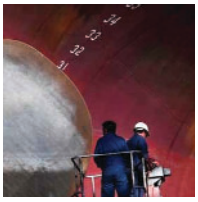
R-MAG

Vacuum Circuit Breaker with Magnetic Actuator Mechanism



R MAG

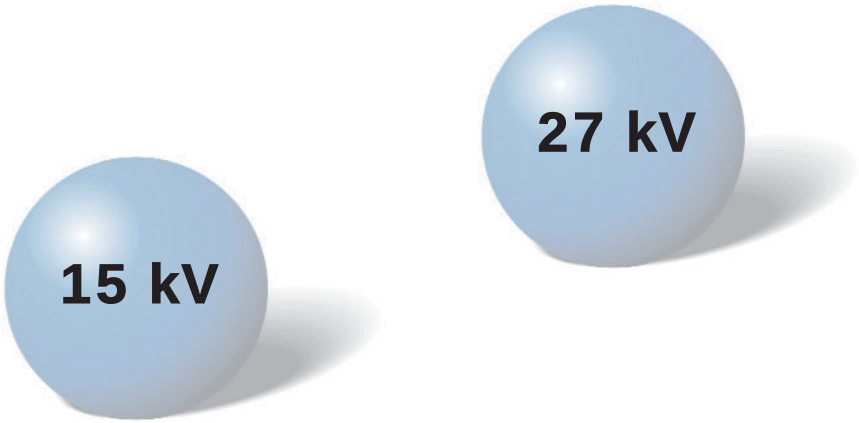
Features:

- **Low maintenance**
  - **10,000 mechanical operations (five times ANSI requirements)**
  - **2,000 operations between servicing (four times ANSI requirements)**
  - **Simple magnetic actuator**
  - **Vacuum interruption**
- **Capacitor switching**
- **Environmentally friendly with no gas or oil interrupting media**
- **No derating of interrupting capability regardless of reclosing cycle**
- **Reactor switching**

R-MAG circuit breakers have been fully tested to the most recent versions of ANSI C37.04, C37.06, C37.09 and IEC 62271.

Available for 15 and 27 kV applications, this next generation circuit breaker offers solutions for many applications.

Breaker Evolution - Matching optimum technologies



Although many refinements have been made throughout the 80 year history of the outdoor circuit breaker, there have only been three generations of circuit breaker design. Early circuit breaker mechanisms were spring charged with separate close and trip springs used for oil breakers. The second generation of breakers used this same mechanism, modified for vacuum interruption. The new R-MAG generation of circuit breakers uses a magnetic actuator mechanism with vacuum interrupters.

Each generation reflects the best technology available at the time of their introduction, building on the strengths of previous designs, while adding new innovations.

Although it is well established that vacuum interrupters are capable of more than 10,000 operations, conventional stored energy mechanisms seldom operate beyond 500 operations without maintenance, re-lubrication, or replacement of parts. The main disadvantage of stored energy mechanisms is the large number of precision moving parts required to perform spring charging, closing and tripping functions. Conventional stored energy breakers also place limitations on the types of control voltages allowed.

The R-MAG is truly the next generation in medium voltage vacuum circuit breaker technology. ABB is the first to combine the unique requirements of vacuum interrupter technology with a magnetic actuator designed to exploit these capabilities. Using a flux-shifting device with integral permanent magnets, the R-MAG mechanism has only one moving part. With simple open and close coils, an electronic controller and capacitors for energy storage, the R-MAG circuit breaker mechanism is capable of 10,000 operations. These are merely a few of the features that mark a departure from the conventional spring operated mechanism, introducing new capabilities and benefits for modern power systems.

R MAG

Summary of benefits:

- **Simple mechanical operation**
- **Fewer than 10 moving parts**
- **Manual opening capability**
- **High reliability**

