PART 1  GENERAL

1.01  SCOPE

A. This specification covers the design, testing and manufacturing requirements for new vacuum replacement (VR) circuit breakers for use in medium voltage (MV) metal-clad switchgear.

B. The VR circuit breakers shall be functional replacements (both mechanically and electrically) for the air magnetic circuit breakers listed in this specification. The VR circuit breakers shall be interchangeable (within the limits of the original switchgear) between different types of cells (structures) of the same voltage, MVA and ampere class without cell (structure) modifications.

C. Retrofits, as defined by IEEE/ANSI C37.59-1996 6.1.4.2 are not covered by this specification and will not be considered as an alternative or substitute for new VR circuit breakers. Retrofitted circuit breakers are not allowed.

D. The manufacturer shall provide all project management, factory and field engineering, short-circuit and coordination studies, supervision, labor, material, tools, rental, test equipment and transportation as defined by this specification for a complete VR circuit breaker replacement of the existing medium voltage switchgear circuit breakers listed in Paragraph 2.03 C “Equipment List.”

E. The VR circuit breakers shall be designed for maximum voltages of either 4.76 kV, 8.25 kV or 15 kV as designated.

1.02  RELATED SECTIONS

1.03  REFERENCES

A. All VR breakers shall be designed, manufactured and tested in accordance with the applicable sections of:

1. ANSI C37.59-1996 (cell interface and testing criteria)
2. ANSI C37.04
3. ANSI C37.06
4. ANSI C37.09
5. ANSI C37.20.2
6. ANSI C37.55
7. ANSI C37.100
8. IEEE STD 4-1995

*^Note to Spec. Writer – Optional
1.04 SUBMITTALS – FOR REVIEW/APPROVAL

A. The following information shall be submitted to the Engineer:
   1. Equipment list
   2. Project work schedule
   3. Product data sheets
   4. Major component ratings including:
      a. Voltage
      b. Continuous current rating
      c. Interrupting ratings.

1.05 SUBMITTALS – FOR CONSTRUCTION

A. The following information shall be submitted for record purposes:
   1. Final as-built drawings and information for items listed in Paragraph 1.04, and shall incorporate all changes made during the manufacturing process
   2. Wiring diagrams
   3. Certified production test reports

1.06 QUALIFICATIONS

A. The manufacturer of the new VR circuit breakers shall be currently engaged in the design and manufacturing of MV vacuum circuit breakers and switchgear structures. The manufacturer shall design & manufacture their own vacuum bottles for quality control & optimum performance. The manufacturer shall have a minimum of 50 years experience in switchgear manufacturing, shall be a member of the National Electrical Manufacturers Association (NEMA), shall have representation on IEEE C37 Switchgear Working and Balloting Groups, and shall own and operate an engineering services organization.

B. The manufacturer shall have a minimum net worth of $500 million to ensure financial stability during and after the completion of the retrofit process.

C. The manufacturer of the VR circuit breakers shall have an engineering service organization with experienced, factory-trained field engineers and technicians familiar with the installation and startup of MV VR circuit breakers.

D. The engineering service organization shall have a minimum of 30 field service locations staffed with engineers that are available on a 24-hour basis for emergency service.

E. The engineering service organization must have the capabilities of on-site cell alignment, breaker levering system repairs, and control system modifications.

F. The manufacturer’s engineering service organization shall have the capabilities to perform computer-generated short-circuit, coordination, and load flow studies for final breaker protective relay settings. The manufacturer’s engineering service organization shall also have the capabilities to perform harmonic analysis studies and filter design, if requested. All studies shall be conducted under the supervision and approval of a registered professional electrical engineer skilled in interpreting studies and test results regarding MV VR circuit breakers. The registered professional electrical engineer shall be a full-time
employee of the engineering service organization/manufacturer. A part-time consulting
engineer, or an engineer that works on a retainer, is not acceptable.

