# Test Plan: Powell Type PowlVac ARM-MV Vacuum Circuit Breaker

## 1. **Equipment Overview**

**Description:** The Powell **PowlVac ARM-MV** is a medium-voltage vacuum circuit breaker with an integral **Automatic Racking Mechanism (ARM)** for enhanced safety. It is designed for use in **5 kV and 15 kV class** metal-clad switchgear, with continuous current ratings of **1200 A, 2000 A, or 3000 A** and fault interruption capacities up to **63 kA** symmetrical[[1]](https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a#:~:text=PowlVac%20ARM%20Automatic%20Racking%20Mechanism,to%2063kA%2C%201200A%2C%202000A%2C%203000A). The breaker utilizes **sealed vacuum interrupters** and a stored-energy spring-operated mechanism to achieve fast interruption (typically 3-cycle interruption time). The ARM feature is a motor-driven racking system that allows the breaker to be remotely moved between CONNECTED, TEST, and DISCONNECTED positions without exposing personnel to high-voltage compartments.

**Specifications:** Key specifications for the PowlVac ARM-MV include:

* **Rated Maximum Voltage:** 4.76 kV or 15 kV (for nominal system voltages ~4.16 kV up to 13.8 kV)[[1]](https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a#:~:text=PowlVac%20ARM%20Automatic%20Racking%20Mechanism,to%2063kA%2C%201200A%2C%202000A%2C%203000A).
* **Basic Insulation Level (BIL):** Designed for standard MV insulation levels (e.g. ~**95 kV impulse BIL** and **36 kV** one-minute power-frequency withstand for 15 kV class)[[2]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV).
* **Continuous Current Rating:** Up to **3000 A** (self-cooled), suitable for feeder, bus, or transformer circuit applications[[1]](https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a#:~:text=PowlVac%20ARM%20Automatic%20Racking%20Mechanism,to%2063kA%2C%201200A%2C%202000A%2C%203000A). (Higher bus ratings like 4000 A may be achieved with forced cooling in some designs[[3]](https://www.powellind.com/powlvac-switchgear#:~:text=%2A%20Available%20in%20one,UL%20and%20CSA%20label).)
* **Short-Circuit Interrupting Rating:** Up to **63 kA** symmetric at rated voltage[[1]](https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a#:~:text=PowlVac%20ARM%20Automatic%20Racking%20Mechanism,to%2063kA%2C%201200A%2C%202000A%2C%203000A), with corresponding short-time current withstand (e.g. 63 kA for 2 seconds) as per ANSI standards.
* **Operation Mechanism:** Spring-charged **stored-energy mechanism** (electrically and manually chargeable) providing quick make/break operation. Typical closing and opening times are in the order of a few cycles (closing < 100 ms, opening ~50 ms). An **anti-pump relay** is included to prevent repeated closings under sustained close commands (ensuring trip priority).
* **Automatic Racking Mechanism:** Integral motorized racking that engages the breaker’s racking cam to move it between positions. The ARM system is **“Powered by Safety®”** (Powell’s safety slogan) and permits **closed-door racking** – operators can rack the breaker remotely, reducing arc-flash exposure risk. Mechanical and electrical interlocks ensure racking only occurs in safe conditions (e.g. breaker must be OPEN to rack, and control circuits prevent misoperation).

**Intended Use:** The PowlVac ARM-MV breaker is used in **medium-voltage power distribution** and control systems to **protect electrical equipment** (transformers, motors, feeders, etc.) by interrupting overloads and faults. It is typically applied in metal-clad switchgear lineups in industrial plants, utility substations, commercial campus power systems, and other critical installations. The **automatic racking** capability makes it especially suited for **arc-resistant switchgear** applications and facilities with heightened safety requirements, as it allows operators to maintain a safe distance during insertion or removal of the breaker[[4]](https://www.powellind.com/powlvac-switchgear#:~:text=Ideal%20for%20use%20when%20operators,minimize%20damage%20to%20surrounding%20equipment). In arc-resistant enclosures, the breaker and cabinet are designed to withstand internal arcing faults and redirect blast pressure upward, keeping personnel safe[[4]](https://www.powellind.com/powlvac-switchgear#:~:text=Ideal%20for%20use%20when%20operators,minimize%20damage%20to%20surrounding%20equipment). Overall, the PowlVac ARM-MV combines the proven reliability of vacuum interruption with modern safety features for **high-reliability, high-fault-duty** environments.

## 2. **Functional Test Procedures**

*Purpose:* Functional tests verify that the circuit breaker operates correctly under **expected normal conditions** and that all control, mechanical, and interlock functions perform as intended. These tests are typically performed during factory acceptance testing (FAT), site commissioning, or routine maintenance to ensure the breaker is in proper working order. According to Powell’s quality program, **routine test procedures** cover mechanical alignment, electrical functionality, timing, and interlocks[[5]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Routine%20test%20procedures%20incorporate%3A%20Setting,Testing%20of%20mechanical%20interlock%20systems).

**Preparation:** Before testing, ensure the breaker is **properly isolated** (not connected to live bus), and test equipment (control power sources, test leads, etc.) is set up. Wear appropriate PPE and follow lock-out/tag-out procedures. Verify the breaker is in the **TEST/DISCONNECTED position** and charging springs are discharged.

