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DESCRIPTIVE BULLETIN

R-MAG[®] magnetically actuated dead tank outdoor vacuum circuit breaker

15.5 kV–38 kV



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**R-MAG[®] magnetically actuated
dead tank outdoor vacuum
circuit breaker**
15.5 kV–38 kV

ABB recognizes the industry's focus on safety and reliability and helps meet these goals with the R-MAG[®] outdoor vacuum circuit breaker for medium voltage primary substations.

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Introduction

The R-MAG® outdoor circuit breaker is truly the next generation in medium voltage vacuum circuit breaker technology. ABB is the first to combine the unique benefits 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 circuit breaker 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 load operations. These are a few of the features that mark a departure from the conventional spring-operated mechanism, introducing new capabilities and benefits for a smarter distribution system.

ABB makes safety our first priority by employing magnetic actuators to eliminate maintenance on coils, motors and mechanically charged springs.

R-MAG circuit breaker benefits

- Simple, less frequent maintenance
 - Rated for 10,000 full load operations (five times ANSI requirements)
 - No maintenance required on magnetic actuator
 - Plug-and-play actuator circuitry
 - Vacuum interrupters rated for 30,000 full load operations
- Increased reliability
 - Magnetic actuator has only one moving part
 - No spring-charging motors to replace
 - No trip/close coils to replace
 - Fewer moving parts result in less maintenance

Increased performance

- 2,000 operations between servicing vs 500 operations between servicing — ANSI C37.06 requirements
- 10,000 mechanical or load operations vs 2,000 no-load mechanical operations — ANSI C37.06 requirements
- No maintenance required on magnetic actuator
- Eliminates open/close coils in stored spring mechanism lubrication requirements

The R-MAG circuit breaker has three main components

- Vacuum interrupter assembly
- Operating mechanism
 - Provides reliable operation even after extended periods of inactivity
- Electronic control board
 - Compatible with all forms of overcurrent, reclosing and control functions



Vacuum interrupters

Manufacturing vacuum interrupters since 1980, ABB is a worldwide leader in vacuum interrupter technology.

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01 Vacuum interrupter family

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02 For more than 25 years, ABB has developed and manufactured vacuum interrupters for medium voltage applications

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03 Construction of a vacuum interrupter

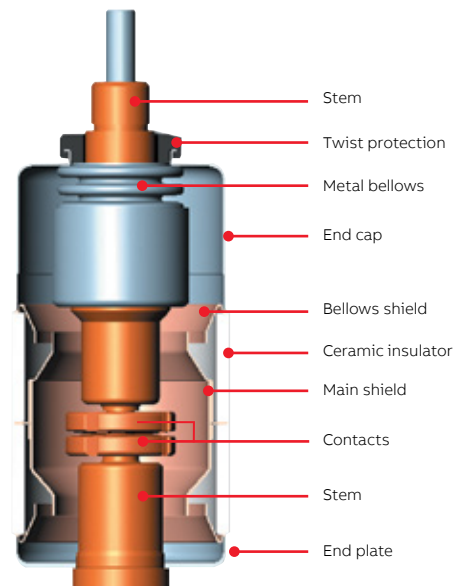
- Rated for 30,000 mechanical or load operations
- Up to 40 operations at maximum interrupting rating
- One of the largest vacuum interrupter producers in the world
- Environmentally friendly and maintenance-free for life
- ABB vacuum interrupters are used in many products globally