1.07 OPERATION AND MAINTENANCE MANUALS

A. Equipment operation and maintenance manuals shall be provided with each assembly
shipped and shall include instruction leaflets, instruction bulletins and renewal parts lists
where applicable, for the complete assembly and each major component.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton
B. ______
C. ______

The listing of specific manufacturers above does not imply acceptance of their products that do
not meet the specified ratings, features and functions. Manufacturers listed above are not
relieved from meeting these specifications in their entirety. Products in compliance with the
specification and manufactured by others not named will be considered only if pre-approved by
the Engineer ten (10) days prior to bid date.

2.02 RATINGS

Note to Spec. Writer
Modify the table as needed.

A. The MVA rating of the VR circuit breakers shall be as follows:

<table>
<thead>
<tr>
<th>Volts kV</th>
<th>Original MVA</th>
<th>New MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.76</td>
<td>100 - 250</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>100 - 250</td>
<td>350</td>
</tr>
<tr>
<td>8.25</td>
<td>150 - 500</td>
<td>500</td>
</tr>
<tr>
<td>15</td>
<td>150 - 500</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>150 - 500</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>150 - 500</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>1000</td>
</tr>
<tr>
<td></td>
<td>150 - 1000</td>
<td>1500</td>
</tr>
</tbody>
</table>

B. All switchgear structures designated for VR circuit breakers with increased MVA levels shall
have the existing bus bracing analyzed by an engineering services organization that is
owned and operated by the VR circuit breaker manufacturer. The engineering services
organization shall determine if the existing bus bracing is capable of withstanding the
maximum (peak) momentary ratings per ANSI C37.09.4.6.2.4 and ANSI C37.20.2.5.2.4

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capabilities of the new VR circuit breakers. The manufacturer’s engineering services organization shall provide documentation to verify that the switchgear bus is sufficiently braced to handle the new ratings or supply the cost as a separate item to increase the bus bracing of all designated switchgear structures in the lineup to comply with the increased MVA ratings. Following the study and/or the bracing modifications, the manufacturer’s service engineer shall affix a nameplate to each switchgear structure stating the new MVA rating, the manufacturer’s name and the date of verification or upgrade.

2.03 CONSTRUCTION

A. The VR circuit breakers shall be interchangeable with existing breakers of the same continuous current and MVA ratings without major mechanical modifications to the existing cubicles. Existing cell coding systems shall be retained and shall not be modified as long as the circuit breaker ratings remain unchanged.

B. VR circuit breakers with upgraded/increased MVA or continuous current ratings shall require modifications to the cubicle coding system to prevent the insertion of breakers that do not have the same ratings as the upgraded VR circuit breakers.

C. The VR circuit breakers shall be utilized to replace the following breakers currently in service at (Location or Substation):

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Catalog Type</th>
<th>kV</th>
<th>Amperes</th>
<th>MVA</th>
<th>MOC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4.76</td>
<td>1200</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.76</td>
<td>2000</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.76</td>
<td>3000</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.25</td>
<td>1200</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.25</td>
<td>2000</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.25</td>
<td>3000</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>1200</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>2000</td>
<td></td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>3000</td>
<td></td>
<td>Yes/No</td>
</tr>
</tbody>
</table>

D. All materials used in the manufacturing of the new VR circuit breakers shall be new and unused. No parts or materials from the original air-magnetic circuit breakers shall be reconditioned and reused in the manufacture of the new VR circuit breakers. All components used in the manufacturing of the new VR circuit breakers including, mechanism, vacuum interrupters, and frame components shall all be manufactured by the same company to ensure single-source reliability and responsibility.

2.04 MAJOR COMPONENTS

A. The VR circuit breakers shall utilize Cutler-Hammer vacuum circuit breaker modules manufactured by Eaton. Acceptable conversion modules are the VCP-18WR, VCP-20WR, VCP-29WR and the VCP-29WRSE.

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B. The circuit breaker mechanism shall open and close all three phases and any auxiliary devices via a common operating shaft to ensure consistent and simultaneous operation of the main contacts. The shaft shall be supported at the ends and along its length with bearings. The main drive shaft shall be connected to the individual vacuum interrupters via insulated drive links.

