STANDARD OPERATING PROCEDURE & TECHNICIAN CHECKLIST

ION GETTER PUMP PRE-START, HIGH-VOLTAGE POWER-UP & PUMP-DOWN SEQUENCES

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Created / Author:	**Kadeem Manning**, Tier II Facility Technician	**System Range:**	10^{-4} mbar down to 10^{-11} mbar (UHV/XHV)
Approved By:	Dr. Marcus Vance, Metrology Director	**Target Equipment:**	TiTan (CV/DI/TR) & Agilent VacIon Plus

1. Purpose & Critical High-Voltage Safety Precautions

1.1 Purpose: This Standard Operating Procedure (SOP) defines the mandatory technical steps and verification criteria for preparing, roughing, powering up, and monitoring Ultra-High Vacuum (UHV) **Ion Getter Pumps** (Gamma Vacuum TiTan series CV/DI/TR and Agilent VacIon Plus) paired with digital controllers (DIGITEL SPCe/QPC/MPCq or Agilent IPCMini/4UHV).

HIGH VOLTAGE & OPERATIONAL SAFETY WARNINGS:

- **High Voltage Hazard (3,000 V to 7,000 V DC):** Ion pump controllers deliver up to 7.0 kV DC at currents up to 500 mA (1000 W). Perform strict Lockout/Tagout (LOTO) and zero-energy verification prior to disconnecting or inspecting HV feedthroughs. Cables MUST feature 10kV SHV or SAFE-CONN interlocks.
- **Primary Roughing Prerequisite:** NEVER energize high voltage at atmospheric pressure or above **1×10^{-4} mbar (100 µTorr)**. Starting at high pressure induces severe glow discharge, excessive thermal loading, rapid cathode sputtering, and immediate controller over-current trip.
- **Bakeout Cable Limits:** High-voltage cables must be rated for bakeout temperatures (up to 200°C–250°C). Remove electronic controller units or thermal shields if chamber bakeout exceeds 85°C.
- **Strong Magnetic Fields:** Ion pumps contain high-coercivity permanent magnets (up to 150 mT). Keep ferrous tools, pacemakers, and magnetic storage media clear of the pump housing.

2. Phase 1: Pre-Start Equipment & Utility Inspection

Step 2.1 — Mechanical & Electrical Inspection: Inspect high-vacuum CF flanges (DN16 to DN250) and confirm OFHC copper gasket installation. Verify high-voltage cable braid integrity, chassis ground strap connection between controller and pump body, and 10kV SHV / SAFE-CONN latch engage condition.

Step 2.2 — Cathode Element Selection Verification: Confirm controller polarity matches cathode type:

- *Conventional Diode (CV) & Differential (DI):* Positive Polarity (+3 kV to +7 kV DC).
- *Triode (TR) & StarCell:* Negative Polarity (-3 kV to -7 kV DC).

Step 2.3 — Roughing System Readiness: Verify dry scroll (Agilent IDP series) or turbomolecular backing system is connected via isolation gate valve and capable of achieving forevacuum below 1×10^{-4} mbar.

3. Phase 2: Rough Vacuum Evacuation & High-Voltage Power-Up

Step 3.1 — Rough Evacuation: Close chamber vent valve. Open roughing isolation valve and start primary roughing pump. Evacuate chamber and pump housing until pressure drops below **1×10^{-4} mbar** (recommended target: 1×10^{-5} mbar to 1×10^{-6} mbar).

Step 3.2 — Controller Power-Up & Config: Switch ON main power to DIGITEL or IPCMini controller. Program output voltage to **+7.0 kV DC** (or -7.0 kV DC for Triode) and set over-current trip limit.

Step 3.3 — HV Activation & Starting Current Monitor: Enable High Voltage. Observe initial current surge (glow discharge ignition). Current will spike up to starting limit (e.g. 40 mA to 125 mA depending on controller size).

Step 3.4 — Glow Discharge Recovery Rule: Monitor ion current draw. Current MUST begin decreasing rapidly within **60 to 120 seconds** as gas molecules are ionized and sputtered. If current remains locked at maximum for >2 minutes, IMMEDIATELY turn off HV, as excessive pressure/outgassing will overheat pump elements.

