

ROTARY VANE & MECHANICAL VACUUM PUMP NOISE & STALL DIAGNOSTIC SOP

Standard Operating Procedure: Acoustic Anomaly Identification, Motor Overload Diagnostics & Decision Trees

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1. Purpose & Scope

This Standard Operating Procedure defines the systematic diagnostic protocols and decision trees for identifying, isolating, and resolving acoustic anomalies (cavitation, hydraulic groaning, metallic knocking) and mechanical motor stalls/overloads in oil-sealed rotary vane, dry scroll, and liquid ring backing vacuum pumps. Adherence to these procedures prevents catastrophic pump seizure, eliminates oil backstreaming risks, and maintains lab safety under OSHA 29 CFR 1910.147 (LOTO) and EPA QA/QC guidelines.

2. Acoustic Anomaly Diagnostic Decision Trees

A. Cavitation & Rattling (Sounds like 'marbles rattling inside the pump')

- **Root Cause Mechanics:** Occurs when the pump operates near its ultimate base pressure under low gas loads, or when vapor bubbles collapse violently within oil/fluid channels due to high liquid temperature or restricted suction.
- **Diagnostic Steps:** 1) Check suction pressure using a calibrated Pirani gauge. 2) Check oil temperature (normal operating range: 60°C–80°C). 3) Verify gas ballast valve position.
- **Corrective Action:** Open the gas ballast valve slightly to introduce a dry N₂ or air cushion into the compression stage. This raises foreline pressure above the vapor threshold, cushioning vane compression and immediately dampening the rattling sound.

B. Groaning & Hydraulic Noise (Heavy hydraulic strain / chattering)

- **Root Cause Mechanics:** Caused by severe liquid carry-over, water condensation buildup in the oil reservoir, or an overfilled oil casing forcing the rotary vanes to push through incompressible liquid slugs.
- **Diagnostic Steps:** 1) Inspect sight glass for foamy/milky oil (water emulsion) or fluid levels exceeding 3/4 sight glass. 2) Inspect inlet foreline traps and knock-out pots for accumulated condensate.
- **Corrective Action:** Isolate pump from chamber. Perform a full oil drain while warm, flush housing using KJLC TKO-FF flushing fluid, and refill with fresh ISO VG 68 vacuum oil. Drain and clean foreline inlet liquid separators.

C. Metallic Knocking & Chattering (Sharp repetitive metal-on-metal impact)

- **Root Cause Mechanics:** Caused by worn rotary vanes (below minimum height spec), broken vane guide springs, loose drive shaft couplings, or failing rotor shaft bearings.
- **Diagnostic Steps:** Perform unpowered manual shaft hand-rotation. Listen for binding, excessive axial play, or clicking.
- **Corrective Action:** Perform Lockout/Tagout (LOTO). Disassemble pump casing, inspect vane heights, replace vane springs, and renew shaft bearings if axial play exceeds 0.005 inches.

3. Motor Stalls & Electrical Overload Diagnostics

D. Motor Stalls, Overcurrent Trips & Startup Failure

- **Power Supply / Thermal Overload:** Verify supply voltage matches motor nameplate (115V ±10%). Reset tripped thermal overload switches. Test motor winding insulation resistance using a megohmmeter (>5 MΩ pass limit).
- **Clogged Exhaust Mist Filter / Backpressure Spike:** Saturated coalescing filter elements create high backpressure (>0.5 bar / 7 psi), overloading the electric motor during pump-down. Measure motor current draw using a clamp meter; if current exceeds Full Load Amperage (FLA) by >10%, replace the exhaust coalescing filter immediately.
- **Internal Mechanical Seizure / Foreign Debris:** Particulates or broken vane fragments trapped between rotor and stator housing physically lock rotation. Attempt unpowered manual shaft rotation. If locked, perform internal teardown and flush foreign particulates.

4. Master Diagnostic Matrix & Action Thresholds

Symptom / Acoustic Profile	Likely Root Cause	Diagnostic Test / Observation	Corrective Action & Action Threshold
Cavitation / Rattling (Marbles inside pump)	Vapor bubble collapse / Low suction pressure	Inlet pressure <10 mTorr; Gas ballast closed	Open gas ballast valve slightly to cushion compression; verify oil temp 60°C–80°C.
Groaning / Hydraulic Noise (Heavy fluid strain)	Water contamination / Overfilled oil casing / Liquid carry-over	Sight glass milky/foamy; Oil level >3/4 full; Liquid in inlet trap	Drain oil completely, run TKO-FF flush, refill fresh ISO VG 68 oil. Empty inlet traps.
Metallic Knocking (Repetitive impact)	Worn vanes / Broken springs / Bearing failure	Hand-rotation clicks; Shaft axial play >0.005"	LOTO pump. Replace rotary vanes, springs, and drive shaft bearings.
Motor Stall / High Amperage (Thermal trip / No start)	Clogged mist filter / Seized rotor / Low voltage	Amperage >110% FLA; Backpressure >0.5 bar; Shaft locked	Replace exhaust coalescing filter. Check voltage (115V ±10%). Clear internal rotor obstructions.
High-Pitched Whine (Squealing noise)	Loose drive belt / Dry shaft seal / Bearing wear	Belt deflection >1/2"; Shaft seal weeping	Adjust belt tension (1/4"–1/2" deflection). Lubricate/replace shaft seals and motor bearings.

5. Document Control & Quality Sign-Off

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