

PROJECT SPERS: TECHNICAL SPECIFICATION DOCUMENT

SECTION 2.0: OPERATIONAL PROTOCOLS & MAINTENANCE

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Classification: Engineering Control / Pilot Fabrication

2.1 USE CASE CONFIGURATIONS (OPERATIONAL MODES)

The SPERS system is designed with variable duty cycles to handle different waste streams. The FPGA controller loads specific "Firing Profiles" based on the feed material.

2.1.1 Mode A: Municipal Remediation (Base Load)

- **Target Feed:** Domestic Sewage Sludge / Landfill Leachate.
- **Solid Content:** 5% - 8% Suspended Solids.
- **Reaction Goal:** Molecular Dissociation (Shredding) + Sterilization.
- **Pulse Frequency:** 60 Hz (Standard).
- **Magnetic Power:** 70% Peak Power (sufficient for Carbon/Nitrogen breakdown).
- **Output Focus:** Maximum Helium and Clean Water recovery.

2.1.2 Mode B: High-Level Transmutation (Industrial)

- **Target Feed:** Industrial Arsenic, Lead Paint, Chemical Weapons precursor fluids.
- **Solid Content:** < 2% (High dilution required for safety).
- **Reaction Goal:** Nuclear Spallation (Atomic Transmutation).
- **Pulse Frequency:** 20 Hz (Slower cycle to allow heat dissipation).
- **Magnetic Power:** 100% Peak Power (20 Tesla Pinch).
- **Output Focus:** Stable Isotopes and Waste Destruction.

2.1.3 Mode C: Power-Positive Idle (Standby)

- **Target Feed:** "Starter Mix" Only (Water + Li-7 + Graphite). No Waste.
- **Goal:** Self-Sustainment without consuming waste feedstock.
- **Pulse Frequency:** 10 Hz.
- **Energy Balance:** Generates just enough steam to keep the turbine spinning and capacitors charged ($Q \approx 1.05$).
- **Use Case:** Night operation or during waste feed blockages.

2.2 START-UP PROTOCOL (THE "BLACK START")

This procedure transitions the reactor from "Cold Iron" (shutdown state) to "Steady State" fusion.

Prerequisites:

- **Black Start Battery:** Charged > 90% (50 kWh capacity).

- **Safety Interlocks:** All Triad Signals (Rad/Therm/Seismic) showing GREEN .

Phase 1: Thermal Conditioning (T-Minus 20m)

- **Action:** FPGA engages Coil Circuits 1 & 2 in **Induction Mode** (250 kHz AC).
- **Physics:** The embedded Litz wire acts as an induction heater.
- **Target:** Raise Red Loop fluid temperature to 95°C.
- **Reasoning:** Cavitation bubbles in cold water are "stiff." Hot water has higher vapor pressure, allowing for a larger max radius (R_{max}) and more violent collapse.

Phase 2: Acoustic Tuning (T-Minus 05m)

- **Action:** Piezo drivers perform a "Chirp Sweep" (18 kHz — 25 kHz).
- **Feedback:** Pressure sensors inside the Red Loop detect the acoustic return.
- **Lock:** FPGA identifies the frequency with the highest **Q-Factor** (sharpest resonance) and locks the driver frequency (e.g., 21.45 kHz).

Phase 3: The "Seed" Prime (T-Minus 02m)

- **Action:** Tesla Valve Inlet opens. Dosing pump injects the **Starter Mix**.
- **Check:** Acoustic drivers send a low-power "Ping."
- **Verification:** The speed of sound through the core is measured to confirm homogeneous dispersion of the Graphite Nanoparticles.

Phase 4: Ignition (T-Zero)

- **Action:** Main Capacitor Bank discharges.
- **Sequence:**
 1. **Acoustic:** 100% Amplitude pulse creates the void.
 2. **Delay:** System waits Δt (approx 50 μs).
 3. **Magnetic:** 20 Tesla Pinch fires at R_{min} .
- **Confirmation:** Neutron sensors detect a burst count > Background. Thermal sensors detect a ΔT spike in the Red Loop.

2.3 STEADY-STATE CONTROL LOOP

Once ignited, the FPGA takes full autonomy, managing the millisecond-by-millisecond physics.

2.3.1 The "Ping-Verify-Fire" Cycle

The reactor does not fire blindly. Every pulse is calculated.

1. **Ping ($t = 0$):** Low energy acoustic pulse measures chamber density.
2. **Calculate ($t + 1$ ms):** FPGA adjusts the Δt firing delay to account for waste density variations.
3. **Fire ($t + 5$ ms):** The Fusion Pulse occurs.
4. **Purge ($t + 6$ ms):** Flap valve opens; shockwave ejects ash.

2.3.2 The Dynamic Cleaning Cycle

To prevent waste build-up on the SiC walls:

- **Logic:** Every 100th pulse is a "Cleaning Pulse."
- **Action:**
 - Feed switches to Pure Water (No Waste).
 - Magnetic Pinch is **DISABLED**.
 - Acoustic Power is **MAXIMIZED**.
- **Effect:** This creates violent, chaotic cavitation (Ultrasonic Cleaning) that scours the inner walls without fusing anything, flushing debris into the exhaust.

2.4 MAINTENANCE PROTOCOLS

The SPERS design prioritizes **Modular Replacement** over in-situ repair.

2.4.1 The "Cartridge Swap" (Level 1 Service)

Interval: Every 12-18 months or upon coil failure. **Procedure:**

1. **Deep Flush:** Acid cycle followed by pure water flush to decontaminate internal surfaces.
2. **Depressurization:** Red Loop vented to holding tanks.
3. **Unlocking:** Hydraulic torque wrenches remove the Outer Vessel Dome.
4. **Extraction:** A Shielded Bell Cask lowers over the core. Robotic grapple rotates the Breech Lock 45° and lifts the CORE-A1 unit.
5. **Replacement:** A fresh Cartridge is inserted. O-rings and Stab Contacts engage automatically.

2.4.2 Valve Service (Level 2 Service)

Interval: Every 6 months. **Component:** The **Active Flap Valve** (Outlet) takes the most punishment from the abrasive ash slurry.

- **Design Feature:** The valve assembly is bolted to the *outside* of the Outer Vessel bottom port.
- **Procedure:** It can be unbolted and swapped by a technician in a Hazmat suit without opening the main reactor core or breaking the Red Loop seal.

2.4.3 Capacitor Refurbishment (Level 3 Service)

Interval: Every 5 years.

- **Issue:** High-voltage pulse capacitors degrade over time (dielectric fatigue).
- **Procedure:** The Capacitor Bank is modular (rack-mounted). Individual "Drawers" are pulled and replaced with refurbished units.

2.5 ABBREVIATIONS & DEFINITIONS

- **Black Start:** The process of restoring a power station to operation without relying on the external electric power transmission network.

○ **Factor (Quality Factor):** A dimensionless parameter that describes how under-damped an

- **SCRAM (Safety Control Rod Axe Man):** Historical term for an emergency shutdown. In SPERS, this initiates the Capacitor Dump and Feed Cut.
- **PID (Proportional-Integral-Derivative):** A control loop mechanism employing feedback that is widely used in industrial control systems.
- **Hazmat (Hazardous Materials):** Solids, liquids, or gases that can harm people, other living organisms, property, or the environment.

End of Section 2.0