Power/Vac® Metal-Clad Switchgear and Vacuum Circuit Breakers

Maintenance and Troubleshooting Suggestions
INTRODUCTION

Observing the following practices will save time, effort and frustration, as well as prevent possible damage to equipment and injury to personnel.

A regular maintenance schedule should be established to obtain the best service and reliability from the switchgear. Plant operation and local conditions will dictate the frequency of inspection required. It is the GE recommendation that, until the user has accumulated enough experience to select a test interval better suited to the individual requirements, all significant calibrations be checked at an interval of one to two years, or 2000 operations whichever occurs first. If the service conditions are mild, the interval between maintenance operations may be extended to 10 years. Mild service conditions are defined by ANSI as an environment in which the switchgear is protected from the deleterious effects of conditions such as:

- Salt atmosphere
- Changes in temperature that produce condensation
- Conductive and/or abrasive dust
- Damaging chemicals and fumes
- Vibration or mechanical shock
- High relative humidity (>90%)
- Temperature extremes (<-30°C or >40°C)

For specific information regarding the maintenance of devices, such as molded case breakers, relays, meters, etc., refer to the separate instruction book furnished for each device. The breaker test cabinet, when furnished, provides a convenient means for maintaining Power/VAC circuit breakers. Under normal conditions, the protective relays do not operate except on a fault, therefore, it is important to check the operation of these devices regularly.

A permanent record of all maintenance work should be kept, the degree of detail depending on the operation conditions. In any event, it will be a valuable reference for subsequent maintenance work and for station operation. It is recommended that the record include reports of tests made, the condition of equipment and repairs and adjustments that were made.

**CAUTION:** Before any covers are removed or any doors opened which permit access to the primary circuits, it is essential that the circuit or circuits be de-energized and breakers be withdrawn to the test position and tagged.

The primary circuits of metalclad switchgear are insulated in order to reduce the size of the equipment. However this insulation, except in one or two instances, requires a certain amount of air gap between phases and to ground to complete the insulation system. Inserting any object in this air space when equipment is energized, whether it be a tool or part of the body, may under certain conditions, in effect short circuit this air gap, and may cause a dielectric breakdown in the primary circuit to ground and cause serious damage or injury or both.
Care should be exercised in the maintenance and checking procedures such that accidental tripping or operation is not initiated.
SPECIFIC

The following items or tasks should always be referred to in the instruction book:

1. Breaker maintenance recommended intervals.
2. Recommended intervals of equipment maintenance.
4. Mechanical adjustments.
5. Lubrication recommendation.
6. Repair and replacement procedures.
7. Ordering instructions for renewal parts.

GENERAL

1. The term "front" of the equipment means facing the breaker door.
2. The terms "left" and "right" side of the equipment refer to a person facing the front of the equipment.
3. Be aware of your limitations. Learn all you can about the equipment operation before you begin to service it.
4. Set up a clean, clear area in which to work.
5. Completely read each procedure while looking at the actual parts before beginning. Thoroughly understand what is to be done and follow the procedure step by step.
6. Use a systematic approach.
7. Do not panic; take a calm and methodical approach.
8. Take precautions and observe safety procedures before servicing the breaker or equipment. Consult NFPA 70B and 70E.
9. Protect finished surfaces from physical damage or corrosion.
10. Use proper tools for each job.
11. Never disassemble more than is required.

12. Parts sequence is important, keep track of parts, place bolts and screws in envelopes and label them. It is also a good practice to re-install bolts and screws after removing the part which they held.

13. No parts, except those assembled with a press fit, require unusual force during assembly. If a part is hard to remove or install, find out why before proceeding.

14. Soaking with penetrating oil can often loosen frozen or very tight bolts and screws. Avoid heat, since it may melt, warp or remove the temper from many parts.

