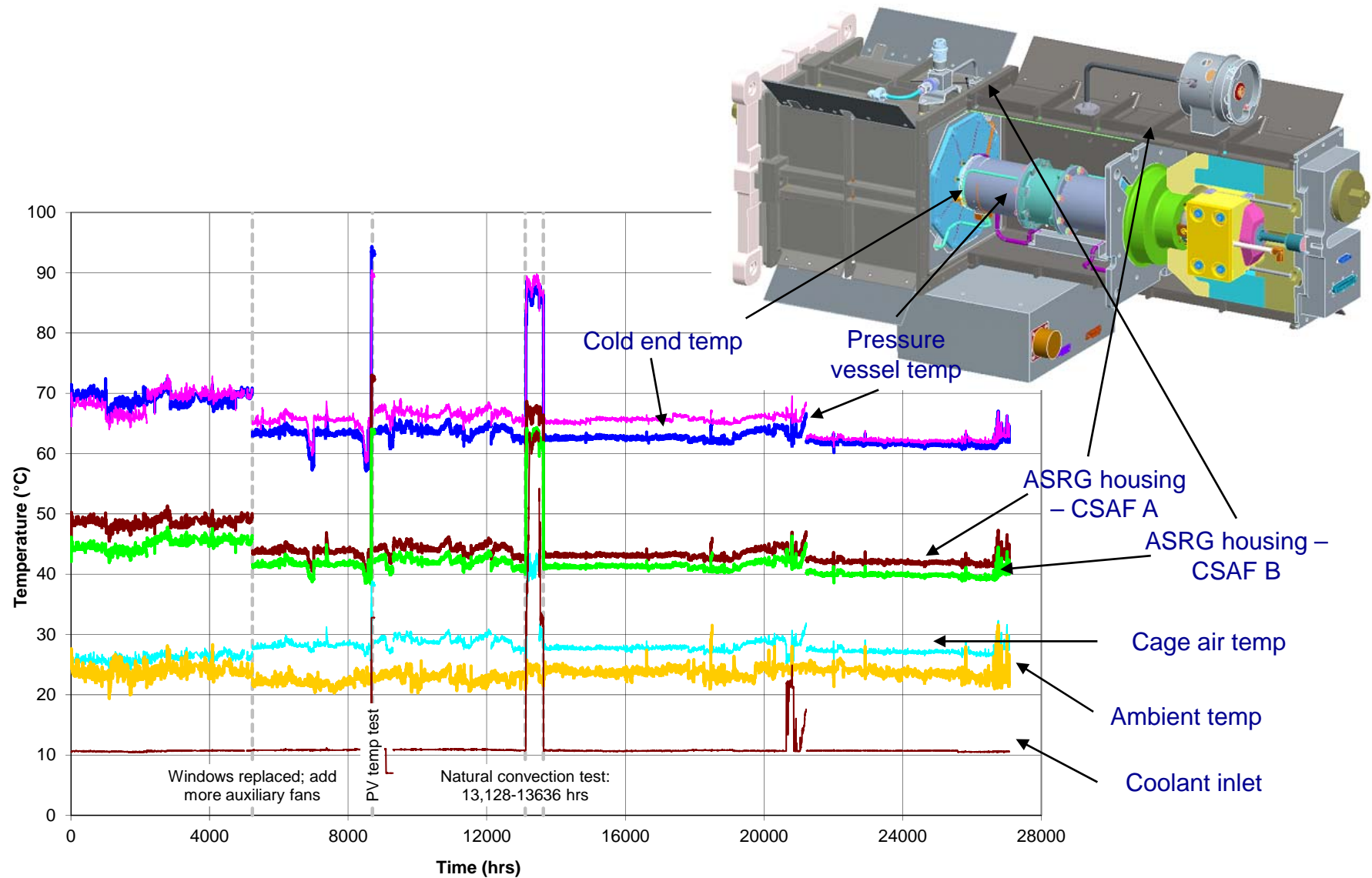
System Characterization Tests

- ASC voltage setpoint variation
- DC bus voltage variation
- Heat input variation
- Core loss test

Converter Output Power



Heat Rejection Temperatures



Conclusion

ASRG EU performed an important role in the ASRG development

- Integrated Stirling convertors with an electronic controller in a housing suited for radioisotope fuel
- Pathfinder for many of the manufacturing processes, assembly procedures, and tests
- Tests provided insight into characteristics and nuances of the ASRG relevant to mission
- EDU 1 controller proved the viability of the PWM-based control approach and paved the way for later generations of the controller (EDU 2, EDU 3, to be followed by the flight-like EDU 4)

Acknowledgments

This work is funded through the NASA Science Mission Directorate, the Radioisotope Power Systems Program Office, and the U.S. Department of Energy. Any opinions, findings, conclusions, or recommendations expressed in this article are those of the author and do not necessarily reflect the views of NASA. The author wishes to acknowledge the many people who supported ASRG EU testing in the Stirling Research Laboratory at the NASA Glenn Research Center.