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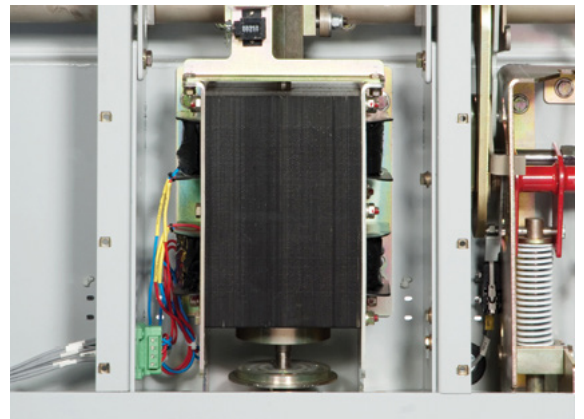
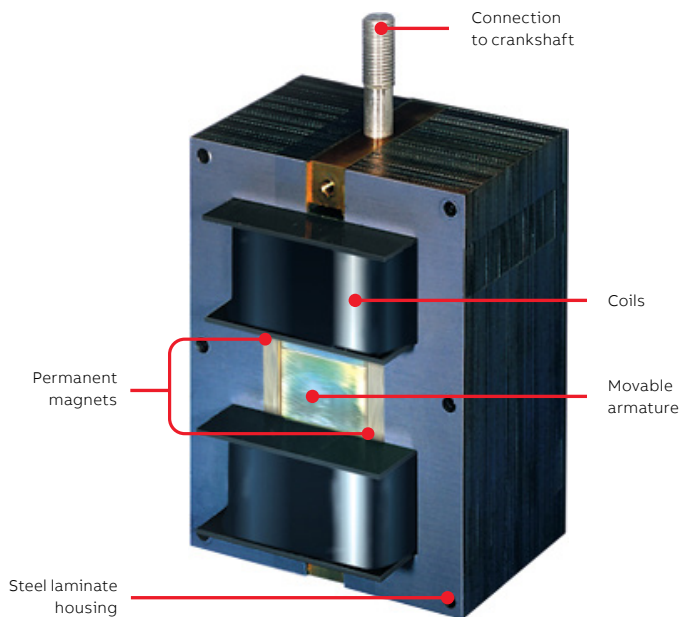
Magnetic actuator

ABB has used magnetic actuators since 1997. One global team is dedicated to designing magnetic actuators for ABB products, including R-MAG® circuit breakers.

- 15 kV rated at 100,000 mechanical operations
- 38 kV rated at 50,000 mechanical operations
- One moving part
- No maintenance required

Magnet life expectancy

Developments in magnetic material technology allow the magnetic actuator to be highly reliable over a long lifetime. Reduction in magnetic flux density is less than 1% over 100 years at 248 °F (120 °C).



A magnetic actuator has only one moving part and requires no maintenance.

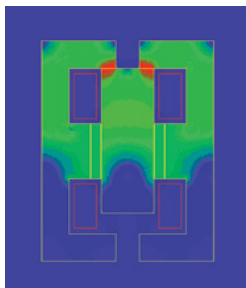
Magnetic actuator operation

All operating mechanism functions are integrated in the magnetic actuator of the R-MAG® circuit breaker. The actuator is a bistable 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 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.

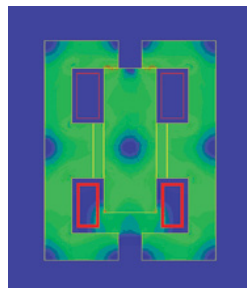
The armature of the magnetic actuator is linked to an operating shaft connected via insulated push rods to each of the vacuum interrupters.



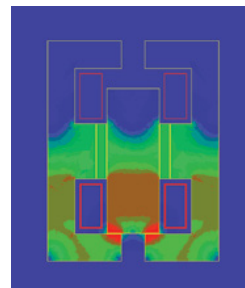
- 05 Magnetic latching in a closed position
- 06 Magnetic latching plus current build-up in one coil
- 07 Armature reaching the open position
- 08 Final open position



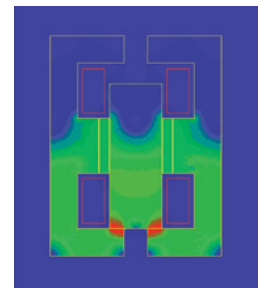
05



06



07



08

Magnetic flux density distribution representation during a magnetic actuator opening operation.

Electronic control board

Low-power consumption electronic control board, with flexible voltage range and alarms, controls the magnetic actuator of the R-MAG® circuit breaker.

Advantages of electronic controls

- Flexibility of control voltages
- Consistency of operation using capacitor energy
- Built-in trip and close coil features
- Built-in circuit breaker status indication
- Coil protection
- Ready and not-ready alarms

Flexibility of control voltages

- Two control boards cover all control power requirements:
 - Low voltage: 17–75 V DC or 21–52 V AC
 - High voltage: 77–280 V DC or 85–264 V AC
- Control board is independent of AC or DC
 - 1 control board covers 120 V AC, 125 V DC, 240 V AC application
 - Ability to test a 125 V DC circuit breaker with 120 V AC
- Low power requirements — 93 watts normal (41 watt power optional)
 - Less than 1 A at 125 V DC during capacitor charging (7 seconds)
- Plug-and-play removal and installation of control board assembly
 - Easy board conversion between low and high control power requirements
 - Eliminates changing of trip and close coils and motors
 - Increases safety
- Wide range of input voltages
 - Minimizes damage from voltage spikes or higher charging voltages