15. When assembling components, start all fasteners evenly.

16. When you need help, refer matters to the GE Resolve help line, 1-888-437-3765.
NOMENCLATURE FOR TROUBLE-SHOOTING GUIDES

POWER/VAC ML-17 & ML-18 OPERATING MECHANISMS

NOMENCLATURE

The following list defines the purpose of the various devices (i.e., switches, relays, etc.) that are associated with the electrical aspect of the ML-17/17H and ML-18/18H operating mechanisms. These mechanisms are the stored energy forms that are used on GE Type VB, VBH, VB1 and VB1H Vacuum Circuit Breakers.

Reference should be made to the specific electrical schematic and connection diagram referenced on the breaker nameplate, to determine the electrical relationship between the various devices. Standard ML-17 (Fig. 1) and ML-18 (Fig. 2) mechanism connection diagrams are included at the end of this guide, and are drawn with the breaker in the open and discharged state.

The descriptions to follow are the basic functions of the various devices. Once a person is able to understand how the mechanical and electrical aspects function separately, realization of how the two function together should follow easily. The two aspects are not independent. If the mechanical aspect does not function properly, the mechanism will not function electrically. The reverse is not true. The mechanism could function mechanically but not electrically.

52 MOTOR   SPRING CHARGING MOTOR

The motor is used to charge the breaker closing springs.

52 CL/MS   CLOSING LATCH MONITOR SWITCH

This contact is used to prevent charging the closing springs until the closing latch is properly reset. Switch contacts are held open between disconnect and connect positions when the breaker is inserted or withdrawn from an enclosure.

52 SM/LS   SPRING MOTOR LIMIT SWITCH

There are two contacts on this switch: both contacts are open when closing springs are charged.

Contacts 1 & 2: This contact removes power from the charging motor when the springs are charged.

Contacts 3 & 4: This contact picks up the 52Y relay when the springs discharge to engage the anti-pump feature.
**IL/MS** NEGATIVE INTERLOCK MONITOR SWITCH

This contact is used to block the charging circuit while the racking crank is engaged. This switch is present on ML-18/18H mechanisms produced after 2002. Reference internal diagram 0209B8267.

**CHG** CHARGE SWITCH

These contacts monitor the closing spring positions. Contacts are closed when closing springs are fully charged and the contacts are in parallel to withstand the current surge of the closing.

**52X** CLOSING COIL (ML-17/17H), or **52** (ON ML-18/18H) CC

This device is a solenoid, which electrically releases the closing latch to allow closing springs to discharge, closing the breaker. This coil is rated as a momentary coil.

**52Y** ANTI-PUMP RELAY

The contacts of this relay prevent uncontrolled discharging of the closing spring, if the closing signal remains complete up to the breaker. If the circuit remains complete, the closing spring would discharge under the wrong conditions, this is called pumping. Therefore the anti-pump relay prevents the spring from doing the following:

A. Re-closing the breaker after the breaker has opened.

B. Closing the breaker automatically when the closing spring initially charges after the breaker is inserted.

C. Cycling the closing spring from charged to discharged to charged and so on until the charging motor fails (motor is not rated for continuous duty).

(ML-17/17H) Contacts 7 & 3 and 4 & 8 or (ML-18/18H) Contacts 7 & 1 and 3 & 9: These contacts are used to break open the closing circuit when the external close signal is removed.

(ML-17/17H) Contact 1 & 7 or (ML-18/18H) Contact 4 & 7: This contact “seals in” (keeps energized) the 52 relay until the external portion of the closing circuit opens.

**TC** TRIP COIL

This device is a solenoid that lifts the trip latch thus allowing the breaker to open. This coil is rated as a momentary coil.
AUXILIARY SWITCH

The contacts of the auxiliary switch provide an indication in the control circuit of whether the power circuit (main) contacts are either open or closed. They also de-energize the closing coil and the trip coil.

(ML-17/17H) Contact 1 & 1C or (ML-18/18H) 1 & 2: This contact de-energizes the closing coil, and also prevents electrically discharging of the closing spring of a closed breaker.

