

(Sample Specification)

New Vacuum Replacement Circuit Breakers And Associated Devices for Air Magnetic Breakers Rated 4.76 kV, 8.25 kV and 15 kV

1.0 General

This specification covers the design, testing and manufacturing requirements for replacement medium voltage vacuum circuit breakers and additional monitoring devices. The breakers shall be mechanical and electrical replacements for _____ type ____ air circuit breakers. The replacement vacuum circuit breakers shall be interchangeable between different types of cells of the same voltage, MVA and ampere class without cell modifications except as noted. It is recognized that there is no "exact replacement" for any type breaker except for a duplicate of the original, however, fit and function are to be maintained and only minor reversible cell modifications are allowed. The term converter refers to the manufacturer of the complete finished product. The terms "conversion" and "replacement breaker" shall be considered interchangeable within the context of the specification.

2.0 Scope of Work

Provide all project management, factory and field engineering, short circuit coordination studies (if required), supervision, labor, material, tools, rental, test equipment and transportation as defined by this specification for a complete vacuum breaker replacement of the existing medium voltage switchgear circuit breakers listed in Section 3.0 "Equipment List". The breakers may be 4.76 kV, 8.25 kV or 15 kV class breakers as designated.

2.1 Increased MVA Ratings

(Spec. writer should modify the table as needed.)

The nominal MVA rating of the replacement breakers shall be as follows: (MVA is an obsolete term as circuit breakers are rated by short circuit.)

Volts	Original MVA	New MVA
4.76 kV	100-250	250
	100-250	350
8.25 kV	150-500	500
15 kV	150-500	500
	150-500	750
	150-500	1000
	750	750
	750	1000
	1000	1000
	1000	1500

Switchgear line-ups designated for new replacement breakers with increased MVA levels shall have the bracing verified by Eaton Electrical Services and Systems Division (EESS) to comply with the new maximum fault close and latch capabilities as well as the new breaker momentary ratings per ANSI C37.09.4.6.2.4 and ANSI C37.20.2.5.2.4. The converter shall supply the cost to perform a study to determine the current bracing capabilities and provide mathematical documentation to support the findings. The converter shall state that the entire switchgear is sufficiently braced to handle the new ratings or supply the cost as a separate item to increase the bus bracing in all cubicles in each line-up to comply with the increased MVA ratings. Following the study and/or the bracing modifications, the converter shall affix a label to the switchgear structure stating the new nominal MVA rating, peak momentary current and the RMS rating of the switchgear/breaker combination, the converter's name and the re-certification date.

2.2 Cubicle Modifications

New replacement breakers categorized as “interchangeable replacements” in IEEE/ANSI C37.59-2007 shall require no cell modifications and shall be electrically and mechanically interchangeable with existing air-magnetic circuit breakers. New replacement breakers categorized as “non-interchangeable replacements” in IEEE/ANSI C37.59-2007 may require some cell modifications to upgrade to newer technologies and increased ratings. These designs shall not be interchangeable with existing air-magnetic circuit breakers and any modifications required to the cells to accommodate the new replacement breakers, shall be reversible, except for minor cutting of the existing structures. All “non-interchangeable replacements” shall require changes to the cell coding system or cell code plates to reject the original breakers.

Increased MVA ratings shall require a modification to the cubicle coding system to prevent the insertion of lower MVA rated breakers or the existing breakers into the cubicles intended for use with the new higher MVA class breakers.

3.0 Equipment List

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

<u>Qty</u>	<u>CAT. Type</u>	<u>kV</u>	<u>Amps</u>	<u>MVA</u>	<u>MOC</u>
x	XXXXXX	4.76	1200	xxx	Yes/No
x	XXXXXX	4.76	2000	xxx	Yes/No
x	XXXXXX	4.76	3000	xxx	Yes/No
x	XXXXXX	8.25	1200	500	Yes/No
x	XXXXXX	8.25	2000	500	Yes/No
x	XXXXXX	8.25	3000	500	Yes/No
x	XXXXXX	15	1200	xxxx	Yes/No
x	XXXXXX	15	2000	xxxx	Yes/No
x	XXXXXX	15	3000	xxxx	Yes/No

4.0 Applicable Standards

All medium voltage replacement circuit breakers shall be designed, manufactured and tested in accordance with the applicable sections of:

IEEE/ANSI C37.59-2007 (cell interface and testing criteria)
IEEE/ANSI C37.04-1979
IEEE/ANSI C37.06-1987
IEEE/ANSI C37.09-1979
IEEE/ANSI C37.20.2-1999
ANSI C37.55-1989
IEEE/ANSI C37.100-1992
IEEE STD 4-1978
ANSI/NFPA 70 (NEC)

5.0 Materials

All materials shall be new and unused. No parts from the original circuit breaker shall be reconditioned and reused in the new replacement breaker. The manufacturer of the vacuum replacement breaker shall also be the manufacturer of the vacuum interrupter and breaker operating mechanism.

6.0 CONVERTER/VENDOR QUALIFICATIONS

The supplier or manufacturer, hereafter designated as “converter”, must meet the following qualifications to be considered for the award of the contract. The converter shall have a minimum of twenty years experience in the manufacture of vacuum circuit breakers and switchgear.

