Earthange Master Protocol: Production and Stabilization of Export-Grade Charcoal

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Document Title: Comprehensive Manufacturing, Curing, and Quality Assurance Protocol for the Prevention of Spontaneous Combustion in Exported Charcoal
Applicability: All Earthange production facilities and partner kilns in Vietnam.
Objective: To establish and enforce a multi-stage production protocol that guarantees the chemical stability and safety of all charcoal products intended for long-distance sea transport. The primary goal is the complete mitigation of risks associated with exothermic oxidation and spontaneous combustion within sealed shipping containers.

Section 1: Introduction and Foundational Principles

1.1. Purpose and Scope:

This document provides the definitive operational framework for all personnel involved in the production, handling, and packaging of charcoal for export. It covers every stage, from raw material selection to final container loading. Adherence is mandatory and non-negotiable.

1.2. The Science of Charcoal Instability:

Charcoal is a highly porous material with a vast internal surface area. Its instability stems from two primary chemical phenomena:

- **Incomplete Pyrolysis:** The failure to fully decompose lignocellulosic material leaves behind volatile compounds (pyroligneous acids, tars, methanol). These compounds are chemically unstable and can readily oxidize.
- **Exothermic Oxidation:** Freshly produced, high-purity carbon has an immense affinity for oxygen. As oxygen from the air adsorbs onto the carbon's porous surfaces, it generates heat (an exothermic reaction). In an unventilated environment like a shipping container, this heat cannot dissipate, leading to a thermal runaway effect where increasing temperature accelerates the rate of oxidation, eventually reaching the material's autoignition temperature.

1.3. The Earthange Safety Philosophy:

Our protocol is not merely about creating charcoal; it is about engineering a **passivated carbon product**. We achieve this by systematically addressing the root causes of instability through controlled carbonization, aggressive heat treatment, and a mandatory, extended atmospheric curing phase.

Section 2: Phase 1 - Pre-Production and Carbonization

2.1. Raw Material Selection and Preparation:

- **2.1.1. Species and Sourcing:** Only approved hardwood species (e.g., *Rhizophora apiculata* for Mangrove, *Eucalyptus urophylla* for Eucalyptus) from sustainably managed and licensed sources shall be used.
- **2.1.2. Seasoning:** Wood must be seasoned for a minimum period of 60 days to reduce moisture content to below 25%. This is critical for efficient and complete pyrolysis. Moisture content must be verified with a calibrated moisture meter before kiln loading.
- **2.1.3. Sizing and Grading:** Logs must be cut to uniform lengths and diameters (as per product specification) to ensure predictable and even heat transfer within the kiln. Any wood showing signs of rot, fungal growth, or insect infestation must be rejected.

2.2. Kiln Technology and Loading:

- **2.2.1. Kiln Integrity:** All kilns (earthen, brick, or retort) must be inspected for cracks or leaks before each cycle. Air leaks lead to uncontrolled combustion and result in low-yield, low-quality ash and dangerously under-carbonized product.
- **2.2.2. Strategic Loading Protocol:** Wood is to be stacked vertically (or horizontally, depending on kiln type) with deliberate spacing (min. 1-2 cm between logs) to create channels for hot gas convection. This ensures uniform heating and prevents the formation of "cold spots" where incomplete carbonization can occur.

2.3. The Carbonization Cycle - A Two-Stage Thermal Process:

- **2.3.1. Stage 1: Endothermic Pyrolysis (Target Temp: 200-500°C):**
  - The kiln is sealed, and a small ignition fire is started. Oxygen supply is then severely restricted.
  - Over a period of 5-10 days (depending on kiln size and wood type), the wood is slowly "baked." During this phase, water is driven off, followed by the decomposition of cellulose and lignin, releasing immense volumes of flammable and volatile wood gas. This gas must be safely vented or re-combusted.
- **2.3.2. Stage 2: Exothermic Refining (Target Temp: >950°C):**
  - This is the primary quality and safety-defining stage. Towards the end of the cycle, air inlets are strategically opened to introduce a controlled amount of oxygen.
  - This ignites the remaining wood gases and surface carbon, rapidly raising the internal kiln temperature to **above 950°C, with a target of 1000-1100°C**. The charcoal mass must achieve a uniform, bright orange-to-yellow glow.
  - **Objective:** This intense heat blast incinerates any residual, stubborn tars and volatile compounds, while simultaneously refining the carbon into a denser, more graphitic-like structure. This process significantly reduces the charcoal's inherent chemical reactivity. This high-heat phase must be maintained for a minimum of 12-24 hours.