(ML-17/17H) Contact 2 & 2C and 4 & 4C or (ML-18/18H) Contacts 3 & 4 and 7 & 8: These contacts are used to de-energize the trip coil after the breaker has opened.

All Other Contacts: These contacts are used in the control circuits as needed for control, indication, transferring and interlocking.

TROUBLE-SHOOTING GUIDES

Each of the four guides is based upon certain conditions having taken place.

FAILS TO CHARGE: means the closing springs will not compress to charged position. This condition can happen after the breaker has been placed in the tested or connected position, or after the breaker has been closed electrically or manually.

FAILS TO CLOSE: means there has been no discharge of the closing springs, which is what mechanically closes the main contacts.

FAILS TO TRIP: means the breaker is closed and will not open.

TRIP-FREE: means when the breaker is given an electrical or manual closing command, the closing springs discharge but the mechanism (i.e. main contacts) will not latch closed. The contacts return to an open position.
SWITCHGEAR INTERLOCKS AND SAFETY

FEATURES

INTRODUCTION

Interlocks and safety features on switchgear are for the purpose of protecting both operating personnel and the equipment from physical harm. It is therefore, important to remember that an INTERLOCK or SAFETY FEATURE should never be bypassed or defeated.

The various mechanical and electrical interlocks and safety features to be described below will be described literally not physically. To determine the physical description, the appropriate instruction book should be referenced. The described list can be found in part or in total on various types of switchgear. To determine which of these features are associated with a piece of equipment, the operating instruction of that equipment should be referenced.

MECHANICAL

POSITIVE INTERLOCK
This interlock mechanically couples the breaker so that the racking mechanism can only be engaged if the breaker is in the OPEN position. This interlock prevents inserting or removing a closed breaker.

NEGATIVE INTERLOCK
This interlock mechanically places the breaker's trip shaft in a tripped position, and thus prevents closing a breaker in any position other than TEST or CONNECTED after the racking mechanism has been disengaged.

SPRING DISCHARGE INTERLOCK
This interlock will discharge the closing springs to provide a mechanical safety feature so that a breaker is DISCHARGED as well as open when it is removed from the equipment. GE PowerVAC switchgear is designed to discharge the springs anytime the breaker is moved from one position to another for enhanced safety.

PADLOCKS
Provisions are provided on either the breaker or the racking mechanism to enable the breaker to be locked out during certain operations or maintenance. The padlocking can either prevent closing the breaker and/or prevent engaging the racking mechanism.

KEY INTERLOCKING
This feature allows the coordination between two or more DEVICES so that certain operations must be performed to one device before proceeding to operate the next device. The above coordination is accomplished by special locks, which hold the key captive until the proper conditions are met. When the conditions are met the key can be removed and inserted into another special lock on another device in order to properly operate it.
SAFETY ROLL-IN STOP
Regardless of the position of the racking mechanism, it is impossible to manually insert the breaker into the rails beyond the disconnect / test position.

SAFETY ROLL-OUT STOP
This safety stop prevents the breaker front being rolled out of the equipment accidentally. This stop has to be manually released prior to breaker removal onto the transfer truck.

GAG SPRING INTERLOCK
While the closing spring may have been gagged for breaker adjustments, without this interlock it would be possible to put the breaker into operational position. This interlock, therefore, assures that only breakers with freely operating closing springs can be inserted into the equipment.

RATING INTERFERENCE INTERLOCK
This is a very sturdy mechanical interlock, which is coded so that only the properly rated breaker can be inserted into its designated location.

