**PURPOSE:** This document shall be used to outline the maintenance and testing requirements of Powell POWLVAC ARM-MV Vacuum Circuit breakers at the Nutrien Redwater Facility.

**SCOPE:** Testing shall be performed using approved testing equipment and as per step-by-step instructions in this procedure.This shall apply to both new installations and previously in service equipment during scheduled maintenance activities. Testing shall be performed by Nutrien HVE personnel or qualified external contractors.

**TIMELINE:** Testing shall be performed during scheduled PM’s. Applicable electrical documentation, including the completed breaker test sheet **(ESM-502-13)** and ITPM report **(ESM-202-05)**, is to be submitted to the Nutrien Electrical HVE and QA/QC within 24 hours of service completion.

1. **Preparation for maintenance of Powell ARM (Automatic Racking Mechanism) circuit breakers**
   1. These documents will be useful in performing the maintenance tasks.
      1. Schematic drawings of the breaker control circuit.
      2. Powell Automatic Racking Vacuum Circuit Breaker instruction manual Document # IB-51056.
      3. Inspection test sheet for medium voltage vacuum breaker (ESM-502-13).
      4. Copy of the last maintenance test sheet.
      5. ITPM report (ESM-202-05).
   2. Obtain the following required test equipment, tools, and consumables.
      1. Low resistance ohmmeter (ductor)
      2. AC hipot tester.
      3. Sockets, wrenches, feeler gauges, screw drivers, and test jumpers.
      4. Lint free rags, Toshiba B9 breaker grease, Metalon Spray.
   3. Check that the required PPE is in good condition and rated for the task.
      1. FR outer wear.
      2. Hearing protection.
      3. Eye protection including face shield or mono goggles.
      4. Gloves (leather work gloves and insulating gloves with leather protectors).
   4. Obtain required hot work permit.
   5. Complete the Work Hazard Analysis Tool (WHAT card).
2. **Execution of the PM task**

***Stored Energy Hazard***

***The Circuit Breaker must be open and the closing springs***

***must be discharged before working on or near the***

***breaker mechanism***.

* 1. **Inspections and cleaning**
     1. Visually inspect the breaker for loose, damaged, or missing parts. Remove the front cover and the rear barriers.
     2. Dust can be cleaned from the breaker using clean, lint free rags. Do not use compressed air for cleaning as this may cause dust to be forced into bearings or other critical parts.
     3. The use of solvents for cleaning is not recommended, but if dirt cannot be removed by wiping with a dry rag, a mild solvent such as denatured alcohol can be used.
  2. **Lubrication**
     1. Apply Metalon Spray sparingly to mechanism moving parts and bearings. Use Toshiba B9 breaker grease for the face of the close latch shaft and for the peripheral surface of the motor cut off cam. Wipe off excess lubricant.
     2. Inspect the primary disconnect contacts. Wipe off any old lubricant and apply a thin film of Toshiba B9 breaker grease to the contact surface portion of the contact.
  3. **Mechanical checks** – Prior to performing the mechanical checks, replace the front cover.

***Noise Hazard***

***PPE is required including gloves, eye protection, and***

***hearing protection.***

* + 1. **Electric spring charging** – Connect the secondary disconnect plug of the test cabinet to the secondary disconnect receptacle of the circuit breaker. Move the secondary latch so that it engages the secondary disconnect plug. When the power switch on the test cabinet is operated, the motor mechanism will charge the closing spring. Verify that the spring is fully charged and that the motor shuts off automatically.
    2. **Manual closing** - Use the manual close operator to close the circuit breaker. Verify that the breaker closes and the charging mechanism operates to again charge the closing spring. Also verify the correct operation of the breaker open/closed indicator.
    3. **Manual tripping** - Use the manual trip operator to open the circuit breaker. Verify that the breaker opens and that the breaker open/closed indicator has operated correctly. Also verify that the operations counter has added one operation.
    4. **Trip free operation** – With the closing spring charged and with the manual trip operator held in, push the manual close operator. The circuit breaker should trip free.
    5. **Electric close** – Use the close control switch on the test cabinet to electrically close the breaker. Verify that the breaker closes and that the motor mechanism operates again to charge the closing spring.
    6. **Electric open** – Use the open control switch on the test cabinet to open the breaker. Verify that the breaker opens.
    7. **Anti-pump operation** – Anti-pump is intended to prevent a second or subsequent close operation if the closing signal is maintained. To test the anti-pump function, close the breaker using the test cabinet breaker close control switch and continue to hold the breaker close control switch in the close position. When the closing spring has charged, use the manual trip operator on the breaker to open the breaker. The breaker should not reclose. Release the breaker close control switch momentarily then operate it momentarily. The breaker should now close.
  1. **Contact resistance test** – With the breaker closed, measure the contact resistance of each pole of the circuit breaker using a low resistance ohmmeter (ductor).
     + 1. Connect the low resistance ohmmeter (ductor) line to load bus and take measurement.
       2. Following this methodology, measure and record the contact resistance of all three poles.
       3. A screenshot of a cell phone

          Description automatically generatedResults should not exceed the limits in the following table.