**Key Functional Tests:** The following functional tests should be conducted in sequence, as applicable:

1. **Visual Inspection & Documentation:** Examine the breaker’s physical condition and nameplate. **Procedure:** Check for any physical damage, loose hardware, or contamination. Verify that ratings (voltage, current, trip settings) match specifications and project drawings. Confirm all accessories (racking motor, auxiliary plugs, etc.) are present. **Expected Outcome:** The breaker is in good physical condition with no signs of damage or misalignment. **Acceptance Criteria:** No visible damage or missing parts; nameplate data matches the required ratings; any discrepancies are resolved before proceeding.
2. **Insulation Resistance (Pre-Test):** Measure insulation resistance with a megohmmeter (e.g. 5 kV Megger) between each phase and ground (with breaker closed) and between phases (breaker open). **Procedure:** Perform IR test on primary circuit insulation and control circuits (if applicable) to establish a baseline. **Expected Outcome:** High insulation resistance values (e.g. **>1000 MΩ** on primary circuits) indicative of clean, dry insulation. **Acceptance Criteria:** IR values meet or exceed manufacturer minimums (typically in the hundreds of MΩ) and show no sudden drops or instability. (This is a safety check before energizing any high voltage.)
3. **Operational Mechanism Test (Closing and Tripping):** Verify the breaker can open and close properly both manually and electrically. **Procedure:** Charge the closing springs (using the manual charging handle or the motor charge feature). Perform a **manual CLOSE** operation using the local control (or push-button) – the breaker should move to the CLOSED position. Then perform a **manual TRIP** (OPEN) via the trip button or lever. Repeat using **electrical controls**: energize the close coil via a control switch or test set to close the breaker, then energize the trip coil to open. Do this at least **3–5 times** to check consistency. **Expected Outcome:** The breaker closes firmly and latches in the closed position, then trips freely to the open position on command. Operation indicators (OPEN/CLOSED flags, spring charged/discharged indicator, operation counter) should respond correctly. **Acceptance Criteria:** **Smooth operation** with no binding or hesitation; closing spring charges and releases correctly; closing and opening **time intervals are within spec** (e.g. opening < 5 cycles, closing < 12 cycles, as per manufacturer data). The operation counter increments with each close-open cycle. There should be **no abnormal noise** or mechanical delay. The anti-pump feature should allow only one close per command (i.e. if a continuous close signal is held, the breaker should not re-close after an immediate trip, preventing a pump condition).
4. **Control Circuit Functional Test:** Verify all control and auxiliary circuits function. **Procedure:** With control power applied (using the specified control voltage, e.g. 125 V DC or 120 V AC as per the breaker’s control scheme), test each control feature: closing coil, trip coil, charging motor, spring release, and any undervoltage or shunt trip devices. Check indicating lamps, alarms, and the operation of the **anti-pump relay** by attempting a close with a sustained close signal – the breaker should not reclose after opening[[6]](https://manualzz.com/doc/2988804/powell-powlvac-38-arm-vacuum-circuit-breaker-instruction-...#:~:text=Motor%20Assembly%20Anti,Cycle%2024VDC)[[7]](https://manualzz.com/doc/2988804/powell-powlvac-38-arm-vacuum-circuit-breaker-instruction-...#:~:text=125VDC%2050027G02P%2050041G10P%2050042G03P%2050028G10,USDC110V%2043684G03P%20250VDC). **Expected Outcome:** Coils energize and perform their function (breaker opens/closes), the spring charging motor automatically recharges the mechanism after a close, and all auxiliary devices (e.g. UV trip, electrical close/trip, spring release, anti-pump relay) operate correctly. **Acceptance Criteria:** Control devices activate within their rated control voltage range (typically **85%–110% of nominal voltage** for closing, and even down to ~55% for tripping coils per standards). All **indicator lamps** and annunciators should correctly reflect breaker status (spring charged, breaker open/closed, etc.). Control fuses do not blow during operation. There should be no overheating of coils or control wiring during repeated operations.
5. **Automatic Racking Mechanism Test:** Validate the on-board racking mechanism (ARM). **Procedure:** Ensure the breaker is **OPEN** and in the TEST/DISCONNECTED position. Engage the automatic racking system (this may involve a local switch or remote control unit to start the racking motor). Command the breaker to rack **IN** to the CONNECTED position. Observe the breaker as it moves forward – it should smoothly transition to the TEST position, then into the CONNECTED position, aligning primary stabs without excessive force. Once connected, command a rack **OUT** back to the DISCONNECTED position. **Expected Outcome:** The breaker racks in and out **under power smoothly**, stopping accurately at the defined positions (TEST and CONNECTED) without manual intervention. All **racking interlocks** must function: the racking motor should not engage if the breaker is closed or if the compartment door is open. If an obstruction or misalignment occurs, the mechanism’s torque limiter should halt the racking to prevent damage. **Acceptance Criteria:** Breaker reaches CONNECTED position firmly (primary disconnects fully engaged) and likewise returns to DISCONNECTED. **Limit switches** or position indicators should show the exact position. The time to rack (typically a few seconds) is within normal range. There is **no damage** to racking components or excessive motor current draw. Interlock logic prevents unsafe racking operations (e.g., cannot rack a closed breaker or close a breaker that’s not fully racked).
6. **Interlock and Safety Feature Verification:** Test all **mechanical and electrical interlocks** for proper function. **Procedure:** Attempt operations that should be prevented by interlocks: try to **insert or withdraw** the breaker while it is in the **CLOSED** position (should be blocked mechanically); try to close the breaker when it is **between positions** or not fully racked in (should be electrically inhibited); open the compartment door when the breaker is **CONNECTED/CLOSED** (door interlock should prevent this or require defeating). If the design includes a **secondary contact interlock** (control plug must be engaged for closing), verify that as well. Also check the **safety shutters**: with the breaker racked out, shutters should automatically cover the live bus stab openings – manually push each shutter to ensure it springs back to closed position. **Expected Outcome:** All unsafe operations are successfully blocked by the interlocks. For example, the racking crank (or motor) cannot be engaged if the breaker is closed, and the breaker cannot be closed unless it is either in the CONNECTED or TEST position with shutters open and fully engaged. The compartment door can only be opened when the breaker is in a safe condition (usually disconnected). Shutters move freely and cover/uncover the primary contacts as the breaker is withdrawn/inserted. **Acceptance Criteria:** **Interlock compliance** with standards and design intent – no forbidden operation should be possible. The breaker’s safety shutters must **fully cover** the primary disconnects when the breaker is removed (no exposure of live parts), and they should open automatically when the breaker is inserted. If any interlock can be defeated (for maintenance), it should require a deliberate tool/action and be clearly labeled. All results should align with the manufacturer’s interlock scheme and ANSI **“closed-door racking”** requirements[[8]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Basic%20Impulse%20Level%20,contactors%20tested%20in%20Type%20298).
7. **Auxiliary Contacts and Trip Circuit Simulation:** Test the auxiliary switches and protective trip circuits. **Procedure:** Using continuity or a breaker test set, verify that auxiliary contact states change correctly with breaker position (e.g., 52a contacts closed when breaker is closed, 52b contacts closed when open). If connected to a protection relay, simulate an **overcurrent trip** by injecting a secondary current or using the relay’s test function to ensure the trip coil energizes and the breaker opens. **Expected Outcome:** All auxiliary circuits operate and give the correct signals to external systems (breaker status, spring charged status, etc.). A simulated protection trip results in the breaker tripping open and the appropriate lockout/alarm indication. **Acceptance Criteria:** **Auxiliary contact timing** and statuses per design drawings (e.g., the number of auxiliary contacts make/break as specified). Trip circuit energizes reliably and opens the breaker within the intended time frame. Control wiring matches the schematic, and no wiring errors are present.