ELECTRICAL

INTERLOCK SWITCHES
The basic function of these switches is to block electrical closing signals and to open the closing mechanism’s current charging circuit whenever a breaker is being inserted or removed. Because the electrical switches can be operated by various mechanical parts to do the same job, INTERLOCK SWITCH is a general term. To determine just which switch provides the feature, the electrical schematics should be referenced.
# GUIDE 1

## FAILS TO CHARGE

<table>
<thead>
<tr>
<th>Fuses</th>
<th>No voltage</th>
<th>Broken wires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounded wires</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pinched wires</td>
<td>Low voltage (Test under load)</td>
<td>Loose connections</td>
</tr>
<tr>
<td>Corroded connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improper adjustment</td>
<td>52 CL/MS &amp; 52 SM/LS &amp; 52 IL/MS*</td>
<td>Loose wires</td>
</tr>
<tr>
<td>Switch failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary disconnect</td>
<td>52 CL/MS &amp; 52 SM/LS &amp; 52 IL/MS*</td>
<td>Poor fitting disconnect</td>
</tr>
<tr>
<td>Poor fitting disconnect</td>
<td></td>
<td></td>
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<tr>
<td>Terminal block</td>
<td></td>
<td></td>
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<tr>
<td>Charging motor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connection loose</td>
<td></td>
<td></td>
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<tr>
<td>Motor failure</td>
<td></td>
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</tr>
</tbody>
</table>

### Mechanical

**Check for rotation of gearbox output shaft**

- (Motor runs but does not charge spring)
  - Check shear pin at drive shaft junction (ML-17/17H)
  - If charging wheel turns
    - Check charging pawl
      - Check to see if fly wheel assembly has stopped in proper position (ML-17/17H)
  - Check for proper reset of closing latch if close spring immediately discharges at end of charging cycle

**Rack mechanism**

- Breaker not in position properly
- Sliding rail has not reset
<table>
<thead>
<tr>
<th>GUIDE 2</th>
<th>FAILS TO CLOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fuses</td>
</tr>
<tr>
<td>No voltage</td>
<td>Broken wires</td>
</tr>
<tr>
<td></td>
<td>Grounded wires</td>
</tr>
<tr>
<td>Low voltage</td>
<td>Pinched wires</td>
</tr>
<tr>
<td>(Test under load)</td>
<td>Loose connections</td>
</tr>
<tr>
<td>Limit switches</td>
<td>Improper adjustment</td>
</tr>
<tr>
<td>52 LCS &amp; 52 CHG</td>
<td>Switch failure</td>
</tr>
<tr>
<td>Secondary disconnect</td>
<td>Poor fit</td>
</tr>
<tr>
<td>52X open coil (52/CC on ML-18/18H)</td>
<td>Loose / corroded pins</td>
</tr>
<tr>
<td>Auxiliary switch</td>
<td>Loose wires</td>
</tr>
<tr>
<td>52Y (Anti-pump relay)</td>
<td>Switch failure</td>
</tr>
<tr>
<td>Trip latch is not resetting</td>
<td>Failure of operating linkage</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Loose wires</td>
</tr>
<tr>
<td>Check to see if breaker is charged</td>
<td>N/O contacts bad</td>
</tr>
<tr>
<td>Check freeness of closing shaft armature linkage</td>
<td>Improper dropout</td>
</tr>
<tr>
<td>Adjust clearance</td>
<td>Not returning to stop</td>
</tr>
</tbody>
</table>
GUIDE 3

FAILS TO TRIP

- **Fuses**
  - No voltage
  - Low voltage
  - (Test under load)

- Broken wires
- Grounded wires
- Pinched wires
- Loose connections
- Corroded connections

- **Electrical**
  - Trip coil
  - 52/TC
  - Secondary disconnect
  - Auxiliary switch

- Open coil
- Poor fit
- Loose / corroded pins
- Loose wires
- Switch failure
- Switch operating
- Linkage failure

- **Mechanical**
  - Linkage on trip plunger bound up
  - Pin missing out of shaft junction
  - Main contacts welded together

GUIDE 4

TRIP FREE

- **Electrical**
  - Trip free
  - Trip latch

- Maintained Voltage on trip circuit
- No clearance
- Broken reset spring
- Not resetting
- Shaft binding
- Linkage binding