Consistency of operation using capacitor energy

- Smaller battery system — can be minimal since there is no high instantaneous load on charging, closing or tripping
- Voltage drop is not an issue when running control power from battery system (smaller wiring can be used)
- Operate multiple circuit breakers simultaneously
 - Sufficient energy to operate multiple circuit breakers from station batteries simultaneously
- Constant energy source
 - Energy for closing and tripping is constant (regardless of station battery voltage), thus closing and opening speed are consistent

Using capacitors for stored energy

- 0.1 farad electrolytic capacitors are designed to be operated in a temperature range of -40 °F to 185 °F (-40 °C to 85 °C)
 - Extreme temperature option also available: -67 °F to 221 °F (-55 °C to 105 °C)
- Recommended capacitor replacement
 - 20 years for an average yearly temperature in the outdoor circuit breaker enclosure of less than 122 °F (50 °C)
 - 15 years for tropical climates

Built-in circuit breaker status indication

Unit-ready and not-ready output contacts provide an alarm under the following conditions:

- Drop off auxiliary supply voltage
- Low voltage on capacitor

09 R-MAG® circuit breaker control board assembly

10 Built-in circuit breaker status indicator



Additional features

Extensively customizable control panel

- Every R-MAG® circuit breaker is equipped with a control panel in which many control elements can be installed (relays, control switches, test switches, lights, Ethernet switches, UPS, etc.)

Extra-creepage bushings

- Regular bushings and extra-creepage bushings available upon request

High flexibility to host current transformers

- ABB produces its own current transformers, allowing for a wide range of current transformer types: protection/metering, IEEE/IEC, special burdens/accuracy
- Some R-MAG circuit breaker units can host up to 3 current transformers

High seismic and extreme wind load configurations available

- High seismic configuration as per IEEE 693
- Up to 200 mph of wind load as per ASCE 7-16

Manual trip lever electronically interlocked

- Allows manual trip and prevents closing in close block position (69 function)
- When manually tripped closing is electrically blocked

Summary of R-MAG circuit breaker advantages

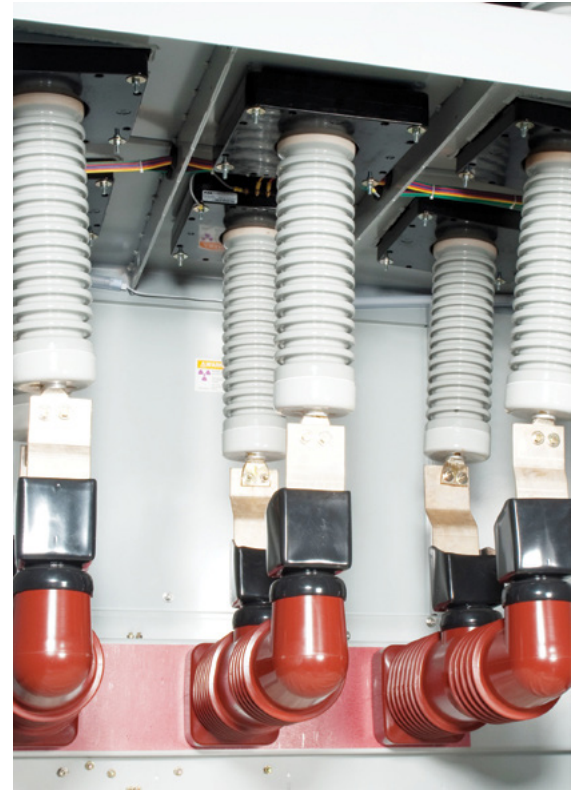
- ABB vacuum interrupters
 - World's largest manufacturer of vacuum interrupters
 - Rated for 30,000 mechanical or load operations
- ABB magnetic actuator
 - Eliminates all maintenance on operating mechanism
 - World's leader in magnetic actuation technology
- ABB electronic controller
 - Plug-and-play removal and installation
 - Independent of AC or DC power
- 5-year full warranty

— 11 Manual emergency trip

— 12 Embedded poles



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NEMA 4 housing

Most robust ever R-MAG® circuit breaker is prepared to perform reliably in the most extreme weather conditions.

The recently released NEMA 4 version is available for all R-MAG circuit breaker ratings and complies with the NEMA 250-2018 standard.