After completing functional tests, document all results (including operation counts, measured control voltages, etc.). Any irregularities should be corrected before proceeding to performance or safety tests. The table below summarizes the main functional tests, procedures, and criteria:

**Table 1: Functional Test Summary (Operations and Interlocks)**

| **Test** | **Procedure** | **Expected Outcome** | **Acceptance Criteria** |
| --- | --- | --- | --- |
| **Visual Inspection** | Inspect breaker (structure, wiring, components); verify nameplate and settings. | No physical damage; all parts in place; ratings correct. | No cracks, dents, or loose parts; ratings match specs; clean interior. |
| **Manual/Electrical Operation** | Charge springs; close & trip breaker manually and electrically multiple times. | Smooth closing and opening; correct indicator responses. | Breaker latches closed and opens on command every time; operation times within spec; no binding or delays. |
| **Control Circuit Test** | Apply control power; activate close coil, trip coil, charging motor, UV release, etc. | All coils and motors function; spring recharges after close; anti-pump prevents repeat close. | Closing coil pulls in at ≥85% V<sub>n</sub>; trip coil activates at ≥55% V<sub>n</sub>; motor charges springs in normal time; no coil overheating. |
| **Automatic Racking (ARM)** | With breaker open, use motorized racking to move breaker from DISCONNECTED to CONNECTED and back. | Breaker racks in smoothly and aligns fully; stops at test/connected positions; no manual effort needed. | Full engagement of primary stabs; racking time normal; motor does not stall; interlocks prevent racking if unsafe (e.g., breaker closed). |
| **Interlock Verification** | Attempt prohibited actions (rack closed breaker, open door when closed, etc.) to test interlocks. | Interlocks block all improper operations; shutters cover live parts when breaker out. | Cannot rack closed breaker; cannot open door unless breaker disconnected; shutters automatically cover bus apertures; all as per design logic. |

## 3. **Performance Test Procedures**

*Purpose:* Performance tests assess the breaker’s behavior under **rated load and fault conditions** or other demanding scenarios. These tests validate that the equipment meets its **electrical performance specifications** – carrying normal load currents without overheating, and interrupting abnormal currents safely. Many performance tests are conducted as **type tests** (during product development per ANSI/IEEE or IEC standards) but some can be repeated or simulated during field commissioning (e.g. primary injection for trip tests). All performance testing should conform to applicable standards such as **IEEE C37.09** (testing of AC circuit breakers) and the **IEC 62271-100** series.

**Key Performance Tests:** (Note: Full short-circuit interrupting tests are normally performed at specialized high-power laboratories for type certification. Field performance tests are typically limited to lower-risk checks like current injection, timing measurements, and thermal monitoring.)

1. **Continuous Current Heating Test (Temperature Rise):** Verify the breaker can carry its rated continuous current without exceeding temperature limits. **Procedure:** Pass a high current (equal to the rated current, e.g. 3000 A) through the breaker pole for an extended duration (e.g. several hours or as specified by standards) using a test source or heating run. Use thermocouples or infrared measurements to monitor temperature on critical parts (primary contacts, bus connections, etc.) during the test. **Expected Outcome:** Temperatures stabilize within allowable rise above ambient. **Acceptance Criteria:** The **temperature rise** of each part does not exceed the limits per standards (often **65°C rise** for primary connections, and lower (e.g. 30°C rise) for accessible external surfaces) when carrying rated current[[9]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=arranged%20as%20shown%20on%20contract,than%203300%20feet%20above%20sea)[[2]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV). No signs of overheating (discoloration or odor) should occur. All connections remain tight. *(This test may be a type test; for field acceptance, measurement of contact resistance and a shorter heating run can be used to infer performance.)*
2. **Contact Resistance Test:** (Often part of performance verification.) **Procedure:** Measure the micro-ohm resistance of each primary contact circuit (using a micro-ohmmeter at high DC current, e.g. 100 A) to ensure minimal resistance. **Expected Outcome:** Very low contact resistance (typically in the range of tens of micro-ohms per contact). **Acceptance Criteria:** Contact resistance values should be within manufacturer’s specified range and roughly equal across all three phases (no phase significantly higher than others). Stable or improved values compared to initial factory test indicate good contact condition. This ensures low I²R heating during service.
3. **Short-Time Withstand Current Test:** Validate the breaker’s ability to withstand high fault current for a short duration without damage. **Procedure:** With the breaker CLOSED and in a controlled test setup, apply a high current (such as the rated short-time current, e.g. 63 kA sym) for the specified short-time duration (usually **2 seconds** per ANSI, or **3 seconds** per IEC[[10]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=%5BPDF%5D%20Type%20298%20,up%20to%204000A%20are)). This is typically done as a type test. Monitor the breaker for any signs of distress (e.g. excessive electrodynamic force causing deformation, or heating). **Expected Outcome:** The breaker carries the fault current for the duration and remains intact and operable afterwards. **Acceptance Criteria:** No **mechanical damage** (no bent bars, loosened connections, or degraded insulation) and no **exceeding of temperature limits** due to the short-time current. The breaker should be able to **open normally after** the test, confirming it hasn’t seized or welded. (ANSI/IEEE C37.09 requires that after short-time and interrupting tests, the breaker can still operate and meet dielectric tests.)
4. **Interrupting Time and Speed Test:** Measure the breaker’s opening speed and total interrupting time under simulated fault conditions. **Procedure:** Use a breaker timing test set or high-speed analyzer to record the time from trip signal to main contact parting, and contact parting to arc extinguish (if possible, via transient detection). Alternatively, conduct a **primary injection trip test**: inject a high current (not full fault level but enough to trigger protection, e.g. a 1× or 2× pickup of the protection relay) and measure the time for the breaker to trip open. **Expected Outcome:** The breaker’s opening time is within design specifications (often on the order of **30–50 milliseconds** from trip coil energization to contact parting for vacuum breakers). Total clearing time (including relay time) meets the coordinated protection settings. **Acceptance Criteria:** **Opening (trip) time** and **closing time** should match the manufacturer’s values (e.g. opening in < 3 cycles for a 60 Hz system). IEEE standards allow certain tolerances, but all phases should interrupt nearly simultaneously (within a few ms). If measured, the contact travel speed and stroke should be per spec, and there should be no evidence of contact bounce or slow operation.
5. **Short-Circuit Interrupting Test (Type Test):** Confirm the breaker can safely interrupt its rated maximum fault current. **Procedure:** In a high-power lab, subject the breaker to a series of **short-circuit make and break operations** at various currents up to 100% of its rated interrupting capacity (e.g. 63 kA). This includes duties like closing onto a fault (momentary withstand), interrupting asymmetrical currents (with DC offset), and performing the standard duty cycle O–0.3s–CO–15s–CO (Open, brief pause, Close-Open, wait, Close-Open) to simulate reclosing duty[[11]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=3,to%20be%20knowledgeable%20of%20these). High-speed instruments record the arc duration, transient recovery voltage (TRV), etc. **Expected Outcome:** The breaker successfully interrupts all test fault currents without internal failure or excessive arc duration. **Acceptance Criteria:** **No restrike or re-ignition** of the arc; the arc is extinguished within the first current zero after the rated arcing time. The measured **interrupting currents and TRV** are within the breaker’s capability envelope as defined by standards (e.g., the breaker’s **rated interrupting time** is achieved, typically 3 cycles). After the tests, the breaker should pass a dielectric withstand test and be capable of normal operation, confirming its integrity[[12]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=Production%20tests%20shall%20be%20performed,16). *(Note: This is a design/type test usually performed once for certification, not repeated for each unit. Routine production tests may instead use lower-level simulations and mechanical verification.)*
6. **Minimum Control Voltage Test:** Ensure the breaker operates correctly at the extremes of control voltage. **Procedure:** Gradually reduce the control supply voltage to the minimum specified (e.g. 85% of nominal for closing, 55–70% for tripping per IEEE standards) and attempt to close and trip the breaker. Also test at +10% above nominal. **Expected Outcome:** The breaker still reliably closes at the low-voltage limit (though slower) and trips at the lower end of the trip coil range. At high control voltage, it should not be damaged or operate too violently. **Acceptance Criteria:** Breaker meets the **ANSI control voltage requirements** (for example, per C37.09: close coil must operate at 85% rated V; trip coil at 55%–70% rated V). The mechanism should fully close or open without hesitation at these extremes. No coil overheating or insulation damage at 110% control voltage.