Section 3: Phase 2 - Post-Kiln Handling and MANDATORY Passivation

3.1. Cooling Protocol:

- The method of cooling depends on the charcoal type, but the goal is to prevent uncontrolled combustion upon exposure to air.
  - **For Black Charcoal:** The kiln is hermetically sealed and left to cool for several days until it reaches near-ambient temperature.
  - **For White Charcoal (Binchotan-style):** The glowing charcoal is rapidly pulled from the kiln and immediately smothered in a prepared mixture of sand, earth, and ash. This "quenching" process rapidly cools the material and deposits the signature white powder.

3.2. The Critical Passivation Stage (Non-Negotiable Safety Protocol):

- **3.2.1. Prohibition:** Under no circumstances, without exception, is charcoal to be moved directly from cooling to the packaging area. All charcoal is considered "hot" (chemically reactive) at this stage.
- **3.2.2. Curing Zone Specification:** A dedicated, physically separate Curing Zone must be maintained. This zone must be:
  - Covered to protect from direct rain and sun.
  - Constructed with open sides or powerful ventilation systems to ensure constant, unimpeded airflow.
  - Equipped with a clean, dry, non-combustible floor (e.g., concrete).
- **3.2.3. Curing Procedure:**
  1. All cooled charcoal is transported to the Curing Zone.
  2. The charcoal is spread into shallow piles, not exceeding 50 cm in depth, to maximize the surface area exposed to air and prevent heat accumulation.
  3. The charcoal must remain in the Curing Zone for a **minimum mandatory passivation period of 96 hours (4 days)**. For high-density woods like mangrove, a period of 120 hours (5 days) is the standard.

- **3.2.4. Scientific Justification:** This extended period allows the charcoal to undergo its primary, most vigorous phase of exothermic oxidation in a controlled, safe environment. The slow, natural reaction with atmospheric oxygen "ages" and "calms" the carbon surfaces, bringing the material to a state of equilibrium. The heat generated is continuously and harmlessly dissipated by the ambient airflow. This process effectively neutralizes the primary cause of spontaneous combustion.

3.3. Quality Control During Curing:

- A designated QC officer will conduct temperature readings of the curing piles twice daily using a calibrated infrared thermometer. Any pile showing a temperature more than 15°C above the ambient air temperature is to be flagged, spread thinner, and investigated. A persistent high temperature indicates a failed batch due to incomplete carbonization, which must be rejected for export.

Section 4: Phase 3 - Final Processing and Packaging

4.1. Fines and Dust Removal (Screening):

- **4.1.1. Mandate:** All charcoal must undergo mechanical screening after the full curing period is complete.
- **4.1.2. Process:** The cured charcoal is passed over a vibrating sorting table with a mesh screen sized to the product specification. This process separates valuable lump charcoal from highly reactive dust, powder, and small fragments (fines).
- **4.1.3. Rationale:** The surface area of 1kg of charcoal dust is exponentially larger than 1kg of lump charcoal. Removing these fines is a critical step in reducing the total reactive surface area within a sealed bag.

4.2. Final Visual and Physical Inspection:

- Trained sorters visually inspect the screened lump charcoal on a conveyor belt or sorting table.
- **Rejection Criteria:**
  - Any pieces with a brownish core or un-carbonized wood texture ("brown-ends").
  - Excessively cracked, brittle, or soft pieces.
  - Pieces contaminated with soil, stones, or other foreign matter.
- **Positive Confirmation:** Sorters will confirm the charcoal has a hard, dense feel and produces a clear, metallic, clinking sound when struck, which is the hallmark of a well-made, stable product.

4.3. Packaging and Sealing:

- Only charcoal that has passed all previous stages is approved for packaging.
- The product is weighed and placed into heavy-duty, multi-laminar PP (polypropylene) woven bags. Inner liners may be used based on client specifications.
- Bags are securely stitched or sealed to prevent spillage and minimize atmospheric moisture ingress during transit.

Section 5: Final Logistics and Documentation

5.1. Warehouse Holding:

- Bagged charcoal should be stored in a dry, ventilated warehouse for a final 48-hour holding period before being loaded into a shipping container. This acts as a final buffer and observation period.

5.2. Container Inspection and Loading:

- Before loading, the designated shipping container must be inspected to ensure it is clean, dry, and structurally sound.
- Bags are to be loaded carefully to prevent breakage and ensure good weight distribution.

5.3. Documentation and Traceability:

- Every batch of charcoal is assigned a unique batch code that traces back to its production date, kiln number, and curing period. A Certificate of Analysis (COA), including confirmation of the completed passivation period, can be provided to the client upon request, certifying that the product has been manufactured in accordance
- with this safety protocol.