This new NEMA 4 version introduces a set of dedicated special improvements, as compared to NEMA 3R, in some key elements of the housing to withstand the most challenging outdoor environments.

The new NEMA 4 housing is ready to withstand sleet, snow, heavy rain, storms and wind-driven rain impacting the housing at rates of more than 60 gal./min. from any direction.

13 R-MAG circuit breaker
NEMA 4 version



Arc-resistant housing

Safety is not a cost — it's investment.

The arc-resistant version of the R-MAG® circuit breaker has been tested to internal arc resistance as per IEEE C37.20.7-2017, Type 2B accessibility. The arc-resistant feature provides an additional level of protection to equipment and personnel in the proximity of the arc-resistant R-MAG circuit breaker.

Arc-resistant protection is provided by special segregation between the compartments and the addition of two exhaust chimneys in each side of the HV compartment.

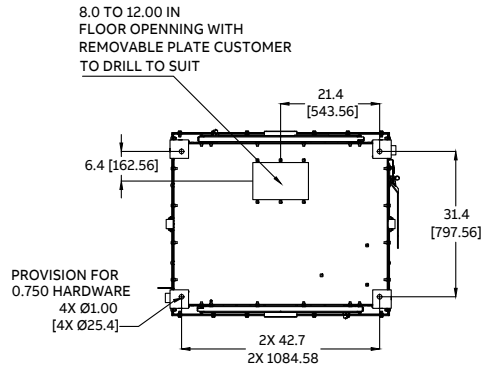
The specially designed enclosure withstands the mechanical and thermal stress of an arc fault, and, in the event of an internal arc fault, the exhaust chimney vents open to release the gases in a controlled manner.

14 R-MAG circuit breaker
arc-resistant housing

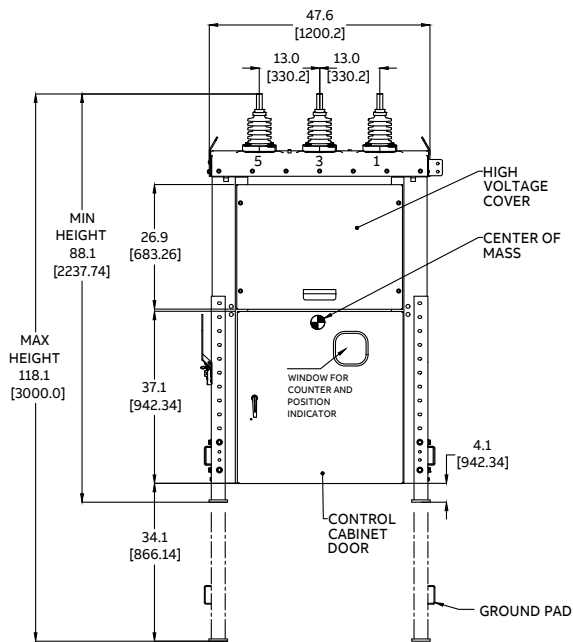
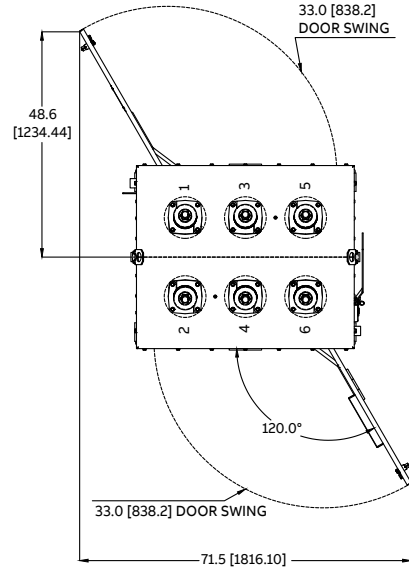


