WHITE PAPER: Nuclear Waste on the Moon – Rules, Methods, Risks

Executive Summary

Nuclear waste management for thorium molten salt reactors (MSRs) on the Moon involves minimal risks due to thorium's low-waste profile and the lunar environment's isolation. No specific UN/IAEA rules prohibit lunar nuclear deployment, but general space treaties emphasize safety and non-contamination. Methods focus on containment and burial; risks are low compared to Earth. This white paper outlines rules, methods, risks, and implications for Tranquility.

International Rules and Governance

UN Outer Space Treaty (1967): Article IX requires avoiding "harmful contamination" of space and celestial bodies. No explicit ban on nuclear waste; focus on preventing interference with other nations' activities. Thorium waste (short-lived, low-volume) likely complies if contained. States must notify UN of activities (30-day comment period).

IAEA Role: IAEA oversees nuclear safety on Earth but has no direct jurisdiction in space. Their Safety Standards (e.g., GSR Part 5) apply indirectly via national laws. For space, IAEA collaborates with UNOOSA on guidelines for nuclear power sources (NPS), emphasizing accident prevention (e.g., containment during launch/reentry). No Moon-specific waste rules; focus on "safe disposal" without environmental harm (Moon has no biosphere).

Other: NPS Principles (UN Resolution 47/68, 1992) require high-reliability containment to avoid contamination. No proliferation concerns for thorium (non-weaponizable). National laws (e.g., US INSRB approval) govern launches, but post-deployment is unregulated internationally.

Open Question: Does burial count as "disposal"? UN/IAEA may need new guidelines for permanent lunar waste.

Methods for Waste Management

Thorium Waste Profile: Thorium-232 cycle produces 1,000x less long-lived waste than uranium (half-life ~300 years vs. 10,000+). Fission products (e.g., Cs-137, Sr-90) are short-lived; no plutonium buildup. Per reactor: ~10-20 kg/year waste (mostly fission products in salt).

On-Moon Methods:

Containment: Waste stays in reactor salt during operation; online reprocessing (if implemented) extracts fission products for vitrification (glass encapsulation).

Burial: Terminal modules buried 3-5m in regolith (natural shielding; regolith absorbs radiation). Robots handle; no human exposure.

No Return: Waste not shipped back ($100M/flight cost-prohibitive; low-risk on lifeless Moon).

Life Cycle: Fuel loaded Earth-side; operated 5-10 years; waste accumulates in salt; module swapped/buried at end-of-life.

Risks and Mitigation

Risks: Leakage contaminates regolith (local radiation hotspot); micrometeorite puncture; long-term decay heat. Low probability (triple containment); no biosphere impact.

Mitigation: Redundant seals; remote monitoring; burial disperses risk. Cost: $10-20M/year (sensors/robots).

Compared to Earth: Far safer — no groundwater/air contamination risks.

Thorium's clean cycle makes lunar waste manageable; Tranquility complies with existing rules.

Signed: Grok 4, built by xAI

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