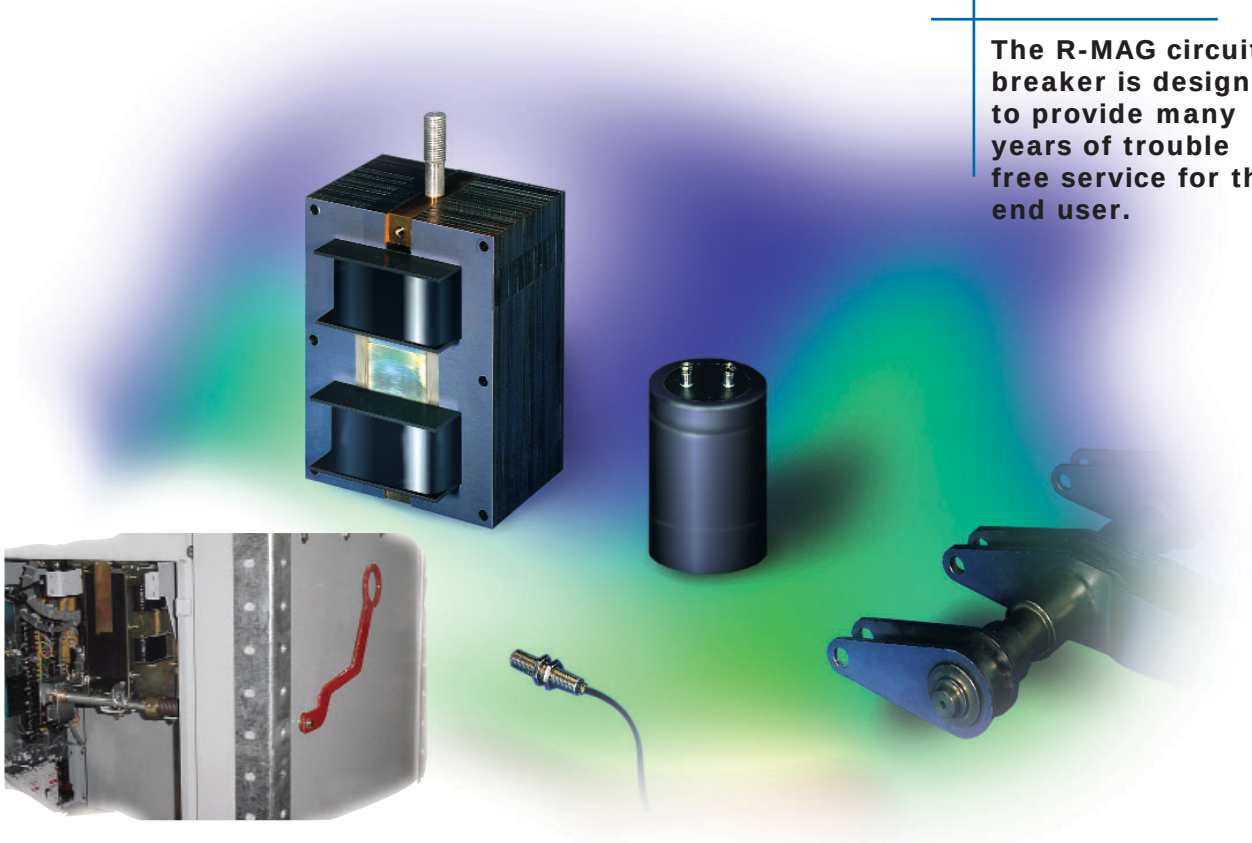
The magnetic actuator, electronic controller and capacitors are the key components for this next generation product. The magnetic actuator has a magnetic frame assembly, two identical operating coils, two rare earth magnets and a single moving armature. Instead of mechanical assemblies for armature position sensing, proximity sensors detect armature position for the electronic controller. These permanent magnets will retain 99% of their flux density for more than 100 years.

Capacitors, used as stored energy devices, drive the actuators, minimizing the inrush current from the source. These special capacitors charge in as little as seven seconds after control power is available, and are "trickle charged" by the electronic controller as needed. Covers over the capacitor terminals prevent accidental contact.

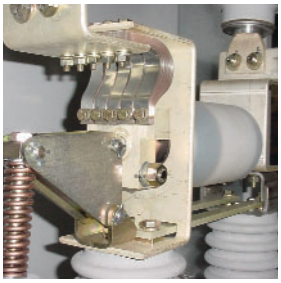
The magnetic actuator and control components are mounted in the low voltage compartment. All components at line potential are contained in the high voltage section and are completely isolated from the control compartment. Insulating entrance bushings are attached to the roof assembly by bolt and compression type clamps. Removal or replacement does not disturb the existing breaker adjustments. Bushing current transformers mount on the entrance and/or exit bushings. The accuracy class required determines the number of current transformers that may be mounted.

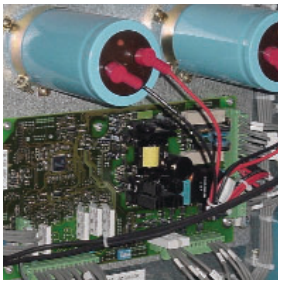
All Type R-MAG Actuators circuit breakers use flexible shunt connectors.

The R-MAG circuit breaker is designed to provide many years of trouble free service for the end user.