Outline drawings

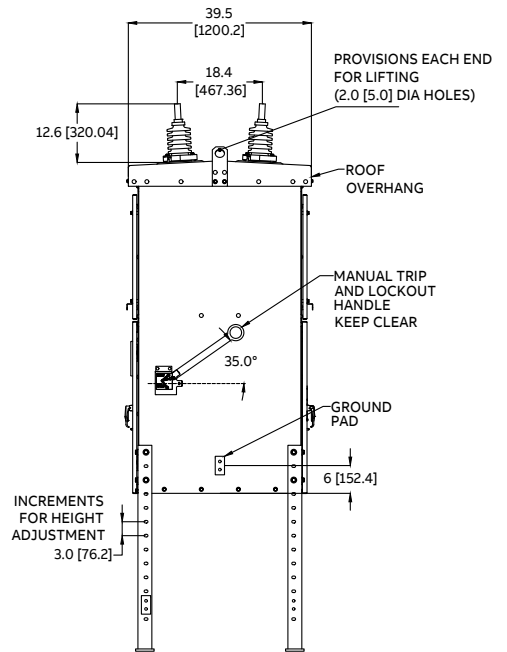
15 R-MAG® circuit breaker
15 kV 1200 A



FOUNDATION PLAN

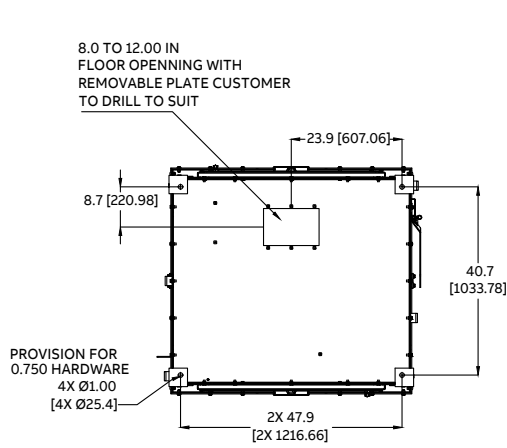


REAR VIEW

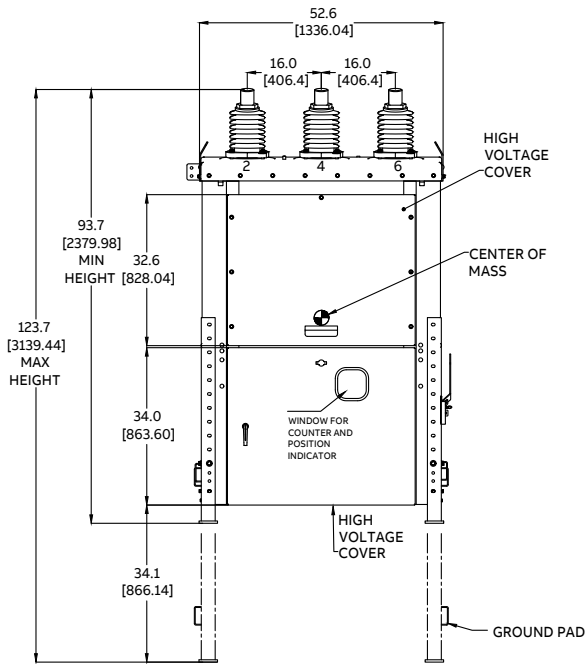
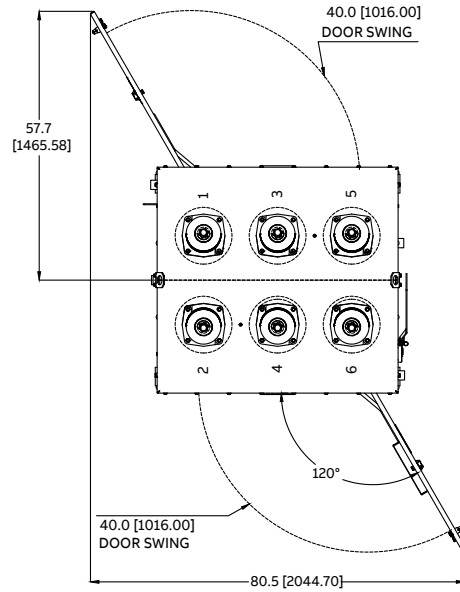