C. The mechanism drive shaft shall be connected to each moving contact via an insulated drive link made of glass reinforced polyester for element types VCP-18WR, VCP-20WR and VCP-29WR and cycloaliphatic epoxy for the VCP-29WRSE. The insulated link material shall be non-hygroscopic and meet the flame-retardant requirements as set forth in ANSI C37.20.2.5.2.7. The drive links shall be easily removable with single clevis pins at each end and spring retaining clips.

D. The mechanism shall contain a shock absorber system to dampen the opening force of the circuit breaker. The shock absorber shall have sufficient resilience to prevent contact bounce that could cause a restrike of the main contacts during the opening of the circuit breaker or during a spring discharge. The VCP-20WR, VCP-29WR and VCP-29WRSE vacuum conversion element’s mechanism shall consist of a series of parallel steel plates with spring separators that spread the plates during breaker opening. The shock absorber shall have a design life of 10,000 breaker opening and closing cycles without the need for repair, replacement or adjustment. The VCP-18WR shall have a sealed replaceable shock absorber.

E. The mechanism shall have front accessible manual close and trip operators that are directly connected to the breaker operating mechanism and are an integral part of the electrical close and trip coils.

F. Each VR circuit breaker mechanism shall have a five (5) digit non-resetting mechanical operations counter connected to the operating shaft as manufactured by Veeder-Root or engineer-approved equal.

G. Each operating mechanism shall be equipped with a visible indicator to show the state of the stored energy mechanism. The indicator shall show when the spring is fully charged or discharged.

H. The breaker shall have a low inertia, rotary operated auxiliary switch connected to the main pole shaft assembly. Connections shall be made via insulated ring-tongue terminals.

I. The vacuum bottle assembly shall be constructed from virgin materials and shall be a Cutler-Hammer product or engineer-approved equal. The contacts shall principally be composed of powdered metal, chromium-copper contact material. The powdered metal shall be fused under high pressure to form a consistent contact material. The contacts shall be machined to form spiral petal contacts to assist in the swirling of the arc during interruption.

J. The edges of the ceramic components shall be “metalized” and fired prior to assembly. The components shall be inspected and assembled in a Class 1000 clean room prior to sealing the components. The components shall be inserted into a vacuum heat chamber and sealed under vacuum. No “pinch tubes” are allowed.

K. A stainless steel corrugated bellows shall achieve isolation of the ambient air and the vacuum. The moving contact stem of the vacuum interrupter shall have a machined groove to prevent rotation of the contact within the vacuum chamber.
L. The vacuum interrupter shall have a visual method of identifying contact wear without the use of gauges or other devices. In addition, a separate visual “T-cutout” shall be used to verify that the mechanism is applying adequate spring pressure to the contacts when the breaker is in the closed position.

M. The contacts shall be self-aligning and shall not require adjustments for the life of the vacuum interrupter assembly. The contacts shall also have a spring system to apply proper contact pressure.

N. Pole assemblies shall be insulated from ground with non-hygroscopic insulating materials manufactured from glass-reinforced polyester.

O. The current transfer from the conductor stem to the primary bushing assemblies shall be via a non-sliding current transfer system consisting of a fused stem assembly and a V-flex silver-plated copper leaf conductor or folded leaf copper shunts. The stems shall have the adjoining conductors mechanically fused with the stem material. This junction shall form a solid current transfer. Neither sliding nor rolling current transfer systems are allowed. The use of half-clamp current transfer systems to clamp the conductor to the stem is not allowed.

P. The new VR circuit breaker operation mechanism shall be a “true Trip-Free” design. When the trip function is mechanically engaged and held and the close function is initiated either electrically or mechanically, the contacts shall not close. The contacts shall be restricted to 10% of the total travel.

Q. Each new VR circuit breaker shall have a mechanical status indicator with the word “CLOSED” on a red background when the breakers are closed and the word “OPEN” on a green background when the breakers are open.

2.05 SUB-COMPONENTS

A. The breaker frame shall be constructed from steel. A combination of bolting and welding to assemble the frames is acceptable. All frames shall be zinc-plated with a yellow dichromate finish.