**Table 2: Performance Test Summary (Electrical Load/Fault Performance)**

| **Performance Test** | **Procedure** | **Expected Outcome** | **Acceptance Criteria** |
| --- | --- | --- | --- |
| **Thermal (Current Carrying)** | Pass rated current through breaker for extended time; monitor temperatures on contacts, bus, etc. | Temperatures stabilize within safe rise over ambient. | Temperature rise ≤ standard limits (≈65°C on contacts)[[9]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=arranged%20as%20shown%20on%20contract,than%203300%20feet%20above%20sea)[[2]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV); no hotspots or damage. |
| **Short-Time Withstand** | With breaker closed, apply rated fault current (e.g. 63 kA) for 2 seconds (type test). | Withstands high current with no mechanical damage. | No deformation of conductors; breaker can still operate and pass insulation test post-test. |
| **Interrupting (Fault Clearing)** | Conduct short-circuit interruption tests at max rating in lab (duty cycle O–CO–CO). | Breaker safely interrupts fault currents (no restrike). | Interrupting time within 3-cycle rating; arc extinguished by first current zero; breaker functional after test[[12]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=Production%20tests%20shall%20be%20performed,16). |
| **Operation Timing** | Measure open/close times with timer or via injection trip test. | Fast response: opens in ~3 cycles; closes per spec. | Trip time meets spec (e.g. <50 ms); close time meets spec; phase timing consistent. |
| **Control Voltage Extremes** | Test closing/tripping at low and high control voltage limits. | Still operates correctly at voltage limits. | Closes at ≥85% V<sub>n</sub>; trips at ≥55% V<sub>n</sub>; no failure at 110% V<sub>n</sub>. |

## 4. **Safety Tests**

*Purpose:* Safety tests confirm that the breaker and its associated switchgear comply with **electrical and mechanical safety standards**, ensuring insulation integrity, proper grounding, and the ability to protect personnel even under fault conditions. These tests often include **dielectric tests, grounding checks, interlock function tests**, and (for arc-resistant gear) arc fault containment tests. Many are performed as routine tests on each breaker and/or during installation. All safety tests should adhere to relevant standards (e.g. IEEE C37.20.2 for metal-clad switchgear, IEEE C37.09 for dielectric tests[[12]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=Production%20tests%20shall%20be%20performed,16), and IEEE C37.20.7 for arc-resistant performance).

