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Title: High-Vacuum Pump-Down & Controlled Venting Sequencing SOP	**Author:** Kadeem Manning (Tier II Tech)	**Status:** Approved

High-Vacuum Pump-Down & Controlled Venting Sequencing SOP

Standardized Interlock Sequencing, Roughing Crossover, Turbo Acceleration, and Dry N2 Venting

1. Purpose & Mandatory Interlock Rules

This SOP establishes the strict valve sequencing and pressure crossover interlocks required when evacuating a high-vacuum chamber from atmosphere down to base pressure (≤ 5×10^{-6} Torr) and safely venting back to atmospheric pressure. Operating valves out of sequence risks catastrophic turbomolecular pump rotor destruction, severe oil backstreaming, or viewport implosion.

CRITICAL SAFETY & HARDWARE INTERLOCK RULES:
1. NEVER open the High-Vacuum Gate Valve while the main chamber is at atmospheric pressure.
2. NEVER open the Roughing Valve to an un-pumped or atmospheric turbomolecular pump.
3. NEVER energize Hot Cathode Ion Gauges at pressures above 1×10^{-3} Torr (prevents filament burnout).

2. High-Vacuum Evacuation & Crossover Sequence

Phase 1: Pre-Flight Audit & System Closure
• Confirm Chamber Vent Valve (Dry N2) and Process Gas Mass Flow Controllers are 100% closed.
• Verify Viton O-ring seal surfaces are clean, free of dust/hair, and lightly lubricated.
• Check turbomolecular pump cooling water flow (≥ 1.5 gpm, temperature 18°C–22°C).

Phase 2: Rough Vacuum Phase (Atmosphere → 100 mTorr)
1. Ensure Foreline Valve and Main Gate Valve are fully CLOSED.
2. Start the Mechanical Roughing/Backing Pump.
3. Open the **Roughing Valve** to evacuate the main chamber through the roughing line.
4. Monitor chamber Pirani/Convection pressure gauge until reading drops below 100 mTorr (1×10^{-1} Torr).

Phase 3: High-Vacuum Crossover & Turbo Acceleration
1. CLOSE the **Roughing Valve** completely.
2. Open the **Foreline Valve** connecting the roughing pump to the turbopump exhaust exhaust backing line.
3. Verify turbopump foreline pressure is ≤ 0.1 Torr, then start the Turbomolecular Pump (TMP).
4. When turbopump reaches >80% nominal RPM (e.g., 60,000 RPM), SLOWLY open the main **Chamber Gate Valve**.
5. Turn ON the High-Vacuum Ionization Gauge once chamber pressure drops below 1×10^{-3} Torr.
6. Allow chamber to reach base pressure (≤ 5×10^{-6} Torr) prior to process/deposition initiation.

3. Controlled Chamber Venting Sequence

1. **Shutdown Active Components:** Turn OFF substrate heaters, deposition sources (e-beam/sputter), and Ionization Gauges. Allow heated elements to cool below 50°C.
2. **Isolate High Vacuum:** CLOSE the main Chamber Gate Valve completely.
3. **Controlled Dry N2 Backfill:** Slowly open the Chamber Vent Valve connected to dry N2 gas (≤ 0.5 bar delivery pressure). *Never vent with room air; moisture adsorption dramatically increases subsequent pump-down times.*
4. **Chamber Opening:** Once internal pressure reaches atmospheric equilibrium (door seal releases), turn OFF N2 vent valve and open chamber cover.

4. Chamber Bake-Out & Outgassing Management Guidelines

Vacuum Regime	Target Base Pressure	Bake-Out Temperature / Duration	Gasket / Seal Type
High Vacuum (HV)	1×10^{-6} to 1×10^{-7} Torr	Unbaked / Ambient (20°C–25°C)	Viton / FKM O-rings
Ultra-High Vacuum (UHV)	1×10^{-8} to 1×10^{-10} Torr	150°C to 250°C for 24–48 hours	OFHC Copper Gaskets (CF Flanges)

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