B. VR circuit breakers shall be supplied with transport system that is a functional replacement of the transport system of the original design. The transport system shall conform to the requirements as listed below:

<table>
<thead>
<tr>
<th>Original Design</th>
<th>VR Circuit Breaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed wheels and dolly</td>
<td>Fixed wheels and dolly</td>
</tr>
<tr>
<td>Fixed wheels and casters</td>
<td>Fixed wheels and casters</td>
</tr>
</tbody>
</table>

C. All hardware shall be minimum grade five (5), zinc-plated with a yellow dichromate finish or black oxide.

D. Primary and power frequency interface conductors shall be constructed of 100% IACS electrical grade conductive copper. Conductors shall be either silver- or tin-plated to a thickness of .0001-.0002 for non-sliding surfaces and .001-.002 for sliding surfaces. The power frequency conductors shall be sized to carry the full load ampacity of the circuit breaker without exceeding the temperature rise established in ANSI C37.09.
E. All bushings shall utilize either glass-reinforced polyester or molded cycloaliphatic epoxy insulation systems or engineer-approved equal. Fluidized epoxy coatings shall be used to insulate interface conductors when necessary.

F. Phase barriers shall be manufactured from GPO-3 glass reinforced polyester or equivalent and shall be designed to isolate individual phase conductors. Openings shall be minimized to reduce the possibility of ionized gas propagation between phases.

G. All 8.25 kV and 15 kV class breakers shall have internal corona shields when bushings are mounted on metallic back planes. The corona shields shall be permanently grounded. Bushings mounted on nonmetallic back planes shall not have internal corona shields.

H. Primary connections (finger clusters) shall be new and designed to carry the full nameplate rating of the replacement breaker without exceeding the allowable temperature rise as stated in ANSI C37.04.5.4.2-1979. In addition, the primary connections shall be capable of withstanding the full momentary/close and latch rating as well as the K*I current rating for two seconds without melting, arcing or pitting the contact surface.

I. A silver-/tin-plated, self-coupling, separable grounding contact shall be supplied and sized to carry the maximum line-to-ground fault for a solidly grounded three-phase system for two (2) seconds.

J. The replacement breaker shall incorporate a manual and an automatic system to completely discharge all stored energy before the circuit breaker is fully withdrawn from the switchgear housing. The system shall never intentionally discharge the stored energy while in the connected position.

2.06 WIRING

A. Control wiring shall be SIS cross-linked polyethylene, #14 AWG minimum except for short runs such as coil and motor leads. Insulated ring tongue terminals shall be used. No solder connections shall be allowed. Upfront, easy access terminal blocks shall be provided for maintenance and troubleshooting.

2.07 ACCESSORIES

A. The mechanism, where possible, shall have a passive interlock to block the insertion or removal of a closed breaker. The system shall prevent the insertion of the levering tool at anytime the breaker is in the closed position.

B. Each breaker shall have an active interlock system. The system shall be operated by the insertion or removal of the VR circuit breaker. In the event the passive interlock is defeated, active interlock system shall trip and open a connected, closed breaker if an attempt is made to remove it from the connected position. The system shall also hold the breaker in the “trip-free” position at all times between the test and fully connected positions.

C. Locking means shall be provided to lock the circuit breaker while in the fully connected or disconnected positions. The lock shall prevent the insertion or removal of the breaker. The lock shall not prevent the breaker from being operated while in the fully connected position.

D. Control wiring connections between stationary structure and the removable breaker shall be provided with automatic, self coupling contacts. The pins shall be drilled and tapped to accept standard 8-32 screws for ease of maintenance and wiring changes. The secondary contact block shall be made of cycloaliphatic epoxy.
E. All breakers shall be furnished with MOC operators when specified. The MOC operator shall have sufficient power to operate the largest MOC switch or combination of switches in the switchgear lineup without affecting the breaker's ability to completely close and latch. The MOC driver shall be completely “decoupled” from the main breaker operating shaft and shall be powered by separate operating springs. The system shall be Cutler-Hammer “SURE-CLOSE” as manufactured by Eaton. Direct drive MOC operators are not acceptable.

F. The manufacturer shall supply or interface with the cell coding system to prevent the accidental insertion of a breaker into a cell of a different voltage, current, interrupting capacity or physical arrangement than the type intended for the switchgear cell receiving the breaker.