**Key Safety and Compliance Tests:**

1. **Insulation Dielectric Withstand Test (Hi-Pot):** Verify the integrity of the breaker’s insulation systems at high voltage. There are usually two dielectric tests: **to-ground** and **across open contacts**. **Procedure:** With the breaker in the OPEN position, apply a **power-frequency high voltage** (typically 60 Hz AC) between each phase and ground (including across the open contacts of the breaker) for 1 minute, as specified by standards. For example, for a 15 kV class breaker, apply ~**36 kV AC** to each phase-to-ground and across the open gap[[2]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV). Alternatively, a **DC hipot** equivalent (such as 50–54 kV DC for 15 kV class) may be used if AC is not available. **Expected Outcome:** The insulation withstands the test voltage for the full duration **without any flashover or breakdown**. **Acceptance Criteria:** **No dielectric breakdown or significant leakage current** during the test (minor capacitive leakage is normal). If using AC, the breaker should not trip or show signs of internal discharge. Upon completion, insulation resistance should be re-measured to ensure it remains high. This confirms the breaker can handle over-voltage conditions and is safe to energize. *(Refer to IEEE/ANSI C37.09 for specific test voltages; e.g., 27 kV AC for 5 kV gear, 36 kV AC for 15 kV gear, etc., and 95 kV BIL impulse withstand)*[*[2]*](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV)*.*
2. **Vacuum Integrity (Across-Open-Contacts) Test:** This test specifically checks the vacuum interrupters for leaks or internal dielectric weakness. **Procedure:** With the breaker OPEN, apply a moderate high-voltage AC across each pair of open contacts (with the breaker removed from the switchgear and in a test fixture or using a special tester). Powell **recommends an AC test of ~25 kV for 10 seconds** across the open vacuum bottle to verify vacuum integrity[[13]](https://bcsswitchgear.com/wp-content/uploads/content-library/Powell_01.4IB.60305.pdf#:~:text=Powell%20recommends%20AC%20testing%20for,period%20constitutes%20a%20successful%20test). **Expected Outcome:** The vacuum interrupter sustains the voltage with **no internal flashover**, indicating a good vacuum. **Acceptance Criteria:** No breakdown or arcing observed across any open gap during the test duration[[13]](https://bcsswitchgear.com/wp-content/uploads/content-library/Powell_01.4IB.60305.pdf#:~:text=Powell%20recommends%20AC%20testing%20for,period%20constitutes%20a%20successful%20test). A passed test indicates the vacuum interrupter’s internal pressure is below the threshold (typically ~10⁻⁶ torr or better) needed for proper dielectric performance. *(This is a routine maintenance test. Note that it supplements but does not replace the full high-pot test to ground*[*[14]*](https://bcsswitchgear.com/wp-content/uploads/content-library/Powell_01.4IB.60305.pdf#:~:text=applied%20across%20fully%20open%20contacts,High%20Voltage%20Insulation)*.)*
3. **Insulation Resistance (Megger) Test:** (If not already done in functional test, it is repeated here after high-pot.) **Procedure:** Using a high-voltage insulation tester (e.g. 2.5 kV or 5 kV megohmmeter), measure the insulation resistance phase-to-phase and phase-to-ground after dielectric testing. **Expected Outcome:** Insulation resistance remains **very high** (similar to pre-test values, typically hundreds or thousands of MΩ). **Acceptance Criteria:** No significant reduction in IR readings compared to before the hi-pot (ensuring the dielectric test did not cause any damage). Typically, IR > 100 MΩ is expected for a clean, dry breaker; any sudden drop might indicate an insulation issue that must be investigated.
4. **Grounding and Continuity Test:** Ensure all external metal parts and frames are properly bonded to ground, and ground-fault current has a safe path. **Procedure:** Use a low-resistance ohmmeter to measure the resistance between the breaker frame (and any designated ground connections) and the ground contact that connects to the switchgear ground bus. Also verify the ground contact fingers on the breaker make solid contact in the gear. **Expected Outcome:** The grounding path is continuous and of very low resistance. **Acceptance Criteria:** Ground connection resistance should be **extremely low** (a fraction of an ohm, typically <0.1 Ω). Visually, the ground straps/fingers should be intact and robust. This ensures the breaker frame cannot float to a dangerous potential and that in case of an internal fault, the fault current will return via the intended ground path.
5. **Interlock Safety Checks:** (Some were done in functional tests, but repeated here as a safety verification.) **Procedure:** Re-validate key safety interlocks with an emphasis on **personnel safety**. For instance, confirm that the **secondary control plug** cannot be inserted or removed under load, the breaker cannot be moved to CONNECTed position with the door open (for closed-door designs), and that **mechanical trip** is possible with the door closed via an accessible lever (in case of emergency). **Expected Outcome:** All safety interlocks work correctly, preventing actions that would compromise safety. **Acceptance Criteria:** Conformance with the interlock design – e.g., *closed-door racking* capability is functional (breaker can be racked while door closed), **door interlock** keeps door locked when breaker is connected/live, and **manual trip** is possible without opening the door (via an external handle) if required for emergency tripping. These features should meet the standards for interlocking in **ANSI C37.20.2 (metal-clad switchgear)**[[15]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=3,Page%201%20of%2011).
6. **Arc-Flash Safety (Arc-Resistant Features) Test:** *(*If the breaker is installed in arc-resistant switchgear or the breaker itself has arc-resistant design features.*)* This is a **type test** done on the switchgear assembly rather than each breaker, but it is crucial to safety. **Procedure:** A high-current arcing fault is artificially initiated inside a test switchgear compartment with the breaker in place (often using a thin wire across phases) to see if the structure can withstand and redirect the arc energy. For example, a test might be done at **50 kA for 0.5 seconds** to simulate a bolted fault arc. Instrument dummies and cotton indicators are placed around to check that hot gases do not escape to injure personnel. **Expected Outcome:** The arc fault is contained within the enclosure; pressures are vented through the plenum system and no doors or panels rupture. The cotton indicators outside remain unburned (no dangerous plasma escaped toward an operator position). **Acceptance Criteria:** The equipment achieves the intended **Arc Resistant rating** (e.g. IEEE C37.20.7 Type 2B: protection from front, sides, and rear for personnel in proximity)[[16]](https://www.powellind.com/powlvac-switchgear#:~:text=). There should be **no permanent deformation** that prevents the doors from opening afterward, and no components expelled. Successful type test certification by an independent lab (such as KEMA) is evidence of compliance. *(For field verification, ensure that all arc-flap panels, gaskets, and plenum connections are installed as per design. No actual arc testing is done in the field – instead, check the arc-resistant features against the certified design.)*
7. **Protective Relay Trip Test:** (Interface safety) If the breaker is part of a system with protective relays, perform an end-to-end trip test to ensure the relay can trip the breaker under fault conditions. **Procedure:** Inject a simulated fault current into the relay or use relay testing equipment to trigger a trip output to the breaker. Ensure the breaker opens and any upstream lockout or alarm functions properly. **Expected Outcome:** The relay reliably actuates the breaker trip coil and the breaker opens, isolating the circuit. All alarm/indicator circuits function (e.g., “Trip” flag on breaker, SCADA alarm). **Acceptance Criteria:** The system trips within the expected time coordination and the breaker opens on the first command. This validates the critical safety chain from fault detection to circuit interruption. *(This is more of a system test, but it is important for verifying the breaker’s role in safety.)*