***If contact resistance results are found to be unacceptable, use the ductor to measure across each current connection of the pole to find where the high resistance point is.***

* 1. **Contact erosion check** – The breaker must be closed for this check. The lock nut on the push rod stud and the spring yoke are found under each interrupter and lower copper at the lower rear of the breaker.
     1. The gap between the loading spring yoke and the lock nut on the operating push rod stud is used to measure contact wear. The original factory setting of this gap and the end-of-life measurement of this gap are recorded on a label on the lower part of each vacuum interrupter. When the gap measurement has decreased to the end-of-life measurement, the vacuum interrupter should be replaced.
     2. Replacement of the vacuum interrupters is not covered in this document. Refer to the manufacturer’s manual.
  2. **Insulation integrity test** - The over potential test (Hipot test) is performed with AC Hipot tester. The breaker should be fully assembled with covers and barriers in place.

***Shock Hazard***

***Before beginning the hipot test define the test area by using red barrier tape and information tags to indicate that high potential testing is in progress.***

***Shock Hazard***

***When setting up the hipot tester or connecting the hipot tester to the circuit breaker, the safety interlock key for the hipot tester should be removed from the hipot tester and kept with the worker.***

***X-Radiation Hazard***

***With the recommended levels of test voltage applied across the open contacts of a vacuum interrupter, low level x-rays may be generated. The x-radiation is extremely low and is well below the maximums permitted by standards. As a precaution against the application of higher than recommended voltage, while test voltage is being applied, personnel should not approach to within 3 meters of the breaker. The test operator should be separated from the vacuum interrupter by the steel frame of the breaker.***

* + 1. **Phase to phase and ground test** - With the breaker contacts closed, each phase will be tested to ground with the other two phases grounded. Connect the high voltage lead to the pole under test and the return lead to the circuit breaker ground connection. Connect the two poles not under test to the circuit breaker ground connection.
       - 1. Set AC Hipot Return mode selector switch to ground.
         2. Set AC Hipot Voltmeter switch to High.
         3. Connect AC Hipot ground lead to same ground point as the Breaker grounded poles are grounded.
         4. Set AC Hipot current range selector switch to (x100).
         5. Set the output dial to zero.
         6. Maintain minimum clearance of 3 meters from Breaker.
         7. Press the main power button and then press the high voltage ON button. Slowly and smoothly ramp the test voltage up to the voltage specified in test form.
         8. Maintain the withstand voltage for one minute. Select the proper current range setting to read leakage current and recorded.
         9. Slowly and smoothly lower the test voltage to zero. Stop the test by pressing High voltage OFF button and then main power button. Wearing high voltage gloves touch a high voltage jumper to the high voltage lead to discharge. Repeat the same procedure for other two phases.
    2. **Vacuum integrity test** – With the breaker contacts open, connect the hipot high voltage lead to the line side contact of the pole under test. Connect the ‘LOAD RETURN’ lead to the load side contact of the pole under test.
       - 1. Set AC Hipot Return mode selector switch to ‘GUARD’.
         2. Set AC Hipot Voltmeter switch to High.
         3. Connect AC Hipot ground lead to proper ground.
         4. Set AC Hipot current range selector switch to (x100).
         5. Set the output dial to zero.
         6. Maintain minimum clearance of 3 meters from starter.
         7. Press the main power button and then press the high voltage ON button. Slowly and smoothly ramp the test voltage up to the voltage specified in test form.
         8. Maintain the withstand voltage for one minute. Select the proper current range setting to read leakage current and record.
         9. Slowly and smoothly lower the test voltage to zero. Stop the test by pressing High voltage off button and then main power button. Wearing high voltage gloves touch a high voltage jumper to the high voltage lead to discharge. Repeat the same procedure for other two phases.

1. **Completion** – When the PM tasks are complete make a final visual inspection of the breaker.
   1. Verify that the circuit breaker has been completely reassembled and no insulating parts, barriers, or fasteners have been left off.
   2. Record the as left number from the operations counter.
   3. Account for all tools and jumpers.
   4. The breaker should be left in the open position with the springs discharged.
2. **Review of results**.
   1. Compare the results with published tolerances.
   2. Compare the results with the previous record of maintenance testing.
   3. Note any results that indicate a failure or deteriorating trend.
3. **Return the hot work permit.**
4. **File test report as per Nutrien**.

References: Powell Industries Instructions IB-51056 PowlVac ARM Vacuum Circuit Breakers.

ANSI/NETA MTS-2007 Standard for Maintenance Testing Specifications