- **Mechanical**
  - Toggle link not making toggle position due to bearing wear
  - Negative interlock not adjusted properly
### BREAKER PREVENTIVE MAINTENANCE CHECK-OFF LIST

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Check that breaker is open and discharged.</td>
</tr>
<tr>
<td>2.</td>
<td>Record breaker serial number and number of operations.</td>
</tr>
<tr>
<td>3.</td>
<td>Inspect for damage to breaker (exterior).</td>
</tr>
<tr>
<td>4.</td>
<td>Perform a visual inspection of the breaker and remove dust and contaminants from the interrupter housing, insulation, and mechanism. Do not use compressed air.</td>
</tr>
<tr>
<td>5.</td>
<td>Inspect the interrupters and operating mechanism carefully for loose nuts, bolts and damaged parts. All cam latch and roller surfaces should be inspected for damage or excessive wear.</td>
</tr>
<tr>
<td>6.</td>
<td>Check that the trip coil plunger and close coil plunger move freely.</td>
</tr>
<tr>
<td>7.</td>
<td>Inspect condition of primary and secondary disconnects.</td>
</tr>
<tr>
<td>8.</td>
<td>Inspect for evidence of overheating or tracking.</td>
</tr>
<tr>
<td>9.</td>
<td>Lubrication</td>
</tr>
<tr>
<td>9.1</td>
<td>On all sleeve, needle, and roller bearings apply 2 or 3 drops of Mobile No. 1 oil.</td>
</tr>
<tr>
<td>9.2</td>
<td>On each silver plated primary disconnect finger assembly, wipe clean and apply a light coat of GE 0282A2048P009 lubricant (red grease).</td>
</tr>
<tr>
<td>9.3</td>
<td>On the vacuum interrupter connector rod (movable, each pole) apply a light coat of 0282A2048P009 lubricant (red grease).</td>
</tr>
<tr>
<td>10.</td>
<td>Operate the breaker slowly to be sure there is no binding or friction and that the movable contact of the interrupter can move to the fully opened and fully closed position.</td>
</tr>
</tbody>
</table>
11. Check interrupter and mechanism adjustments.

12. Check contact erosion indicator.

13. Inspect transfer finger wear.

14. Check all wiring for tightness of connections and possible damage to insulation.

15. Check primary circuit integrity by means of a 2500 volt megohmmeter (breaker in the closed position phase to phase and phase to ground).

16. Check control circuit integrity by means of a 500/1000 volt megohmmeter. (Note: Disconnect motor leads to prevent winding insulation damage.)

17. Perform a high potential test (vacuum integrity test) on each vacuum interrupter as described in instruction book. **WARNING**: X-Radiation may constitute a health hazard. Refer to instruction book for proper procedures.

18. Operate the breaker using the test cabinet and observe the following:

   18.1 Breaker charges properly.
   18.2 Breaker closes and opens correctly.
   18.3 Breaker trips freely.
   18.4 Indicators show correct position.

19. Place breaker in the equipment in the test position and operate it electrically.

20. Check the operation of all electrical relays (including protective relay devices), solenoid switches, motors, control switches, and indicating devices.

