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Advanced Stirling Radioisotope Generator Life Certification Plan

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Abstract. An Advanced Stirling Radioisotope Generator (ASRG) power supply is being developed by the Department of Energy (DOE) in partnership with NASA for potential future deep space science missions. Unlike previous radioisotope power supplies for space exploration, such as the passive MMRTG used recently on the Mars Curiosity rover, the ASRG is an active dynamic power supply with moving Stirling engine mechanical components. Due to the long life requirement of 17 years and the dynamic nature of the Stirling engine, the ASRG project faced some unique challenges trying to establish full confidence that the power supply will function reliably over the mission life. These unique challenges resulted in the development of an overall life certification plan that emphasizes long-term Stirling engine test and inspection when analysis is not practical. The ASRG life certification plan developed is described.

National Aeronautics and Space Administration

RADIOISOTOPE
POWER SYSTEMS

Jeffrey J. Rusick
ASRG Product Assurance

ASRG Life Certification Plan

NETS Conference Albuquerque, NM

February 27, 2013

POWER TO EXPLORE

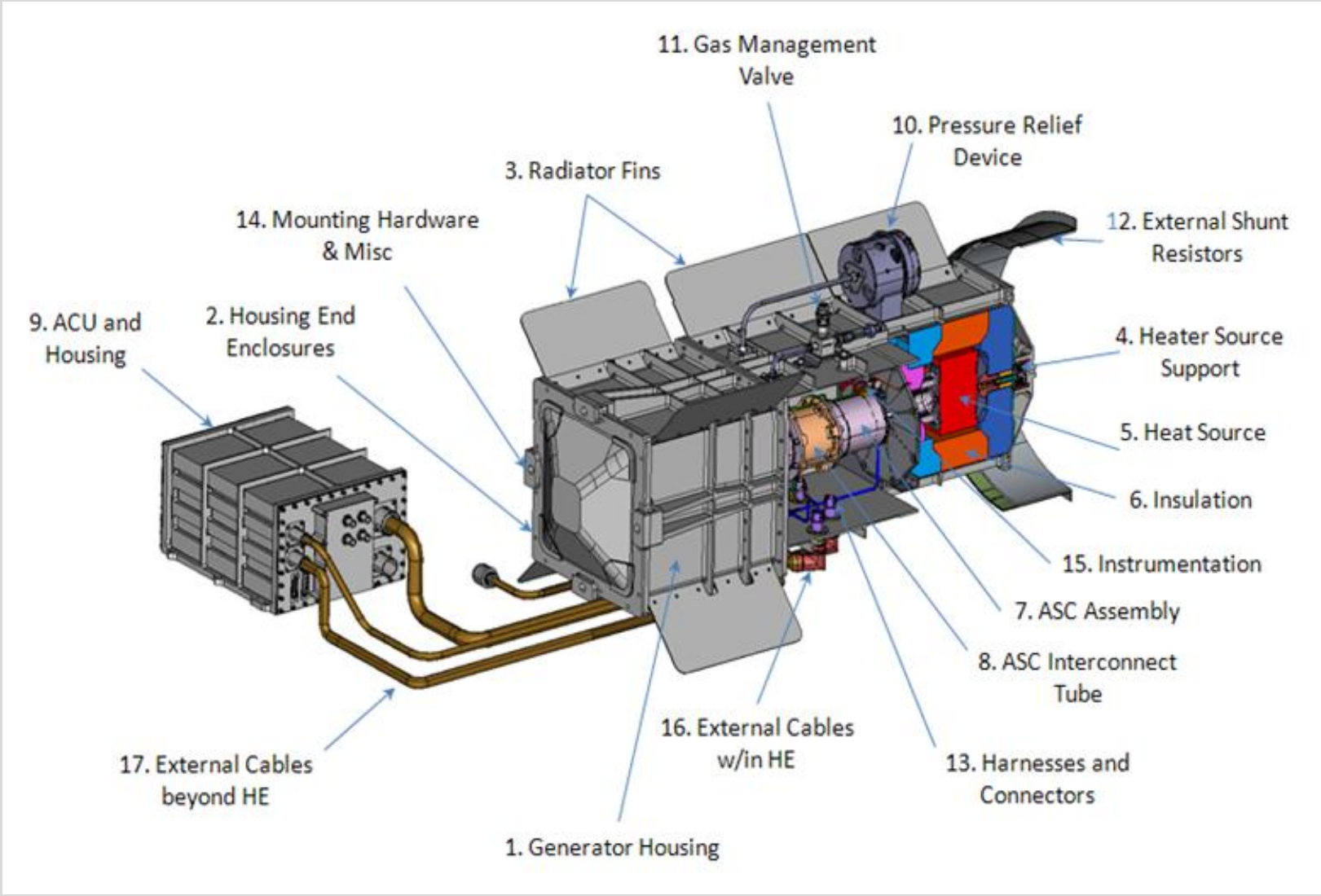
ASRG Project

(*Advanced Stirling Radioisotope Generator Project)*

MISSION

Develop and deliver 2 flight ASRGs by 2016 to POWER future NASA Science Mission Directorate deep space exploration