SIDE VIEW

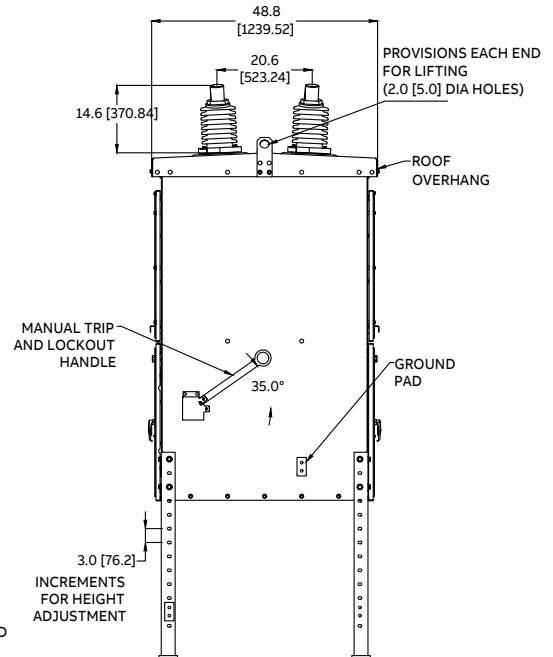
16 R-MAG® circuit breaker
15 kV 2000 A



FOUNDATION PLAN



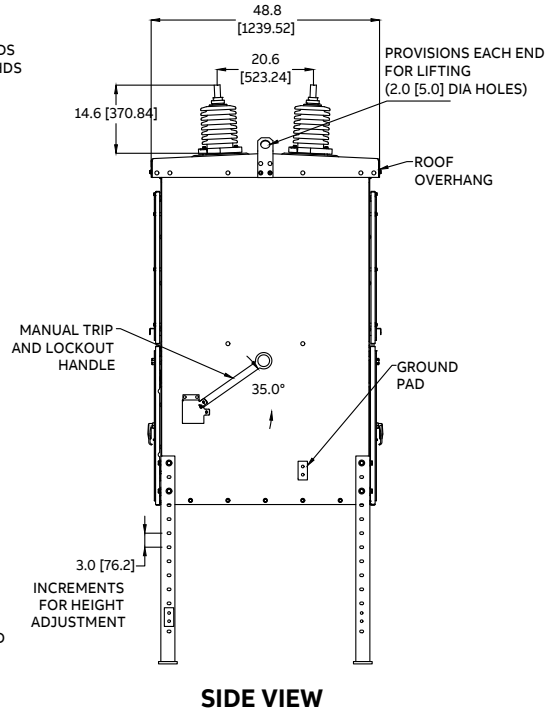
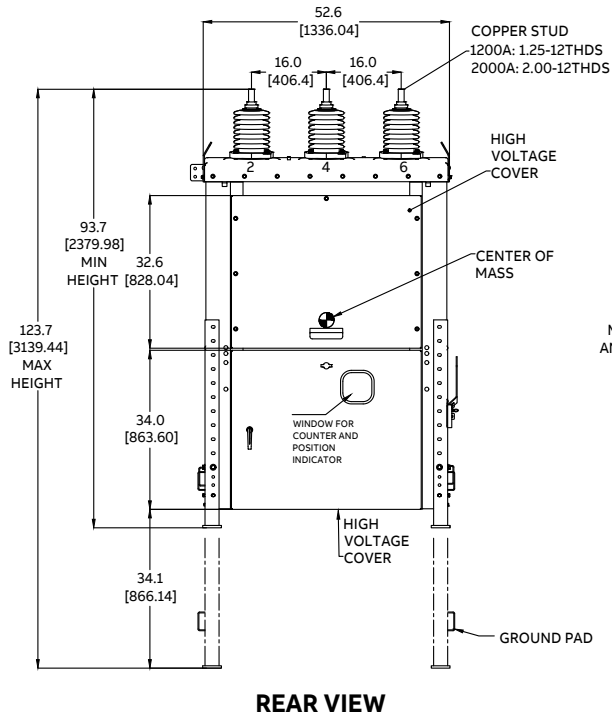
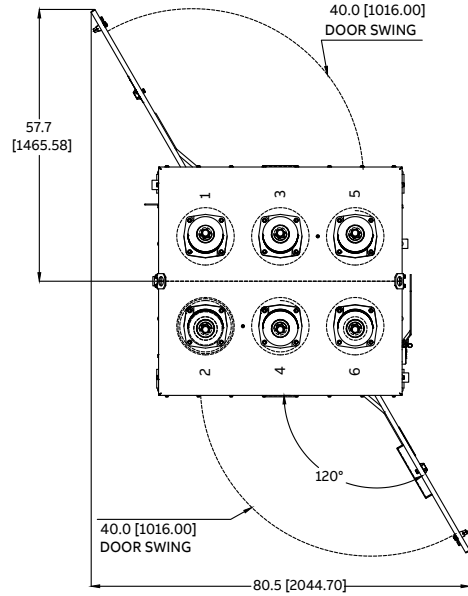
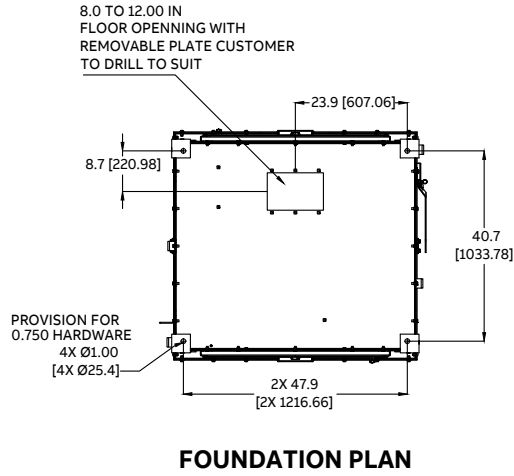
REAR VIEW