R-MAG. Circuit-breaker of the high tech generation.





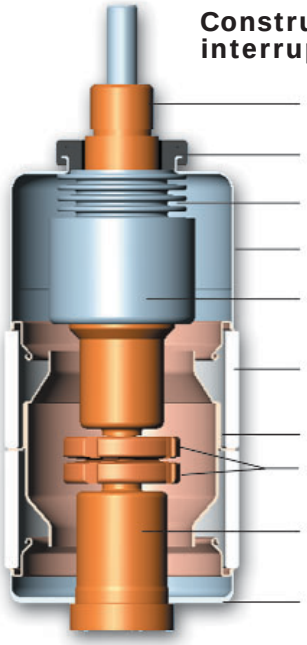
Mechanism window with easy to read position indicator and non-re-settable operation counter.

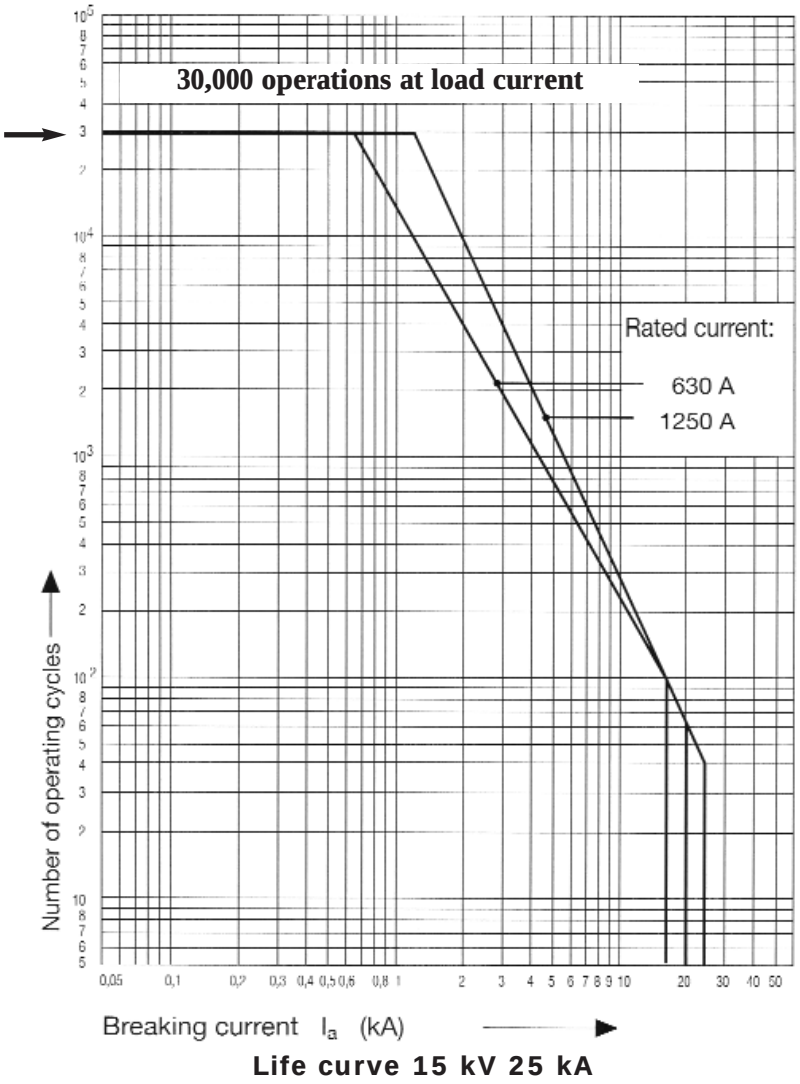
Vacuum Interrupter
The conduction and interruption of short-circuit currents places great demands on vacuum interrupters. The robust construction of the ABB vacuum interrupters ensures fault-free and maintenance-free operation for decades.

Control Wiring
Auxiliary control relays and the electronic control module are mounted on panels located in the low voltage compartment. Fused switches protect control circuits. All bushing current transformer connections are brought down into the low voltage compartment and wired to shorting type terminal blocks.

