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

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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

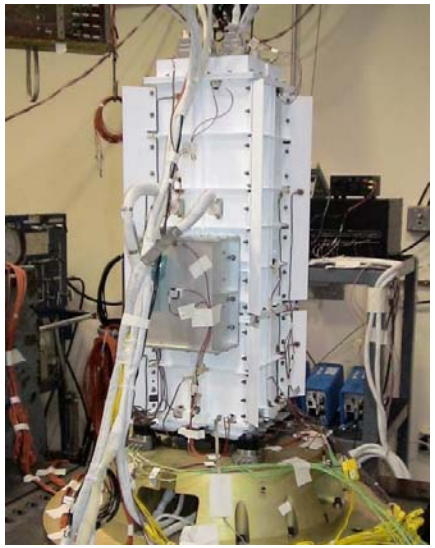
  Sine transient – verify ASRG response to 5 to 80 Hz range to qualification level in two axes

  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

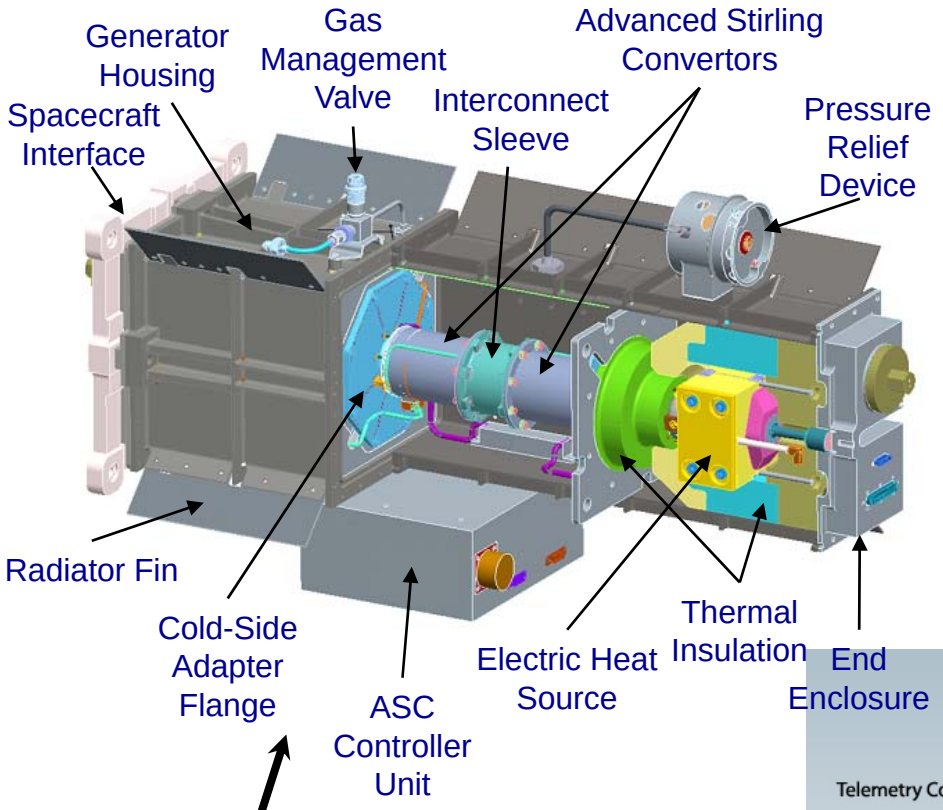


ASRG Flight Unit, courtesy of Lockheed Martin

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

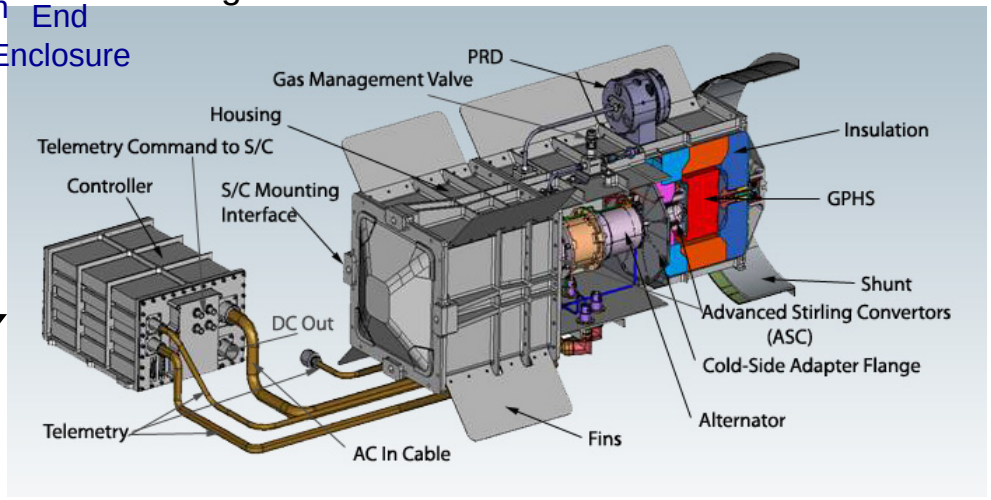


Engineering Unit

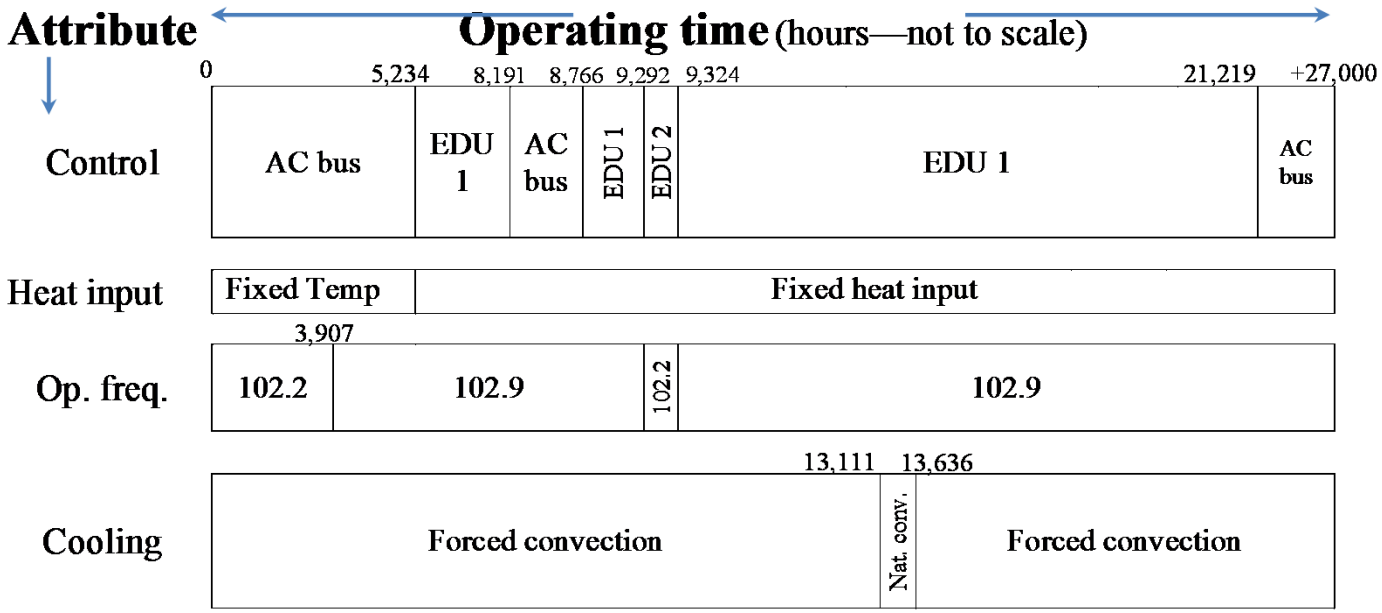
Differences between the ASRG EU and ASRG Flight Unit