21. Check negative interlock.

22. Check positive interlock.

23. Check spring discharge interlock
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td><strong>SWITCHGEAR EQUIPMENT</strong></td>
<td><strong>PREVENTIVE MAINTENANCE CHECK-OFF LIST</strong></td>
</tr>
<tr>
<td>1.</td>
<td>Disconnect primary power from switchgear.</td>
</tr>
<tr>
<td>2.</td>
<td>Disconnect control power except for Items 9, 10, and 19.</td>
</tr>
<tr>
<td>3.</td>
<td>Check exterior of equipment for damage.</td>
</tr>
<tr>
<td>4.</td>
<td>Check equipment ground bus and its connection(s) to station ground.</td>
</tr>
<tr>
<td>5.</td>
<td>On outdoor switchgear, check integrity of seal against weather and rodents.</td>
</tr>
<tr>
<td>6.</td>
<td>Check doors for damage.</td>
</tr>
<tr>
<td>7.</td>
<td>Check door handles, locking bars, keys and interlocks for positive operation.</td>
</tr>
<tr>
<td>8.</td>
<td>Insure structure is tight.</td>
</tr>
<tr>
<td>9.</td>
<td>Check cabinet lighting (if present).</td>
</tr>
<tr>
<td>10.</td>
<td>Check heaters and heater circuits (if present).</td>
</tr>
<tr>
<td>11.</td>
<td>Check that all power and control cable entrances are sealed against rodents and fire contaminants.</td>
</tr>
<tr>
<td>12.</td>
<td>Check all wiring connections, including those on terminal blocks.</td>
</tr>
<tr>
<td>13.</td>
<td>Check draw-out racking mechanisms (also check lubrication).</td>
</tr>
<tr>
<td>14.</td>
<td>Check shutter mechanism.</td>
</tr>
<tr>
<td></td>
<td>Task</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>15</td>
<td>Inspect bus and support insulators for evidence of corona or insulation deterioration</td>
</tr>
<tr>
<td>16</td>
<td>Megohmmeter test switchgear lightning arresters (if present).</td>
</tr>
<tr>
<td>17</td>
<td>Check control knobs and switches for freedom of movement and contact condition.</td>
</tr>
<tr>
<td>18</td>
<td>Check mechanical and electrical integrity of all relays</td>
</tr>
<tr>
<td>19</td>
<td>Perform sequencing check of protective, auxiliary, and control relays.</td>
</tr>
<tr>
<td>20</td>
<td>Inspect switchgear instruments (meters, switches, and indicating lights).</td>
</tr>
<tr>
<td>21</td>
<td>Inspect all instrument transformers.</td>
</tr>
<tr>
<td>22</td>
<td>Inspect all fuses.</td>
</tr>
<tr>
<td>23</td>
<td>Inspect and check batteries and battery charging equipment (perform a load test).</td>
</tr>
<tr>
<td>24</td>
<td>Clean all compartments and bus sections.</td>
</tr>
<tr>
<td>25</td>
<td>Lubricate racking mechanism, if not done under Item 13.</td>
</tr>
<tr>
<td>26</td>
<td>Check to insure that all key interlocks are operational and no spare keys are used.</td>
</tr>
</tbody>
</table>
BREAKER MAINTENANCE TOOL LIST

The following common tools are recommended for proper maintenance of the breaker (NOTE: Obtain from local hardware supplies; do not order from General Electric Company.)

**Socket Wrenches (1/2" drive)**
- Ratchet Handle
- 10" Extension Bar
- 4" Extension Bar
- 7/16" Socket
- 9/16" Socket
- 5/8" Socket
- 3/4" Socket

**Hand Wrenches**
- Adjustable 10"
- 7/16" Open End
- 9/16" Open End
- 15/16" Open End
- 1 1/16" Open End
- 1 1/8" Open End

**Miscellaneous Tools**
- Hammer or Mallet
- Micrometer
- Flashlight
- Torque Wrench 0-60 Ft. Lbs.
- Feeler Gages
- Inspection Mirror
- Ruler "Accurate" 6" Long
- Calipers
- Depth Micrometer

**Instruments**
- Simpson Multi-Meter or similar
- Insulation Tester
- Vacuum Integrity Tester

**Allen Head Wrenches**
- 3/16"
- 1/4"

**Screw Drivers**
- Long Thin Slotted Screw
- Standard Slotted Screw

**Pliers**
- Long Nose 6"
- Wire Cutters
- Wire Strippers
- Stakon Pliers
- Slip-joint Pliers 8"
I. MEGGER

Primary Circuit

The primary circuit insulation on the equipment and the breaker may be checked phase-to-phase and phase-to-ground using a 2500V megohmmeter.