Electronic Controller
The electronic controller uses robust components and a conformal coating to prolong the life of the device. The electronic controller will operate on AC or DC control power because it internally utilizes an AC to DC converter. Instead of selecting from a long list of control power options, the user only needs to select a controller for the low voltage range control power (20.4-52.8 VAC or 16.8-75 VDC) or a controller for the high voltage range control power (85-264 VAC or 77-280 VDC). Inside these ranges, the user may apply any value of direct current, or any value of 50 or 60 cycle alternating current to achieve circuit breaker operation. The electronic controller incorporates all capacitor charging, open/close coil switching, anti-pumping, interlocking and armature position details. Programmed self-monitoring functions monitor proximity sensors, coil continuity, capacitor voltage, the microprocessor and other key functions. Radio frequency and transient testing have been performed on the electronic controller to ensure it is resistant to abnormal conditions. Only six watts of energy is needed to maintain controller functions and capacitor full charge. There is an optional 33 watt setting, however it extends the charging time which is suitable for smaller batteries or power sources. For normal operation, the minimum requirement of the auxiliary power supply is 93 watts. Contact ABB for details.

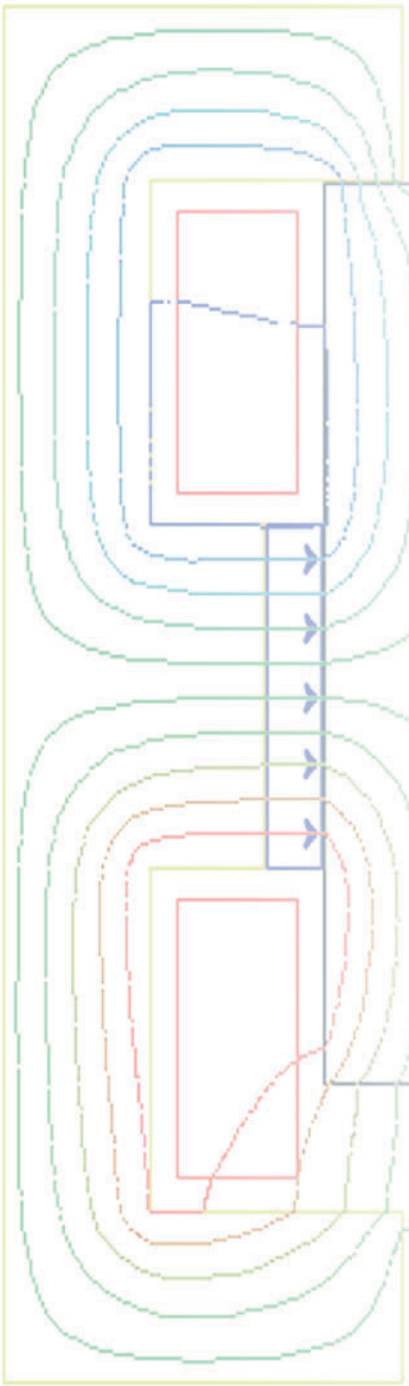
Construction of a vacuum interrupter





Life curve 15 kV 25 kA

R-MAG. Low maintenance permanent magnet technology.



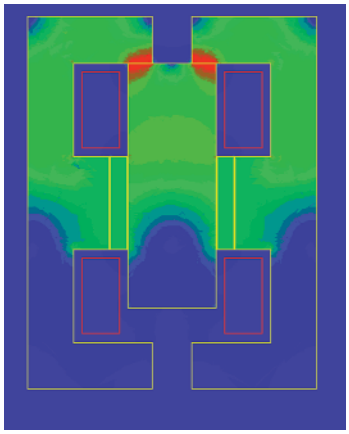
Following the advance of vacuum interruption in the field of medium voltage circuit breakers in the last 20 years, a natural amalgamation of technology has been achieved with the addition of magnetic actuator technology. The requirements of one technology optimally match the opportunities of the other. Magnetic actuator technology naturally provides the suitable travel-time and force-travel characteristics for the vacuum switching devices.

All operating mechanism functions are integrated in the magnetic actuator of the R-MAG circuit breaker. The actuator is a bi-stable magnet system, in which armature change-of-state is accomplished by the magnetic field of two electrically excited coils. The armature is held magnetically in the limit positions by the fields of two rare-earth permanent magnets. Switching operations are achieved by excitation of one of the two coils until the retaining force of the permanent magnets is exceeded.

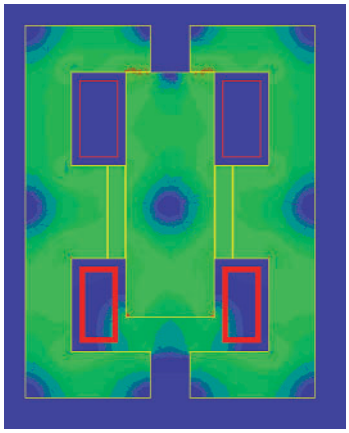
Even after complete failure of the auxiliary power, the energy stored in the capacitors will allow electrical operation for 200 seconds. In the event of complete loss of control power, the circuit breaker can be tripped manually.