- 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

Flight Unit

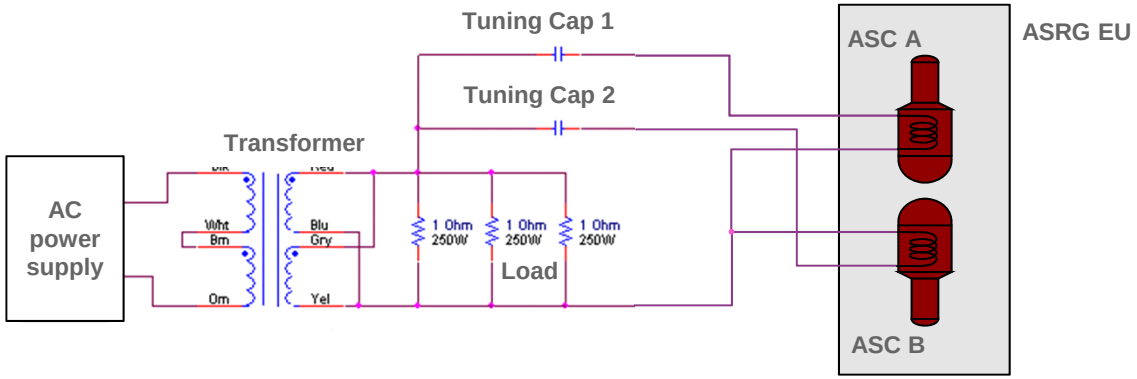


Summary Overview of ASRG EU Testing

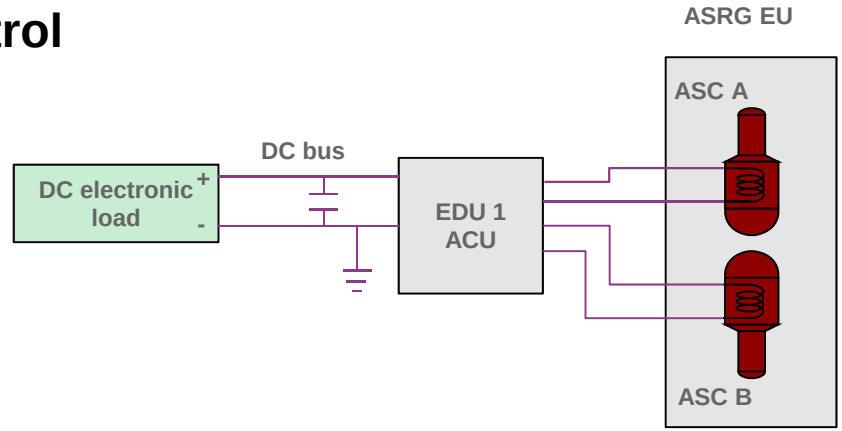


- Over 27,000 hours total operation
- 15,378 hours of operation on EDU 1 ACU

How the ASRG EU was Controlled



