METROLOGY CALIBRATION PROTOCOL & FIELD VERIFICATION FORM

STANDARD CALIBRATION PROTOCOL FOR VACUUM GAUGES, CONTROLLERS & TURBOMOLECULAR PUMP SYSTEMS

Document ID:	CAL-TMP-2020-015	**Effective Date:**	September 14, 2020
Form Number:	CAL-VAC-F03 (Rev 2.1)	**Recalibration Due:**	September 14, 2021 (12 Mo)
Technician Name:	**Kadeem Manning**	**Technician Title:**	**Tier II Facility Technician**
Facility Location:	High Vacuum Metrology Bay 4	**Traceability Standard:**	DAkkS / PTB / ISO 17025
Ambient Temperature:	22.0°C ± 1.0°C	**Relative Humidity:**	45% ± 5% RH

1. Purpose, Scope & Metrology Traceability

This standard calibration protocol defines the mandatory technical procedures for testing, adjusting, and certifying vacuum measuring instruments, active transducers, ionization gauges, and turbomolecular pump drive controllers. All calibration procedures performed under this protocol by **Kadeem Manning (Tier II Facility Technician)** must strictly adhere to ISO 17025 and ISO 3567 metrology standards. The reference calibration vacuum rig (Leybold CS3/CS7) utilizes reference standard gauges directly traceable to national standards (DAkkS / PTB).

2. Equipment Under Test (EUT) Identification Log

Item #	Equipment Description	Manufacturer & Model	Serial Number	Location / Rig
EUT-1	Capacitance Diaphragm Gauge	Leybold CERAVAC CTR 100 N	SN-481920-C	Chamber A - Process Line
EUT-2	Thermal Conductivity (Pirani)	Leybold THERMOVAC TTR 101	SN-391029-P	Foreline Manifold
EUT-3	Cold Cathode Transmitter	Leybold PENNINGVAC PTR 90 N	SN-772019-K	High Vacuum Chamber B
EUT-4	TMP Frequency Converter	TURBOVAC MAG DRIVE iM	SN-882011-M	Pump Bay 4 - Turbo #2
EUT-5	Calibrated Helium Reference Leak	Leybold TL 6 Capillary Leak	SN-102948-L	Leak Detector Standard

3. Calibration Protocols & Field Data Verification

3.1 Capacitance Diaphragm Gauge (Leybold CERAVAC CTR 100 N)

Zero-Point Adjustment Procedure: Evacuate reference chamber to p < 1.0 × 10⁻⁸ Torr (using TMP system). Allow CTR 100 N sensor head to reach thermal equilibrium at 45°C internal cell temperature. Adjust zero potentiometer or digital offset until output signal equals exactly 0.000 V DC (0.00% FS). Verify 4-decade linear voltage response (0 to 10 V DC).

Nominal Reference Pressure	Ref. Voltage (V)	Indicated Voltage (V)	Calculated Pressure	Error (%)	Spec Limit	Status
p < 1.0 × 10⁻⁸ Torr (Zero)	0.000 V	0.001 V	< 1.0 × 10⁻⁸ Torr	+0.01%	±0.05% FS	PASS [X]
1.00 × 10⁻² Torr (10% FS)	1.000 V	1.002 V	1.002 × 10⁻² Torr	+0.20%	±0.25% RD	PASS [X]
1.00 × 10⁻¹ Torr (50% FS)	5.000 V	4.998 V	9.996 × 10⁻² Torr	-0.04%	±0.25% RD	PASS [X]
1.00 × 10⁰ Torr (100% FS)	10.000 V	10.001 V	1.000 × 10⁰ Torr	+0.01%	±0.25% RD	PASS [X]

3.2 Thermal Conductivity (Pirani) & Cold Cathode Combination Transducers

Calibration Procedure (TTR 101 & PTR 90 N): 1. Perform high-vacuum zero adjustment at p < 1.0 × 10⁻⁸ mbar (Pirani) and p < 1.0 × 10⁻⁸ mbar (Cold Cathode). 2. Verify MEMS-Pirani to Cold Cathode sensor handoff transition at approximately 5.0 × 10⁻³ mbar. 3. Adjust atmospheric span setting at 1000 mbar ± 10 mbar ambient dry air/N₂ pressure.

