

The PANT R - Pioneer Advanced Nuclear Thermal Helium Reactor

Assumptions And Design Needs:

Key Design Needs:

- · Energy Output
- Weight Limitations
- Lunar Regolith Mitigation
- Long No-Maintenance Lifespan
- Transportable

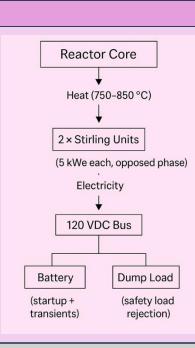
Key Design Assumptions and Decisions

- Geometry mimics original XENITH Design and payload removing need of neutronics validation
- Weight assumption: original at maxweight ≤ 10 metric tons from loading standards of large trucks
- Energy/Performance Output 3-10 MW
- Structural Factory Assembled
- Materials Corrosion, Radiation, and Oxidation resistant
- Thermal Stability 750 ± 50°C
- Safety/Environmental Compliance
- TRISO-X Fuel Utilization
- CAD Software Design



Energy Conversion Cycle

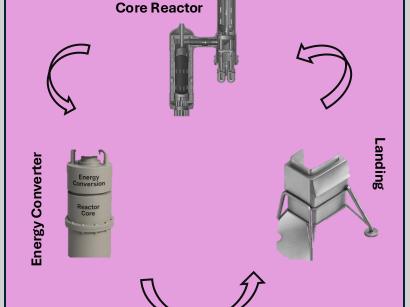
- 1- Reactor heat (750–850 °C) drives two Stirling convertors operating in opposed phase for continuous power.
- 2- Stirling engines produce ~10 kWe total, feeding a regulated 120 V DC power bus.
- 3- Battery (1–2 kWh) handles startup, transients, and short load spikes.
- 4- Dump load (10–15 kW) protects the system by absorbing excess power if main loads disconnect.



The **PANTHeR** is a retrofitted X-energy Xenith reactor modified to withstand extreme lunar conditions and provide long term power to future lunar missions.

Designed for remote and limited infrastructure locations; and has the capability to completely decommission within two years.

The lunar micro-reactor design was split into three subgroups



Additional SRIM/TRIM Data

Recoil Distribution

Supply 1982 Index of 1982

Recoil Distribution

Supply 1982 Index of 1982

Target Ionization

Part Index of 1982

Supply 1982 Index of 1982

Supply 198

References

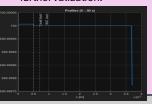
PANTHeR core - X-energy XENITH Retrofit

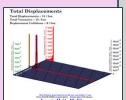


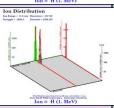
- Modern TRISO-X fuel ensures high temperature resilience and 20- year maintenance free lifes pan
- Carbide layer surrounding UCO kernels serves as a diffusion barrier, limiting fission product migration and improving particle integrity under irradiation.

SRIM/TRIM

- Effective shielding demonstrated at 0.03 cm thick B₄C monolithic layer with Si substrate layer for clear data
- 10,000-ion simulations used to validate B₄C shielding against alpha, recoil, and proton beams, across energy range of 100-1,500 keV
- Lunar Regolith Contamination Mitigation Refueling
- Traditional refueling methodology would expose the entire reactor the lunar dust.
- Vacuum purgeseal chambers designed for safe fuel cask removal and refueling; detailed implementation pending further validation.







Housing and Landing – Materials and Lunar regolith mitigation

Primary Structure:

- · Shell: Carbon Fiber Reinforced Polymer Composite
- Abrasion: Titanium alloy patches resist lunar dust wear.

Multi-Layer Radiation Shielding:

- **Neutron capture:** 5 cm borated polyethylene (B-PE) attenuates >90% thermal neutrons.
- Shield: 10-30 cm HD PE/U HMWPE panels reduce SPE 10-30 cm HD PE/U HMWPE panels reduce SPE dose

Ouer Exclusion Overhang Retractable Bulkhead Ventilated Dust Buffer Gap Purpe and Filter Dust Exclusion

LUNAR REACTOR HOUSING

KW Scale Control:

Path: Al 6061-T6 heat-pipe chan nels conduct waste heat. • Rejection: C-C composite radiators (ε

≈ 0.9). Q = €AT^4

Limit: Polymer layers ≤ 120-140 °C.

Passive Dust Protection:

Design: Dust overhang, retractable bulkhead, and vented buffer gap minimize contact.

Seals: PTFE-graphite composite prevents