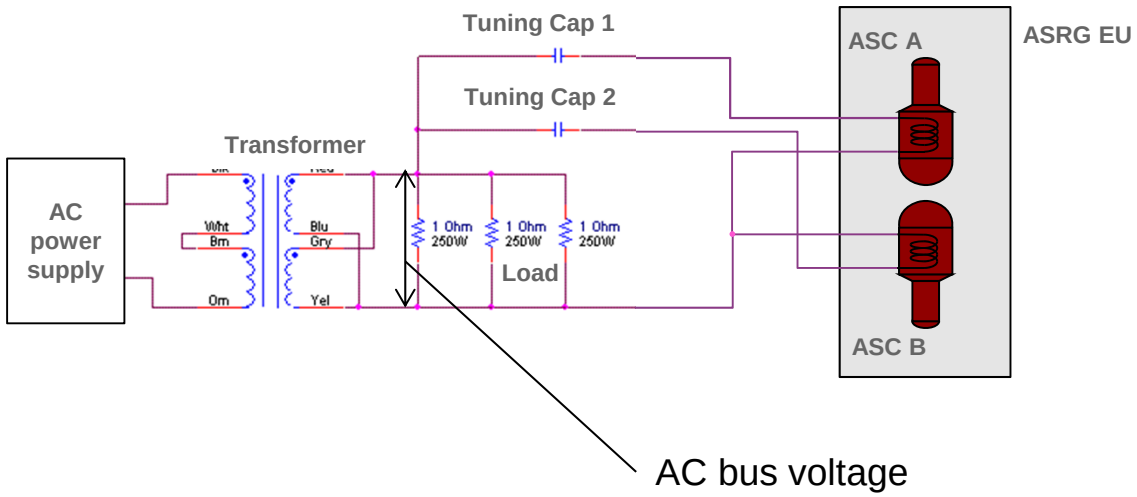
ASRG EU under AC bus control



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

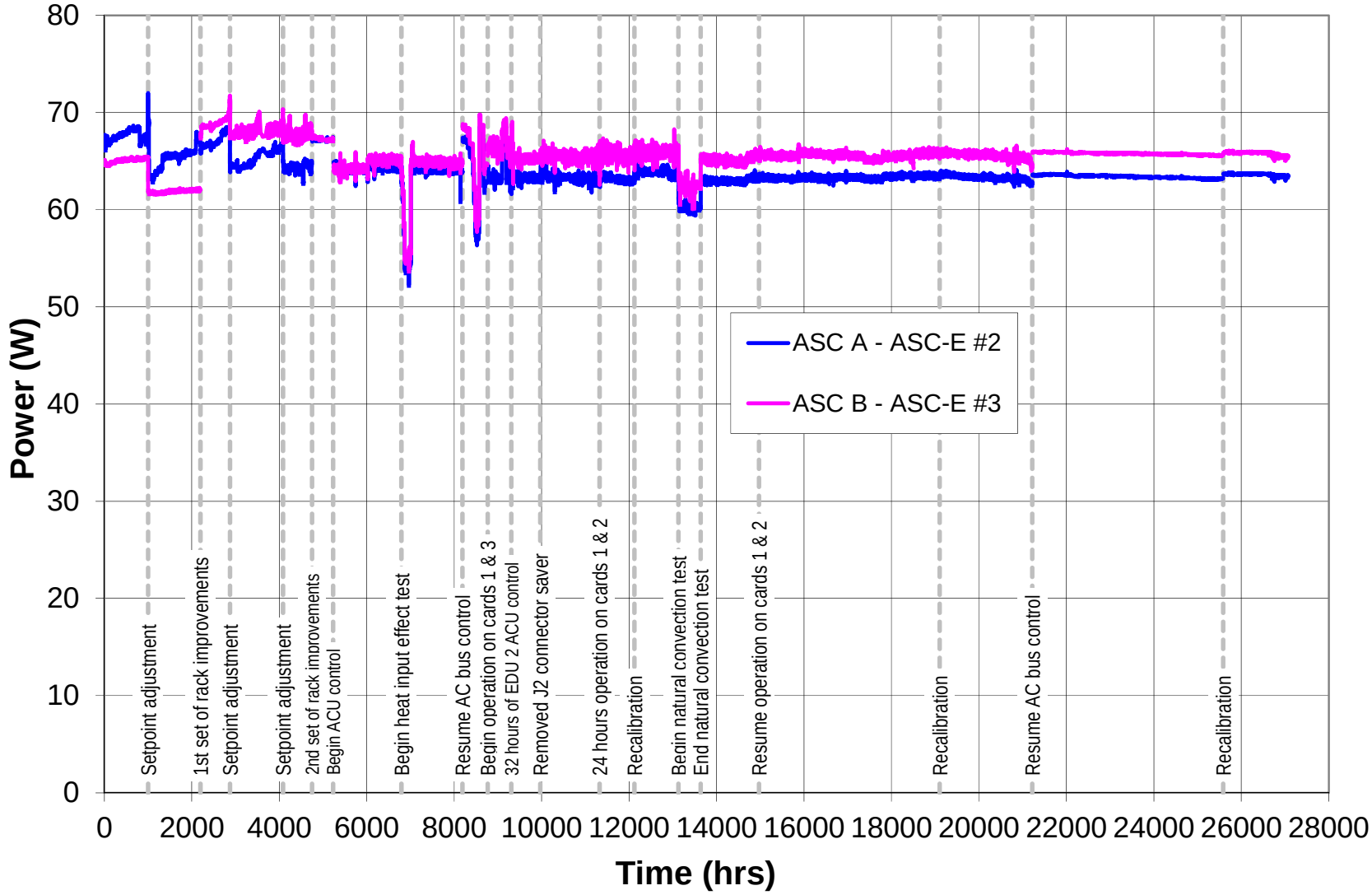
Controller level tests

- 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

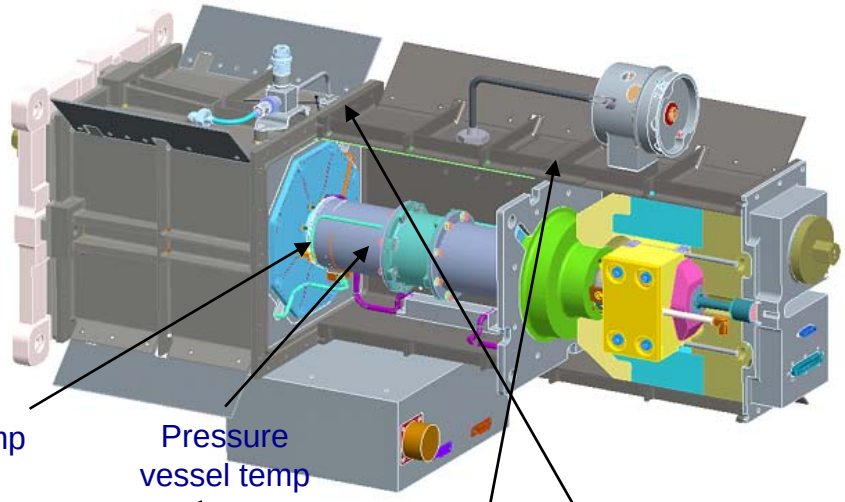