Sensor / Gauge Type	Test Point / Pressure	Reference Standard	Indicated Readout	Output Signal (V)	Tolerance	Status
THERMOVAC TTR 101 (Pirani)	Atmospheric Span	1013 mbar (Barometer)	1012 mbar	8.52 V DC	±15% RD	PASS [X]
THERMOVAC TTR 101 (Pirani)	Zero Point	p < 1.0 × 10⁻⁸ mbar	1.2 × 10⁻⁸ mbar	1.90 V DC	±10% RD	PASS [X]
PENNINGVAC PTR 90 N	Handoff Transition	5.0 × 10⁻³ mbar	4.8 × 10⁻³ mbar	4.12 V DC	±15% RD	PASS [X]
PENNINGVAC PTR 90 N	High Vacuum Point	1.0 × 10⁻⁸ mbar	1.05 × 10⁻⁸ mbar	6.02 V DC	±30% RD	PASS [X]

3.3 Turbomolecular Pump Controller & Magnetic Bearing Zero-Offset Test

TURBOVAC MAG DRIVE iM Frequency Converter Verification: Inject reference frequency command signal and measure output drive frequency, acceleration current, and motor phase balance. For active magnetic bearing pumps (MAG series), execute 5-axis position sensor zero-offset calibration (X1, Y1, X2, Y2, Z) with rotor at standstill.

Parameter / Calibration Point	Target Spec Value	Measured Value	Calculated Error	Acceptance Criteria	Status
Output Drive Frequency (Ramp)	1,200 Hz (72,000 RPM)	1,200.1 Hz	+0.01%	±0.1 Hz	PASS [X]
Full-Speed Drive Current (Idle)	< 1.20 A (Normal Vacuum)	0.82 A	N/A	< 1.20 A	PASS [X]
Radial Bearing Offset (X1/Y1)	0.000 mm ± 0.002 mm	0.0003 mm	N/A	±0.002 mm	PASS [X]
Radial Bearing Offset (X2/Y2)	0.000 mm ± 0.002 mm	-0.0004 mm	N/A	±0.002 mm	PASS [X]
Axial Bearing Offset (Z-Axis)	0.000 mm ± 0.003 mm	+0.0008 mm	N/A	±0.003 mm	PASS [X]
Over-Temperature Cutoff Test	60°C Bearing Housing	60.2°C Trip	+0.33%	58.0°C - 62.0°C	PASS [X]

4. Helium Mass Spectrometer Leak Detector Calibration

Leybold TL 6 Reference Capillary Leak Verification: Connect DAkkS-certified reference leak (SN-102948-L) to test port. Measure background helium signal, open reference leak valve, and measure quantitative leak rate response. Adjust mass spectrometer ion source emission and multiplier gain to achieve < 5% error against certified leak rate.

Reference Leak Standard	Certified Value (mbar·l/s)	Measured Value (mbar·l/s)	Calculated Error (%)	Tolerance Limit	Status
Leybold TL 6 (Helium)	2.30 × 10⁻⁹ mbar·l/s	2.26 × 10⁻⁹ mbar·l/s	-1.74%	±5.0%	PASS [X]
Background He Signal	< 1.0 × 10⁻¹² mbar·l/s	2.10 × 10⁻¹³ mbar·l/s	N/A	< 1.0 × 10⁻¹²	PASS [X]

5. Metrology Certificate Summary & Technician Authorization

CERTIFICATE OF CALIBRATION COMPLIANCE: The vacuum gauges, controllers, and reference standards identified in this protocol have been tested and calibrated in accordance with ISO 17025 procedures. All measurement results recorded above fall within manufacturer specifications and DAkkS/PTB reference tolerances. Calibration sticker **STK-2020-0914** has been affixed to each certified unit.

Performing Lead Technician:	Kadeem Manning	**Signature:** *Kadeem Manning*	**Date:** Sept 14, 2020
Title / Role:	**Tier II Facility Technician**	**Badge ID:** TECH-8402	**Cert No:** CERT-2020-0914
QA / Metrology Reviewer:	Dr. Marcus Vance	**Signature:** *M. Vance*	**Date:** Sept 15, 2020