VACUUM SYSTEM ADVANCED DIAGNOSTICS SOP

Decision-Tree Protocols for Pressure Stalls, Virtual Leaks, Outgassing, and Mechanical Overloads

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1. Purpose & Diagnostic Philosophy

This SOP establishes systematic decision-tree troubleshooting for vacuum system anomalies, including rough vacuum stalls, high vacuum outgassing barriers, virtual leaks, and mechanical pump overloads. Isolating root causes prevents unnecessary component replacement and enforces ALCOA+ data defensibility across all vacuum operations.

2. Decision-Tree Troubleshooting Framework

Branch 1: Stalls at Rough Vacuum (~1 Torr / 1000 microns)
• Step 1.1: Close foreline/isolation valve to isolate the roughing pump.
• Step 1.2: Measure standalone pump ultimate pressure. If pump achieves <100 mTorr (<10–20 µm), the pump is healthy.
• Step 1.3: Inspect chamber main door Quad-Ring / Viton O-ring for hair, lint, or particulate contamination. Clean with IPA and re-seat.
• Step 1.4: Perform helium spray test on foreline KF clamps and shaft seals.

Branch 2: Stalls at 10^{-4} Torr Range (Outgassing vs. Real Air Leak)
• Step 2.1: Analyze Residual Gas Analyzer (RGA) spectrum at m/z = 18 (H2O), m/z = 28 (N2), and m/z = 32 (O2).
• Step 2.2: If m/z = 28 and 32 display a 4:1 ratio, a real atmospheric leak exists. Execute SOP-LEAK-2021-18 helium spray testing.
• Step 2.3: If m/z = 18 (water vapor) dominates, outgassing is occurring. Initiate chamber bake-out at 100°C–150°C for 4–8 hours under dry N2 purge.

Branch 3: Virtual Leaks (Trapped Blind-Hole Air Pockets)
• Step 3.1: Virtual leaks exhibit a slow, linear pressure rise during rate-of-rise testing that flattens out over extended time, unlike real leaks which rise indefinitely.
• Step 3.2: Inspect internal chamber mounting hardware. Replace all solid screws in blind-tapped holes with center-drilled vented screws or slotted washers.

Branch 4: Pump Cavitation, Thermal Trips & Overloads
• Step 4.1: If roughing pump chatters ('marbles sound'), open gas ballast valve to purge trapped moisture.
• Step 4.2: If turbopump thermal trips, verify cooling water flow (≥1.5 gpm) and exhaust mist filter backpressure (<0.5 bar).

3. Master Diagnostic Matrix & Action Thresholds

mptom / Anomaly	Likely Root Cause	Diagnostic Test	Corrective Action	
~1 Torr	Chamber door O-ring leak or pump seal	Standalone pump isolation test	Clean O-ring; replace KF gasket	<ParagraphStyle 'TbB
10^{-4} Torr	Water outgassing or micro-leak	RGA m/z = 18 vs 28/32 evaluation	Bake-out at 100°C–150°C / He spray	<ParagraphStyle 'TbB
ressure decay	Virtual leak in blind tapped hole	Rate-of-rise asymptote test	Install center-drilled vented screws	<ParagraphStyle 'TbB
ion / Rattling	Moisture condensation in oil stage	Acoustic check; oil clarity audit	Open gas ballast valve for 15 min	<ParagraphStyle 'TbB

hermal trip	Exhaust mist filter clogged (>0.5 bar)	Clamp meter FLA & Delta P check	Replace exhaust coalescing element	<ParagraphStyle 'TbB

4. Authorization & Document Control Sign-Off

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