**Table 3: Safety Test Summary (Insulation, Grounding, and Protection)**

| **Safety Test** | **Procedure** | **Expected Outcome** | **Acceptance Criteria** |
| --- | --- | --- | --- |
| **Dielectric Withstand** | Apply high-voltage (AC or DC) to each phase-to-ground and across open contacts (1 min). | No flashover or insulation breakdown. | Withstands test voltage (e.g. 36 kV AC for 15 kV) with **0** breakdown[[2]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV); leakage current within normal limits. |
| **Vacuum Integrity** | Apply ~25 kV AC across each open vacuum interrupter for ~10 s (vacuum bottle test). | No internal arc; vacuum interrupter holds voltage. | **No arcing** observed; test current < 5 mA (capacitive only); indicates good vacuum seal[[13]](https://bcsswitchgear.com/wp-content/uploads/content-library/Powell_01.4IB.60305.pdf#:~:text=Powell%20recommends%20AC%20testing%20for,period%20constitutes%20a%20successful%20test). |
| **Ground Continuity** | Measure resistance from breaker frame and ground contacts to station ground. | Solid bonding (low resistance path). | Ground resistance < 0.1 Ω; all metal parts properly bonded; ground fingers make full contact. |
| **Interlock Function** | Test door, racking, and control interlocks (try improper operations). | Interlocks prevent unsafe actions. | Door locked when breaker connected; cannot rack closed breaker; breaker trips or blocks on any unsafe condition; meets C37.20.2 interlock rules[[15]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=3,Page%201%20of%2011). |
| **Arc-Resistant Test** *(type)* | Simulate internal arcing fault in enclosure (type test). | Arc fault contained; no hazardous venting. | Passes IEEE Type 1/2 arc-resistant criteria (panels intact, no unsafe gas escape)[[16]](https://www.powellind.com/powlvac-switchgear#:~:text=); breaker remains secured in cell. |
| **Protective Trip Check** | Inject fault into relay or trip circuit to operate breaker. | Breaker trips via relay as intended. | Instantaneous trip at setpoint; breaker opens on first command; correct alarm/indicator responses. |

## 5. **Environmental and Durability Tests**

*Purpose:* These tests evaluate the breaker’s performance under **environmental extremes and long-term operation**, ensuring it can withstand the conditions of its intended installation over its service life. Environmental tests may include temperature, humidity, and vibration/seismic assessments. Durability (or reliability) tests focus on mechanical endurance (number of operations), electrical endurance (number of fault interruptions), and general wear over time. Many of these are type tests done during design qualification, though some (like environmental storage tests) might be done on samples or specific units if required by the project. The PowlVac ARM-MV is expected to meet typical service condition requirements (e.g. ambient -30°C to +40°C, moderate humidity, altitude < 1000 m)[[9]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=arranged%20as%20shown%20on%20contract,than%203300%20feet%20above%20sea) and relevant durability standards.

**Environmental Tests:**

* **Temperature Extreme Test:** Verify operation at both low and high temperature limits. **Procedure:** Place the breaker (or its mechanism) in a **temperature chamber** or perform a cold start test. For low temperature, soak the breaker at around the lowest service temperature (e.g. **-30°C**[[9]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=arranged%20as%20shown%20on%20contract,than%203300%20feet%20above%20sea)) for several hours. Attempt a closing and opening operation at this temperature. For high temperature, heat the unit to around **+40°C to +50°C** (or higher if specified, e.g. +50°C for tropical climates) and repeat operations. **Expected Outcome:** The breaker operates properly at temperature extremes: at low temp, the mechanism may be stiffer but should still close/trip; at high temp, no component should overheat or fail. **Acceptance Criteria:** **Cold performance:** The closing spring can charge and release, and the breaker closes/trips without hesitation at -30°C (no brittle fracture of parts, lubrication still effective). **Hot performance:** No melting or degradation; insulation retains dielectric strength, and control electronics (if any) function up to their rated temp. The breaker should meet the **ANSI/NEMA ambient condition specs** for switchgear (usually -30°C to +40°C without derating)[[9]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=arranged%20as%20shown%20on%20contract,than%203300%20feet%20above%20sea). If optional space heaters or special grease are used for extreme cold, they should be verified.
* **Humidity / Moisture Resistance:** Ensure the breaker tolerates high humidity or condensation without failure. **Procedure:** This might involve a **humidity chamber** test (e.g. 95% RH at 20–30°C for 24 hours) or a spray/mist test to simulate condensation. After exposure, perform insulation tests and operations. **Expected Outcome:** No tracking or surface flashover on insulation due to moisture; the breaker operates normally after being in high humidity. **Acceptance Criteria:** Insulation resistance in high humidity is still within safe range (it may drop compared to dry values but should remain high enough, e.g. >10 MΩ). No corrosion appears on metal parts (or minimal, if tested over extended time). Any anti-condensation heaters (in the switchgear compartment) are functioning. The breaker’s dielectric design (polymeric insulation, etc.) should handle **humid conditions as per IEC/ANSI standards** (e.g. IEC class II humidity requirements).
* **Dust and Dirt Ingress:** (If applicable for environment) Check that the breaker and its mechanisms are not unduly affected by dust. **Procedure:** Visually inspect and perhaps do a light **dust exposure** (per IEC 62271-200, the standard indoor switchgear assumes a relatively clean environment[[17]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=will%20apply,6)). If the breaker is in a particularly dusty environment, additional sealing or filtering might be tested. **Expected Outcome:** Mechanism and contacts free of excessive dust accumulation; no obstruction to moving parts or insulating surfaces. **Acceptance Criteria:** The breaker can perform an open/close after dust exposure; no electrical tracking observed on insulation due to dust. (In standard indoor applications, this is usually not formally tested beyond ensuring the design is enclosed; outdoor gear would require NEMA 3R/4 enclosures, etc.)
* **Seismic Vibration Test:** Qualify the breaker and switchgear for seismic conditions if the site is in a seismic zone. **Procedure:** A shaker table test on a representative switchgear assembly (with breaker installed) per IEEE 693 (or applicable UBC/IBC code) is performed. The assembly is subjected to simulated earthquake motions (frequency spectra per seismic level). **Expected Outcome:** The breaker remains securely latched in its compartment; no trip or disconnect occurs during the vibration. **Acceptance Criteria:** The equipment meets **seismic qualification** requirements (usually **IEEE 693 High** level for critical facilities). That means no mechanical damage or disengagement; the breaker can still operate after the seismic event. Powell gear is typically certified to meet seismic standards for installations where required[[18]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=4,as%20specified%20by%20the%20manufacturer). Field verification includes checking that all anchor bolts, structure supports, and breaker hold-down devices are in place.
* **Corrosion Protection Test:** (If required for corrosive environments) Validate that metal parts and finishes resist corrosion. **Procedure:** Sample components (or a mock-up breaker) may undergo a **salt spray (fog) test** per ASTM B117 for a set period (e.g. 500 hours) to evaluate paint and plating durability. **Expected Outcome:** Minimal corrosion on painted or galvanized surfaces; no impact on functionality. **Acceptance Criteria:** Coatings should show no blistering or significant rust beyond acceptable limits. Stainless steel parts should not show rust. This ensures longevity in coastal or industrial atmospheres. *(Typically, Powell uses galvanized or plated steel and epoxy powder coat paint for robust corrosion resistance.)*