The armature of the magnetic actuator is linked to an operating shaft connected via insulated push rods to each of the vacuum interrupters. The only points of lubrication for this mechanism are at the union of the armature to the operating shaft, the pivot points of the operating shaft and the pivot points of the operating shaft to the push rods. Long life synthetic lubricants are applied during assembly to further reduce the need for lubrication during the life of the circuit breaker.

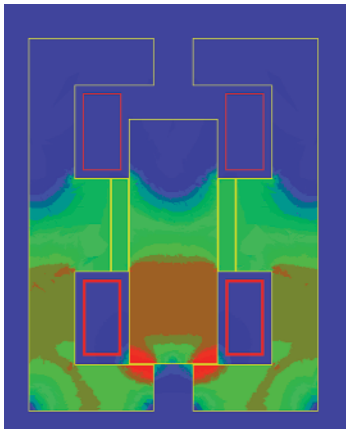
Instantaneous representation of magnetic flux density distribution



Magnetic latching in a limit position



Magnetic latching plus current build up in one coil



Armature reaching the opposite limit position

R-MAG. Technical data.

Voltage Class (kV)	15 kV	15kV	15 kV	15 kV	15 kV	15 kV	15 kV	15 kV	15 kV	15 kV	15 kV	15 kV	27 kV	27 kV	27 kV	27 kV	27 kV	27 kV
Continuous Current A	800	800	800	1200	1200	1200	2000	2000	2000	3000	3000	3000	1200	1200	1200	2000	2000	2000
Rated Maximum Voltage (kV)	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	27	27	27	27	27	27
Voltage Range Factor K***	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Frequency (Hz)	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60	50/60
Low Frequency Withstand																		
Dry 60 Hz for 1 Min	50	50	50	50	50	50	50	50	50	50	50	50	60	60	60	60	60	60
Wet 60 Hz for 10 Sec	45	45	45	45	45	45	45	45	45	45	45	45	50	50	50	50	50	50
Full Wave Withstand (BIL)	110	110	110	110	110	110	110	110	110	110	110	110	125/150	125/150	125/150	125/150	125/150	125/150
Operating Duty (Standard Duty Cycle)	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
Interrupting Time (Cycles)	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5	<= 3.5
Permissible Tripping Delay Y (Sec)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Closing Time (Cycles)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Reclosing Time (Sec)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Short Circuit Interrupting Current (at Contact Pan)																		
kA, RMS, Sym	12.5	20	25	12.5	20	25	12.5	20	25	12.5	20	25	12.5	20	25	12.5	20	25
kA, RMS, Asym	14.4	23.1	29	14.4	23.1	29	14.4	23.1	29	14.4	23.1	29	15	24	29	15	24	29
Close & Latch (Initial Current Loop) kA, RMS, Asym	19.4	32	40	19.4	32	40	19.4	32	40	19.4	32	40	19.4	32	40	19.4	32	40
Close & Latch (kA Peak)	32.5	52	65	32.5	52	65	32.5	52	65	32.5	52	65	32.5	52	65	32.5	52	65
Short Time Current (3 Sec) kA, RMS, Sym	12.5	20	25	12.5	20	25	12.5	20	25	12.5	20	25	12.5	20	25	12.5	20	25
Transient Recovery Voltage (kV Peak)	29	29	29	29	29	29	29	29	29	29	29	29	51	51	51	51	51	51
Load Current Switching Capability (A)	1200	1200	1200	1200	1200	1200	2000	2000	2000	3000	3000	3000	1200	1200	1200	1200	1200	1200
Wire Line Charging Current	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Isolated Cable Charging Current (A)	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Isolated Capacitor Bank Switching Current (A RMS)	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Back-to-Back Shunt Capacitor Bank Switching Current (A RMS)	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Transient Overvoltage Factor	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**	3.0* 2.5**
Transient Inrush Current (kA Peak) Back-to-Back	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Transient Inrush Frequency (Hz) Back-to-Back	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240	4240
Grounding of System and Capacitor Bank System	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Capacitor Bank	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Contact Resistance (micro ohms)	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
Mechanical Life (No Load Operations)***	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000

a O-0.3 sec-CO-3 min-CO - meets old standard O-0.3 sec-CO-15 sec-CO
b Grounded or Ungrounded

** general purpose*
*** definite purpose*
**** Interrupter life good for 30,000 operations when interrupting loads are less than 1 kA. For interrupting loads greater than 1 kA, consult interrupter life curves that are available upon request.*

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