PART 3 EXECUTION

3.01 TESTING

A. Each new VR circuit breaker supplied shall have type tests performed on its base design to certify it to IEEE/ANSI standards. Extrapolation of test values based on individual components is unacceptable.

B. All certification (type) shall will be performed in a switchgear cell/structure when required or an equivalent structure where permitted by ANSI C37.09. Written test reports, data logs and digital reproductions of the pulse used to perform the BIL test are required to be on hand for review by the buyer.

C. Non-compliance with these certification/type tests or the failure to produce evidence of such test shall result in the immediate disqualification of the manufacturer without obligation to the buyer.

D. The following tests shall be performed:

1. BIL - <60 kV for 4.76 kV applications, 95 kV for 8.25- and 15 kV applications as a minimum> crest with 1.2 µsec x 50 µsec x 50% wave shape per ANSI C37.09.4.5.4. The tests shall be conducted per IEEE STD 4-1995. This test shall be performed in a breaker cell or cell equivalent with controlled humidity levels. Corrections for barometric pressure and ambient temperature shall be applied to the test parameters. The breaker shall pass a total of 54 shots

2. Mechanical operations tests of each breaker design shall be performed in a switchgear cell designed to accommodate MOC switches. The maximum number of auxiliary MOC devices or their equivalent force shall be applied during the test to ensure that the vacuum breaker has sufficient power to operate the auxiliary devices, successfully closes and latches during each operation, and that no fatigue or failure occurs. The system shall pass the number of operations as listed in “the first scheduled maintenance point” of 10,000 life expected mechanical operations per ANSI C37.06-1987 Table 8. Consideration shall be given to designing a system that will not damage the MOC switch in the switchgear cell structure

3. Momentary tests per IEEE/ANSI C37.20.2.5.2.4 shall be performed of the completed vacuum replacement breaker including the vacuum breaker element, bushings, primary disconnects (finger clusters), all bus in the breaker unit, and all insulators and braces per ANSI C37.09, 4.6.2.4. This shall prove the mechanical strength and integrity of the
conductor and frame assembly of the complete new vacuum replacement breaker. This test must be performed in a switchgear cell designed to accommodate the circuit breaker being tested. Anti-rotation devices may be added to the cell if required to prevent rotation. If anti-rotation devices are used in the test breaker, then they shall be installed in all the switchgear cells intended to accommodate the new breakers.

4. Short-time current tests for three (3) seconds at K*I current shall be performed to confirm the \( I^2t \) capability of the breaker. The test shall be performed in a switchgear cell.

5. Continuous rated current testing shall be performed per ANSI C37.04-1979 without exceeding 65 degrees C hotspot rise in a maximum ambient of 40 degrees C. This test shall be performed in a breaker cell or a cell structure of the same equivalent volume, dimensions and ventilation as the original switchgear structure.

6. Low frequency withstand shall be 19 kV rms for 4.76 kV applications, and 36 kV rms for 8.25 kV and 15 kV applications per ANSI 37.09, 4.5.3.1.

7. Interlock functional test per ANSI C37.20.2, 6.2.4.

8. All production tests as stated in ANSI C37.09-1979.5. Timing values per pole shall be provided for the vacuum element in msec.

9. A certified test of all standard production tests shall be available to the Engineer upon request.

3.02 FIELD QUALITY CONTROL

A. The manufacturer shall utilize his own factory trained and certified field service engineer(s) to perform the commissioning of each breaker at the customer’s site.

B. The Contractor or owner’s maintenance personnel will provide the necessary switching and breaker operation to accommodate the requirements of the manufacturer’s field service Engineer to perform the field commissioning of the VR circuit breakers.

3.03 MANUFACTURER’S CERTIFICATION

A. A qualified factory-trained manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer’s recommendations.

3.04 TRAINING

A. The manufacturer shall provide a training session for up to five (5) owner’s representatives for _____ normal workdays at a job site location determined by the owner.

B. The training session shall be conducted by a manufacturer’s qualified representative. The training program shall consist of the instruction on the operation of the assembly, circuit breakers and major components within the assembly.

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