- 6.1 Converter shall supply evidence of ANSI certification of the circuit breaker element and the completed assembly prior to delivery.
- 6.2 Converter shall have local switchgear service engineers within a 150-mile radius of the jobsite. The converter shall have a minimum of 30 years experience in the maintenance of medium voltage switchgear. Provide address and telephone number of the service office nearest to the jobsite with the bid proposal.
- 6.3 All converters are required to verify nameplate data, control wiring requirements and cell-to-breaker interface. If the converter requires a site visit, contact the department issuing the request for bid to coordinate.

7.0 BID EVALUATION

All bids will be evaluated on the following criteria. All items will carry equal weight.

- 7.1 Converter experience and references. Supply a list with the bid.
- 7.2 Converter shall have a minimum net worth of \$500 million ensuring financial stability.
- 7.3 Manufacturing Facilities - The converter's facility shall be dedicated to medium voltage conversion and replacement breaker manufacturing. The buyer reserves the right to send a representative to visit the converter's manufacturing facilities prior to the award of a contract. The buyer further reserves the right to send representatives to the converter's manufacturing facilities during the course of the project for inspection and witness testing.
- 7.4 Quality Assurance and Total Quality Process: The converter shall have in place a functional Total Quality Process plan. The plan shall be pursuant to 9001 compliance.
- 7.5 Technical Specification Compliance.
- 7.6 Compliance with ANSI production and design test requirements as stated in IEEE/ANSI C37.59-2007.
- 7.7 Compliance with requested delivery schedule. Provide the following schedules with the bid proposal:
 - Drawings for approval (include review time)
 - Final factory drawings
 - Equipment delivery
 - Final test reports
- 7.8 The bid shall include approval drawing preparation time and best delivery of the vacuum replacement breaker(s).
- 7.9 Total installed price.

8.0 Vacuum Element Features

The conversion shall utilize vacuum circuit breaker modules manufactured by Eaton. Acceptable conversion modules are the VCP-18WR, VCP-20WR, VCP-29WR, VCP-29WRSE, VCP-29WRC, VCP-29WRG, and VCP-29WRGC.

8.1 Common Pole Shaft

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.

8.2 Insulated drive links

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-hydroscopic 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.

8.3 Shock Absorber System

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 re-strike of the main contacts during the opening of the circuit breaker or during a spring discharge. The VCP-20WR and VCP-29WR (CGSE) 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 and shall be capable of being adjusted if replaced or during initial mechanism assembly. High interrupting/close-and-latch ratings may use a combination of both.

8.4 Manual Trip and Close

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.

8.5 Operations Counter

Each 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.

8.6 Spring Charged Indicator

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.

8.7 Auxiliary Contacts

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.

8.8 Vacuum Bottle Assembly

The vacuum bottle assembly shall be constructed from virgin materials and shall be manufactured by Eaton or engineer approved equal. The contacts shall 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 open petal spiral contacts to assist in the swirling of the arc during interruption.

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.

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.

The vacuum interrupter shall have a visual method of identifying contact wear without the use of gauges or other devices. In addition, a second separate wear/wipe indicator shall be incorporated into the breaker operating mechanism.

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.

8.9 Insulated Pole Assemblies

Pole assemblies shall be insulated from ground with non-hydroscopic insulating materials manufactured from glass-reinforced polyester, epoxy or cycloaliphatic epoxy.

8.10 Current Transfer System

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 on VCP-20WR, VCP-29WR and VCP-29WRSE elements and folded leaf copper shunts on the VCP-18WR. The stems shall have the adjoining conductors mechanically fused, swaged with the stem material. This junction shall form a solid current transfer. Neither a sliding nor a rolling current transfer system is allowed. The use of half-clamp current transfer systems to clamp the conductor to the stem is not allowed.

8.11 Trip Free Operation

The new circuit breaker operating 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 contact travel shall be restricted to 10% of the total travel and shall be in compliance with the requirements of IEEE/ANSI C37.06.

8.12 Mechanical Status Indicator

Each new vacuum replacement 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.

9.0 Replacement Breaker Assembly

9.1 Frame Materials and Plating

The frame shall be constructed from steel. A combination of bolting and welding to assemble the frames is acceptable. All frame designs shall be plated with a corrosive resistant finish and shall be constructed to place all non-conducting metal surfaces to ground potential.

9.2 Wheels and Casters for Transport

Replacement breakers shall be supplied with a functional replacement of the transport systems of the original design. The transport system shall conform to the requirements as listed below:

<u>Original Design</u>	<u>Replacement Breaker</u>
Fixed wheels and dolly	Fixed wheels and dolly
Fixed wheels and casters	Fixed wheels and casters

9.3 Hardware

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

9.4 Bushing and Interface Conductor Material

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. The conductors for all breakers larger than 1200A shall have a maximum current density of 1000A per square inch of cross sectional area for copper conductors as stated in Article of ANSI/NFPA 70.