4. Phase 3: Roughing Isolation & UHV Base Vacuum Achievement

Step 4.1 — Roughing Isolation: As ion pump current drops below 1 mA (corresponding to ~1×10^{-6} mbar pressure), close the primary roughing isolation valve. The ion pump now acts as a standalone, vibration-free UHV pump.

Step 4.2 — Pressure Readback Calibration: Ion current draw is directly proportional to pressure (1 nA resolution). Monitor digital current/pressure display as vacuum drops from 10^{-6} mbar down to target base level (10^{-8} to 10^{-10} mbar).

Step 4.3 — Auxiliary TSP / NEG Operation (Hybrid Systems): If equipped with Titanium Sublimation Pump (TSP) or Non-Evaporable Getter (NEG) modules (CombiNEG):

- *TSP Sublimation:* Fire TSP filaments at pressure < 1×10^{-7} mbar (45 A–55 A for 120 seconds) to deposit clean titanium film for rapid H_2 and N_2 pumping.
- *NEG Activation:* Perform getter activation heating sequence at 450°C for 45 minutes if base pressure plateaus.

5. Field Technician Verification Checklist & Operational Log

Phase	Step / Inspection Item	Acceptance Spec / Target Range	Field Readback	Status
Pre-Start	Visual Inspection & Grounding	OFHC Copper CF Flange sealed; Ground strap secure	Physical Visual OK	[X] PASS
Pre-Start	High Voltage Cable Connection	10kV SHV / SAFE-CONN locked; No insulation damage	Cable Latch Engaged	[X] PASS
Pre-Start	Controller Polarity Setup	+7 kV (Diode/Diff) OR -7 kV (Triode/StarCell)	+7.0 kV DC (CV Diode)	[X] PASS
Pre-Start	Primary Roughing System	Dry scroll / Turbo operational & valved in	IDP-15 Running	[X] PASS
Power-Up	Foreline Roughing Pressure	Chamber pressure ≤ 1×10^{-4} mbar before HV ON	2.4×10^{-5} mbar	[X] PASS
Power-Up	High Voltage Ignition Check	HV ON enabled; Initial current surge observed	Surge: 42.5 mA	[X] PASS
Power-Up	Glow Discharge Recovery	Current drops below starting limit within 120 sec	Dropped in 48 sec	[X] PASS
Pump-Down	Roughing Isolation Closure	Close roughing valve when ion current < 1 mA	Valve Closed @ 0.6 mA	[X] PASS
Pump-Down	Current-to-Pressure Decay	Ion current decreases linearly into nA range	Current: 180 nA	[X] PASS
Pump-Down	Ultimate Base Vacuum Check	System achieves target UHV base (< 1×10^{-8} mbar)	3.8×10^{-9} mbar	[X] PASS
Auxiliary	TSP Sublimation Fire (Optional)	Filament 1 fired at 48 A for 120 sec (p < 10^{-7} mbar)	48.5 A / 120 s Fired	[X] PASS
Operation	Acoustic & Thermal Stability	Zero vibration; Housing temp < 45°C ambient	Silent / Temp: 28°C	[X] PASS

6. Technician Field Observations & System Configuration

System Notes: Gamma Vacuum TiTan 75S Conventional Diode ion pump connected to DIGITEL SPCe single-pump controller. Primary roughing performed by Agilent IDP-15 dry scroll pump. Chamber pump-down executed following routine UHV chamber servicing. Glow discharge ignition occurred cleanly at 2.4×10^{-5} mbar with current spiking to 42.5 mA before rapidly decaying to baseline. Base UHV pressure of 3.8×10^{-9} mbar reached within 3.5 hours.

7. Return-to-Service Sign-Off & Authorization

Performing Technician:	Kadeem Manning	**Role / Title:**	Tier II Facility Technician
Technician Signature:	*Kadeem Manning*	**Date Signed:**	November 14, 2021
Quality QA Reviewer:	Dr. Marcus Vance	**QA Signature:**	*M. Vance*
System Authorization:	**[X] APPROVED FOR UHV OPERATION**	**Cert Tag ID:**	CERT-ION-2021-1114