Secondary Circuit

Prior to meggering the equipment secondary circuit, remove all circuit grounds, thread a wire throughout the equipment which will connect all devices and their terminals together.

Prior to meggering the breaker secondary circuit, remove the motor leads, thread a wire connecting all secondary disconnect pins together except for pin #24 which is the ground pin.

The breaker and the equipment may be meggered by connecting a 500V megohmmeter from the wire to ground.

Since definite limits cannot be given for satisfactory insulation values, a record should be kept of the megger readings as well as temperature and humidity readings. This record would be used to detect any weakening of the insulation from one check period to the next.

II. HIGH POTENTIAL TEST

High potential tests to check the integrity of the insulation are not necessary at start-up.

Should high potential tests be required, the AC high potential test described is strongly recommended by the GE Switchgear Business. **DC high potential testing of the bus or equipment is not recommended, except for the Vacuum Interrupter Integrity Test.**

If DC high potential cable testing is required, the DC high potential machine must not produce peak voltages that exceed 50 kV, and the following procedure must be adhered to:

1. The calibration of the DC test set has been checked to read peak voltages correctly at the peak test level noted in Table 1.
2. That all voltage sensitive devices are removed or disconnected prior to test (i.e. surge arrestors, surge capacitors, VT’s, CPT’s). The breaker associated with the cables to be tested should be in the disconnected position, and any rollout trays withdrawn. All insulators to be energized should be clean and dry.
3. Voltages should be increased and decreased slowly (2 kV per second maximum).
4. Peak DC voltage does not exceed peak test level noted in Table 1.
After reassembly of components, all disturbed wiring and insulation systems should be restored to original conditions and inspected. Some integrity test for dielectric capability is recommended – at least a megger test.

Primary Circuit

Prior to high potential testing of the equipment primary circuit, the potential transformers; control power transformers, lightning arresters, surge suppressors, and breakers must be electrically disconnected from the equipment.

The breaker should be hi-potted in the closed breaker mode.

An AC hi-pot machine capable of producing the voltages shown in Table 1 of this instruction may be used to hi-pot the equipment and breaker phase-to-phase and phase-to-ground.

The machine should be connected with its output potential at zero, the voltage can then be increased to the voltage shown in Table 1 and that voltage maintained for 60 seconds. DC high potential tests voltages from Table 1 are to be maintained for 15-30 seconds and are not to exceed 30 seconds. The voltage should then be returned to zero, and the hi-pot machine removed from the circuit. (NOTE: Voltages shown in Table 1 should not be exceeded).

Secondary Circuit

Prior to hi-potting the equipment secondary circuit, remove all circuit grounds. Thread a wire throughout the equipment, which will connect all devices and their terminals together. Short out all meter, relay or other coils so that a possible ground will not draw damaging current through such coils. Isolate all GE and other vendors “non-hi-pot” devices, small commutator-type motors or any other apparatus of unknown hi-pot value. Remove all known ground connections.

Prior to hi-potting the breaker secondary circuit, remove the motor leads, thread a wire connecting all secondary disconnect pins together except for pin #24 which is the ground pin.

The breaker and the equipment may be hi-potted by connecting the hi-pot machine from this wire to ground with the output voltage at zero. The voltage can then be increased to 1125 volts (rms) 60 Hz. and maintained for 60 seconds. (1600 volts DC maintained for 15-30 seconds not to exceed 30 seconds). Reduce the voltage to zero and remove the high potential machine from the circuit.

NOTE: After removing high potential machine, return equipment and breaker to original state.