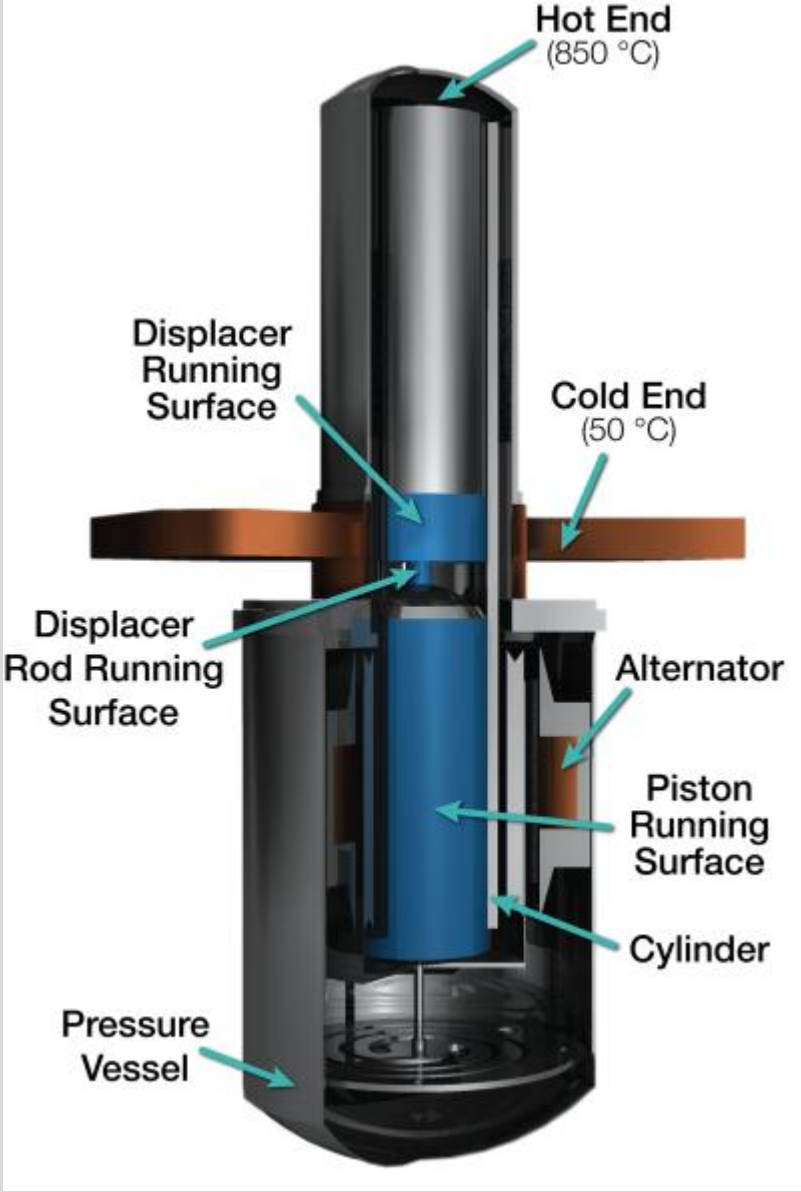
ASRG


11. Gas Management Valve
10. Pressure Relief Device
3. Radiator Fins
14. Mounting Hardware & Misc
12. External Shunt Resistors
9. ACU and Housing
2. Housing End Enclosures
4. Heater Source Support
5. Heat Source
6. Insulation
15. Instrumentation
7. ASC Assembly
8. ASC Interconnect Tube
16. External Cables w/in HE
13. Harnesses and Connectors
17. External Cables beyond HE
1. Generator Housing

ASC – Advanced Stirling Converter

LIFE CERTIFICATION CHALLENGES

- Free-piston Stirling engine
- “Non-contacting” piston/displacer designs supported within a cylinder by gas bearings
- Xylan lubrication on piston/displacer running surfaces
- Extremely tight running surface clearances (~20 microns)
- Large operating temperature gradients (850 C to 50 C)



ASRG Life Certification Plan

- Standard ASRG Flight Testing and Analysis

- Unique ASC testing and analysis
  - Extended Operational Testing of 8 EM ASCs
  - Durability Testing of EM ASCs
  - Integrated Testing of EM ASCs and EM ACUs (Advanced Controller Units)
  - Full fidelity ASRG QU and FU Testing to qualify ASCs via similarity

Extended Operational Testing

- Infant mortality test of 2,000 hours on all 8 ASC EMs
- Reassemble the ASC EMs and continue testing for 1000's of hours
- Disassemble at regular intervals and inspect
- PASS/FAIL Criteria:
  - Measure level and duration of power fluctuations, and assess acceptability per Red Team findings
  - Disassemble, measure/inspect running surface wear on piston/displacer
  - Inspect for internal debris generation

Durability Testing of ASCs

- Start/stop testing
- Centrifuge acceleration testing and analysis
- Flight vibration testing and analysis
- PASS/FAIL Criteria:
  - Disassemble, measure/inspect running surface wear on piston/displacer
  - Inspect for internal debris generation

Integrated Testing of ASCs and an ACU

- Run EM ASCs integrated with an ACU for many months, which will include many daily startup/shutdown cycles.
- After integrated testing, put the pair on test for 1000s of hours, and disassemble at regular time intervals.
- PASS/FAIL Criteria:
  - Measure level and duration of power fluctuations, and assess acceptability per Red Team findings.
  - Disassemble, measure/inspect running surface wear on piston/displacer.
  - Inspect for internal debris generation.

ASRG Flight Certification

The acceptability of the QU and FU power level fluctuations and durations during testing will provide the basis and confidence to certify the ASRG life for flight, via similarity comparisons with the power fluctuations observed during EM testing.

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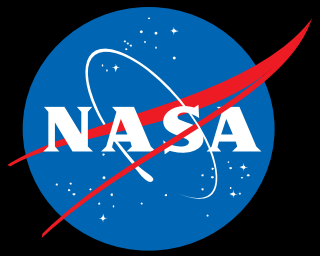
NASA

ASRG Testing & Analysis