If requested, all 2000 amp rated breakers shall be capable of being used interchangeably with 1200 amp rated breakers of the same voltage, MVA and manufacturer, provided the two continuous current ratings are dimensionally interchangeable. The converter shall supply removable primary conductor adapters that can be quickly and easily removed to convert the breaker between the two different continuous current ratings. Instructions shall also be provided to allow field modification of the cell coding system.

9.5 Insulation Systems

All bushings shall utilize molded cycloaliphatic epoxy or fluidized bed epoxy insulation systems. The line and load bushings shall be interchangeable. Phase barriers shall be designed to isolate individual phase conductors. Openings shall be minimized to reduce the possibility of ionized gas propagation between phases.

9.6 Corona Shields

All 8.25 kV and 15 kV class breakers shall be designed to limit the effects of corona when bushings are mounted on metal back planes. When corona shields are mounted integral to the bushings, they shall be permanently grounded via metallic mounting inserts. Bushings mounted on non-metallic back planes shall not have internal corona shields.

9.7 Primary Connections

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 three (3) seconds without melting, arcing or pitting the contact surface.

9.8 Ground Contacts

A plated, self-coupling, separable grounding contact shall be supplied to adequately ground the breaker frame to the cell ground bus. No ground wires shall be required to tie the frame components to ground.

9.9 Control Circuit Wiring

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. "Fast on" or plug-on terminal connections are not allowed. No solder connections shall be allowed. Up-front, easy access terminal blocks shall be provided for maintenance and troubleshooting. All coil and charging motor leads shall be brought to an intermediate terminal board. No splices shall be allowed.

9.10 Stored Energy Discharge

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 automatically discharge the stored energy while in the connected position.

9.11 Passive Interlocks

The mechanism 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, if used, at anytime the breaker is in the closed position.

9.12 Active Interlocks

Each breaker shall have an active interlock system. The system shall be designed to protect the operator in the event the passive interlock is defeated. The system shall trip the breaker at anytime attempts are made to insert or withdraw a closed circuit breaker. The system shall also hold the breaker in the "trip free" position at all time between the test and fully connected positions.

9.13 Locking Means

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.

9.14 Secondary Contact Block

Control wiring connections between stationary structure and the removable breaker shall be provided with automatic, self-coupling contacts. The secondary blocks shall be manufactured from high dielectric strength insulating material. The secondary contacts shall be drilled and tapped to accept standard 8-32 screws for ease of maintenance and wiring changes.

9.15 MOC Operator

All breakers shall be furnished with MOC operators unless specified. The MOC operator shall have sufficient power to operate the largest MOC switch or combination of switches in the switchgear line-up without affecting the breaker's ability to completely close and latch. The MOC driver shall be completely "de-coupled" from the main breaker-operating shaft and shall be powered by separate operating springs. The system shall be "SURE-CLOSE" as manufactured by Eaton. Direct drive MOC operators are not acceptable. Removal of the MOC switches and their operators from the cells is not allowed. Substituting other devices designed to replace mechanical operated contacts shall not be allowed.

9.16 Cell Coding System

The converter 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.

10.0 Design and Certification (Type) Testing

The vacuum breaker supplied shall have type tests performed on its base design. Extrapolation of test values based on individual components is unacceptable. The tests shall be performed on the complete assemblies. All type tests will be performed in the actual switchgear cell 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. **Non-compliance with these base type tests or the failure to produce evidence of such test shall result in the immediate disqualification of the converter without obligation to the buyer.**

- a) BIL - <60KV for 4.76KV applications, 95KV for 8.25 and 15KV applications as a minimum> crest with 1.2 sec x 50 sec x 50% wave shape per ANSI C37.09.4.5.4. The tests shall be conducted per IEEE STD 4-1979. This test shall be performed in a breaker cell or cell equivalent in an environmentally controlled "semi-clean room" area with controlled humidity levels. No adjustment shall be required for humidity. Corrections for barometric pressure and ambient temperature shall be applied to the test parameters. The breaker shall pass a total of 54 shots.
- b) 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 shall be installed in the switchgear cell 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.
- c) 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.

- d) Short-time current tests at K^*I current shall be performed to confirm the breakers I_t capability. The test shall be performed in a switchgear cell.
- e) Continuous rated current testing per ANSI C37.04-1979 without exceeding 65°C hotspot rise with a maximum ambient not to exceed 40°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.
- f) Low Frequency Withstand - <19kV RMS for 4.76kV applications, 36kV RMS for 8.25kV and 15kV applications> per ANSI 37.09, 4.5.3.1
- g) Interlock functional test per ANSI C37.20.2, 6.2.4
- h) All production tests as stated in ANSI C37.09-1979.5.
Timing values per pole shall be provided for the vacuum element in milliseconds.

11.0 Execution

- 11.1 The converter shall utilize his factory trained and certified field engineer to perform the installation of each breaker at the customer's site. The field engineer shall be familiar with vacuum replacement to the point that he/she can offer initial training to the owner's on-site operators and maintenance personnel.
- 11.2 The owner's maintenance personnel will provide the necessary switching and breaker operation to accommodate the requirements of the Vendor/Converter to perform the removal, and reinstallation of the breakers.
- 11.3 The converter shall provide training on the vacuum technology and new replacement breaker operation and maintenance.