**Durability (Operational) Tests:**

* **Mechanical Endurance Test:** Confirm the breaker’s mechanism can perform the required number of operations over its life. **Procedure:** Conduct an extended cycling test where the breaker is opened and closed repeatedly (without load) to simulate wear. For example, perform **500 close-open operations** for a baseline endurance check, or up to **1000–10,000 operations** for full type-test endurance class verification. Apply periodic lubrication or maintenance per manufacturer intervals if required during the test. **Expected Outcome:** The breaker completes all operations successfully. The mechanism should not seize or fail; parts may show normal wear but remain within tolerance. **Acceptance Criteria:** The breaker meets at least the **Class M2 mechanical endurance** per IEC (typically 10,000 operations) or the ANSI equivalent classification. After the test, the breaker should still **meet critical performance specs**: contact timing, alignment, and insulation withstands are within spec, and there are no broken springs or fatigued components. Any inspections after the test may allow minor refurbishments (like replacing worn springs) but no fundamental damage.
* **Electrical Endurance Test:** Validate the breaker’s capability to handle multiple fault interruptions as per its duty cycle rating. **Procedure:** Using a test lab, subject the breaker to a series of **interruptions at lower current levels** or a few at high-current (if type testing) in sequence. For example, perform the standard duty cycle of interruptions (O–CO–15s–CO) at rated current, and possibly additional interruptions at lesser currents to simulate cumulative stress. **Expected Outcome:** The vacuum interrupters and contacts successfully interrupt all test faults. Erosion of contacts is within allowed limits and the vacuum bottles maintain dielectric strength. **Acceptance Criteria:** The breaker should safely interrupt the **required number of operations** at rated fault current (usually specified in standards, e.g., breakers might be required to interrupt a certain number of times at various currents). **Contact wear** measurements after tests must be within the replacement criteria (vacuum interrupter contact erosion usually has a measurable gap or wear indicator – it must not exceed the limit). If the breaker is an IEC class E2, it means it can handle frequent fault operations without loss of performance.
* **Operating Mechanism Duty Cycle Test:** Ensure the closing spring and other energy storage can handle fast reclosing duty if applicable. **Procedure:** Charge and close the breaker, then after the minimum reclosing time (e.g. 0.3 seconds) trip and reclose again, repeating per the rated duty cycle (this is part of performance type tests as well). **Expected Outcome:** The mechanism can support rapid close-open-close sequences without failing or mis-timing. **Acceptance Criteria:** The breaker successfully performs the O–0.3s–CO sequence (if it has an auto-reclosing application) as per ANSI C37.09 requirements, demonstrating adequate energy in the closing spring and proper operation of charging motor to re-charge within the allotted time for a subsequent close.

**Table 4: Environmental & Durability Test Summary**

| **Environmental/Durability Test** | **Procedure** | **Expected Outcome** | **Acceptance Criteria** |
| --- | --- | --- | --- |
| **Temperature Extreme** | Operate breaker at -30°C (cold soak) and +40/+50°C (heat soak). | Functions at both low and high ambient temperatures. | No mechanism stall in cold; no component overheating in heat; meets -30°C to +40°C service range[[9]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=arranged%20as%20shown%20on%20contract,than%203300%20feet%20above%20sea). |
| **Humidity Exposure** | High-humidity chamber or condensation test, then operate and test insulation. | No flashover; insulation still effective in wet conditions. | IR values remain high (no tracking); breaker operates normally; no corrosion or moisture ingress issues. |
| **Seismic Vibration** | Shaker table test per IEEE 693 or applicable standard with breaker in place. | Breaker remains secure and operable under seismic motion. | No damage or disengagement; breaker stays latched; meets seismic qual (e.g. IEEE 693 High)[[18]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=4,as%20specified%20by%20the%20manufacturer). |
| **Mechanical Endurance** | Perform numerous close-open operations (hundreds to thousands). | Mechanism survives all operations; minimal wear. | Achieves required number of operations (e.g. M2 class ~10k ops) without failure; timing still in spec post-test. |
| **Electrical Fault Duty** | Perform multiple fault interruptions (type test series). | Interrupts faults repeatedly; contacts within wear limits. | Meets standard duty cycle (O–CO–CO) at rated fault levels; contact erosion under limit; vacuum integrity intact after tests. |
| **Corrosion Protection** *(if req.)* | Salt fog spray test on representative parts/coatings. | Coatings protect metal; no significant rust. | Paint/plating shows no blistering; structural parts have ≤ light surface rust; suitable for intended environment (industrial/coastal). |

## 6. **Applicable Standards and References**

Testing and acceptance criteria for the Powell PowlVac ARM-MV are governed by industry standards to ensure safety and performance. The test plan should be aligned with the latest revisions of these standards (as of 2025)[[19]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=of%20this%20specification,1)[[11]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=3,to%20be%20knowledgeable%20of%20these):