System Characterization Tests

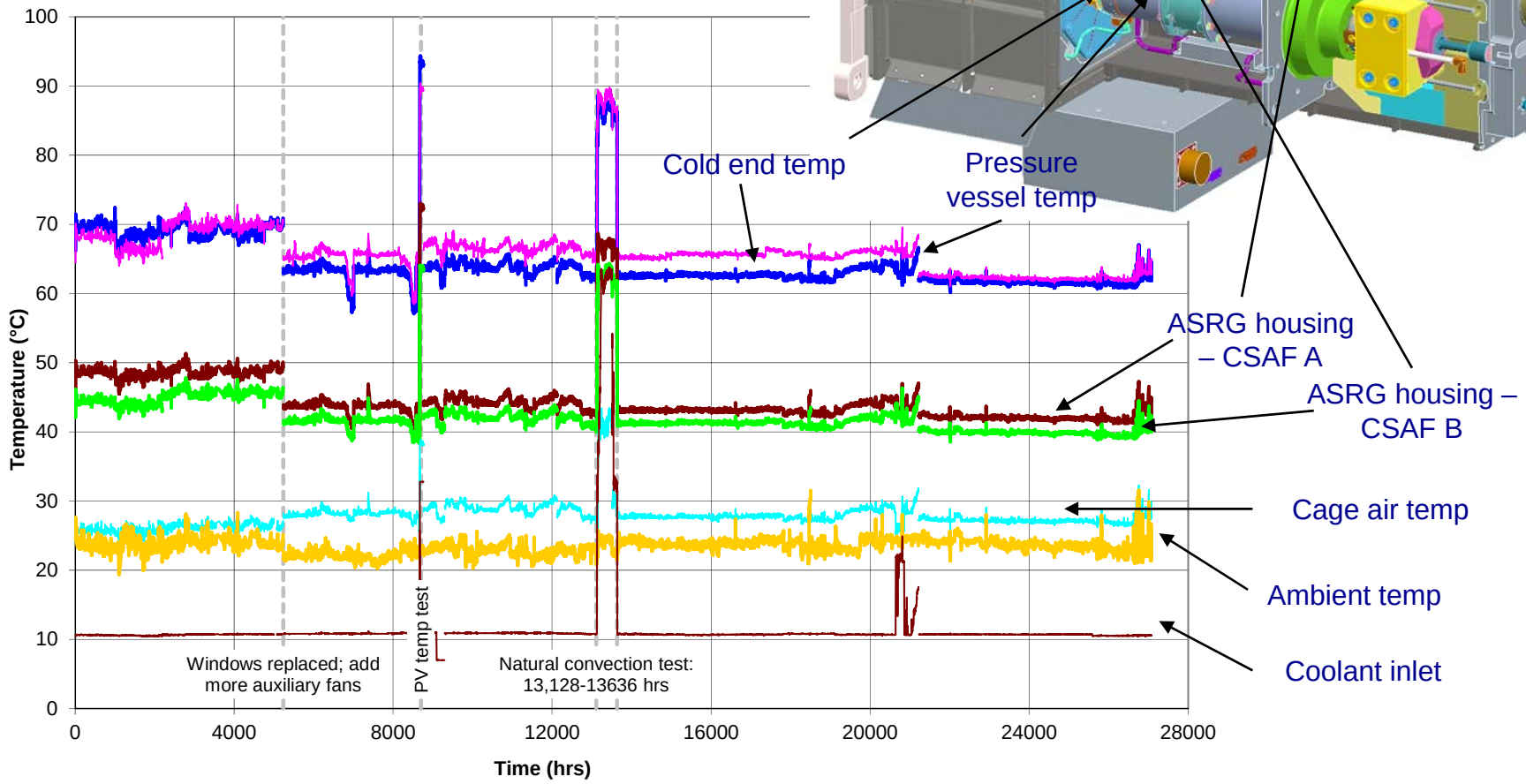
- ASC voltage setpoint variation
- DC bus voltage variation
- Heat input variation
- Core loss test

Convertor 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

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