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Voltage</td>
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</tbody>
</table>


<table>
<thead>
<tr>
<th>4.16</th>
<th>14 kV</th>
<th>20 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>27 kV</td>
<td>38 kV</td>
</tr>
<tr>
<td>13.8</td>
<td>27 kV</td>
<td>38 kV</td>
</tr>
</tbody>
</table>

*The AC voltages are 75% of factory test voltages in accordance with ANSI standards.*
III. VACUUM INTERRUPTER INTEGRITY TEST

This test of the vacuum interrupter will determine its internal dielectric condition and vacuum integrity. Prior to performing any vacuum interrupter integrity tests, the outside (external surface) of the interrupter should be wiped clean of any contaminates with a non-linting cloth. This is critical that the entire external surface is to be completely free of all dirt, dust, oil, etc. With the breaker open, individually check each interrupter by connecting the hi-pot machine across the primary studs (bars) on the breaker side of the disconnect fingers. Ground the other two interrupters line and load side of the primary studs, the frame, and the secondary wiring. Increase the hi-pot machine voltage to 36kV (rms) 60 Hz. and maintain for 60 seconds. If no breakdowns occur during any of the three hi-pot tests, the interrupters have passed and the breaker can be put into service. If a breakdown occurs in an interrupter, it must be replaced.

GE Burlington continues to strongly recommend the use of an AC high potential machine for vacuum interrupter integrity tests. DC testing of vacuum interrupters should only be utilized if an AC tester is not available, and should be used for quick field checks only. Our experience with DC testers over many years indicates they frequently yield false negative test results, due partially to the capacitive component of the vacuum interrupter during DC testing, and to the fact that most lightweight DC testers have a very low leakage current trip setting. They will however, reliably indicate a truly failed bottle if the voltage output is set at 50kV DC.

If using a DC tester, and a test indicates a bad interrupter, retest with the polarity of the DC test voltage reversed. If this results again in a failure, we would recommend a final AC test prior to contacting GE Post Sales Service or discarding the interrupter.

No attempt should be made to try and compare the condition of one vacuum interrupter with another, or to correlate the condition of any interrupter to low values of DC leakage current. There is no significant correlation.

After the high potential voltage is removed, discharge any electrical charge that may be retained.

CAUTION: MANY OLDER DC HIGH POTENTIAL MACHINES ARE HALF-WAVE RECTIFIERS. THIS TYPE OF HI-POT TESTER MUST NOT BE USED TO TEST VACUUM INTERRUPTERS. THE CAPACITANCE OF THE POWER/VAC BOTTLE IS VERY LOW AND THE LEAKAGE IN THE RECTIFIER AND ITS DC VOLTAGE MEASURING EQUIPMENT IS SUCH THAT THE PULSE FROM THE HALF-WAVE RECTIFIER MAY ACTUALLY BE IN THE NEIGHBORHOOD OF 120KV, WHEN THE METER IS ONLY READING 40KV. IN THIS CASE, SOME PERFECTLY GOOD BOTTLES CAN SHOW A RELATIVELY HIGH LEAKAGE CURRENT SINCE IT IS THE PEAK VOLTAGE OF 120KV THAT IS PRODUCING ERRONEOUS BOTTLE LEAKAGE CURRENT. IN ADDITION, THE X - RADIATION WILL BE OF CONCERN.
An acceptable AC high potential test machine is available from the GE Electrical Equipment Business, Burlington, Iowa, catalog number 282A2610P001.

Other acceptable manufacturers of portable AC and DC insulation testers include Hipotronics models numbers 7BT60A, 60HVT, 860PL (DC) and 880PL (DC), or GE/Programma model VIDAR (DC).

**MECHANISM ADJUSTMENTS**

Adjustments are set at the factory and will seldom require more than a quick check. Mechanism life testing has proven that normal wear is negligible and only severe contact erosion may require readjustment. Major repairs such as replacing interrupters may also require some readjustment. Refer to the specific breaker instruction book for the mechanism type being used. For ML-18/18H see Instruction Book GEK-86132G, and for ML-17/17H see Instruction Book GEK-39671F & supplement DET-002.
Fig. 1 Typical Wiring Diagram for ML-17/17H Mechanism
Fig. 2 Typical Wiring Diagram for ML-18 Mechanism
These instructions do not purport to cover all details or variations in equipment or to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

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DET-456