* **ANSI/IEEE C37.04** – Standard for ratings and requirements of AC high-voltage circuit breakers (provides basis for voltage, current, and duty cycle ratings)[[11]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=3,to%20be%20knowledgeable%20of%20these).
* **ANSI/IEEE C37.06** – Standard for preferred ratings of primary vacuum circuit breakers (gives standard voltage/current rating combinations, e.g. 15 kV, 1200 A, 25 kA, etc.)[[11]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=3,to%20be%20knowledgeable%20of%20these).
* **ANSI/IEEE C37.09** – Standard test procedure for AC high-voltage circuit breakers. All key performance tests (mechanical operation, dielectric, interrupting, etc.) are defined here[[12]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=Production%20tests%20shall%20be%20performed,16). This includes required test sequences, voltage withstand values, interrupting duty cycles, and permissible results.
* **IEEE C37.20.2** – Standard for metal-clad **switchgear** applicable to 5 kV–38 kV. It covers design and testing of the switchgear assemblies that house breakers, including **production tests** that each breaker-panel combination must pass (like dielectric tests, mechanical operation, etc.)[[12]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=Production%20tests%20shall%20be%20performed,16). It also addresses safety features and interlocks for metal-clad gear.
* **IEEE C37.20.7** – Guide for testing **arc-resistant switchgear**. Defines the types (1, 2, 2B, 2C) and how to perform arc fault containment tests. PowlVac switchgear offers Type 1, 2B, 2C designs that meet this standard[[16]](https://www.powellind.com/powlvac-switchgear#:~:text=). The test plan references this for any arc-resistant design verification.
* **IEC 62271-100** (International Electrotechnical Commission) – Standard for high-voltage AC circuit breakers. If IEC standards are applicable (Powell also supplies IEC-certified versions), this covers similar type tests (dielectric, mechanical endurance, breaking capacity, etc.) under IEC criteria.
* **IEC 62271-200** – Standard for metal-clad switchgear (medium voltage) in IEC markets. Relevant if testing to IEC protocols (e.g. LSC2B-PM loss of service continuity category, partition class, etc., which correspond to how the gear is built and tested)[[20]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=%5BPDF%5D%20Type%20298%20,and%20flexibility%20in%20operation).
* **UL and CSA Standards:** Powell PowlVac switchgear and breakers can carry a **UL listing** or **CSA certification** for use in North America[[3]](https://www.powellind.com/powlvac-switchgear#:~:text=%2A%20Available%20in%20one,UL%20and%20CSA%20label). UL Vacuum Circuit Breaker standards (e.g., UL 1066 for LV breakers and analogous standards for MV gear) and CSA C22.2 No. 31 (for switchgear) may apply. The test plan should ensure any additional **hi-pot or design tests** required by these certification bodies are included.
* **NEMA Standards:** NEMA SG-5 and SG-6 cover power switchgear and MV breakers, providing additional guidelines for construction and testing (largely aligned with IEEE standards). While not test procedures per se, they ensure consistency with industry practice.
* **Environmental and Safety Codes:** IEEE 693 (Seismic qualification of substations) for seismic tests, if needed; NFPA 70 (NEC) and NFPA 70E for safe work practices (ensuring the test procedures themselves are conducted safely). Also, any client or project-specific standards (e.g. utility company standards or international standards like ANSI C37.54 for indoor breakers, etc.) should be cross-referenced and complied with.

**References:**  
1. Powell Industries – *PowlVac ARM Automatic Racking Mechanism Vacuum Circuit Breaker, 5kV & 15kV, up to 63kA* – *Instruction Bulletin 01.4IB.51056B* (provides equipment description and ratings)[[1]](https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a#:~:text=PowlVac%20ARM%20Automatic%20Racking%20Mechanism,to%2063kA%2C%201200A%2C%202000A%2C%203000A).  
2. Powell Industries – *PowlVac® Switchgear Product Brochure* – features of standard and arc-resistant constructions, including ratings and standards compliance[[3]](https://www.powellind.com/powlvac-switchgear#:~:text=%2A%20Available%20in%20one,UL%20and%20CSA%20label)[[4]](https://www.powellind.com/powlvac-switchgear#:~:text=Ideal%20for%20use%20when%20operators,minimize%20damage%20to%20surrounding%20equipment).  
3. Power System Partners – *Type 298 IEC Switchgear Brochure* (Powell PowlVac-100 breakers in IEC switchgear) – outlines routine test procedures and IEC ratings (for cross-reference on dielectric values and endurance)[[5]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Routine%20test%20procedures%20incorporate%3A%20Setting,Testing%20of%20mechanical%20interlock%20systems)[[2]](https://powersystempartners.com/wp-content/uploads/2024/07/Type298-Brochure-PV100.pdf#:~:text=Lightning%20impulse%20withstand%20voltage%20%3D,36kV%20and%20BIL%20of%2095kV).  
4. Powell/ABB – *Arc Resistant Switchgear Guide* – describes arc-resistant design tests (Type 1, 2, etc.) and construction features[[21]](https://www.powellind.com/powlvac-switchgear#:~:text=).  
5. Powell Industries – *Production Test Requirements* (from Powell 38kV Switchgear spec) – mandates that production tests follow IEEE C37.20.2 and ANSI C37.09[[12]](https://studylib.net/doc/7110549/powlvac-38ar-arc-resistant-metal#:~:text=Production%20tests%20shall%20be%20performed,16).  
6. Powell Instruction Manual – *Vacuum Circuit Breaker Maintenance* – recommends vacuum integrity test (25 kV for 10 s across contacts) and other routine tests[[13]](https://bcsswitchgear.com/wp-content/uploads/content-library/Powell_01.4IB.60305.pdf#:~:text=Powell%20recommends%20AC%20testing%20for,period%20constitutes%20a%20successful%20test).

All these standards and references ensure that the PowlVac ARM-MV circuit breaker is thoroughly tested for **functionality, performance, safety, and durability** before being placed into service. Adherence to these guidelines provides confidence that the equipment will operate reliably in its intended application and protect both the electrical system and personnel throughout its lifespan.

[[1]](https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a#:~:text=PowlVac%20ARM%20Automatic%20Racking%20Mechanism,to%2063kA%2C%201200A%2C%202000A%2C%203000A) PowlVac ARM Automatic Racking Mechanism Vacuum… | Powell Industries

<https://www.powellind.com/resource/powlvac-arm-automatic-racking-mechanism-vacuum-circuit-breaker-5kv-15kv-up-to-63ka-1200a-2000a-3000a>

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