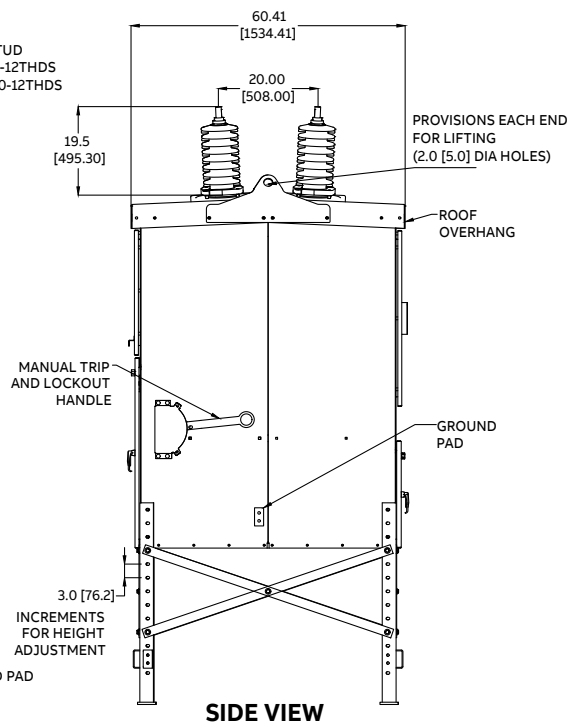
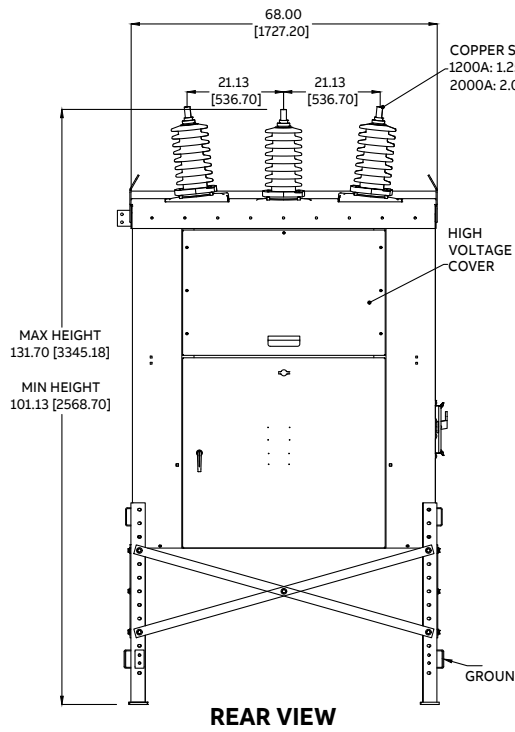
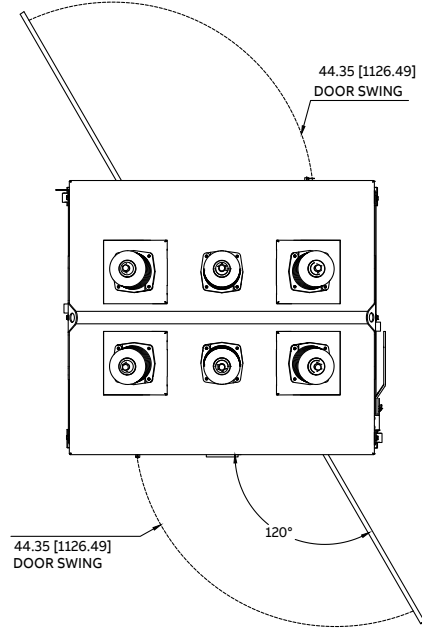
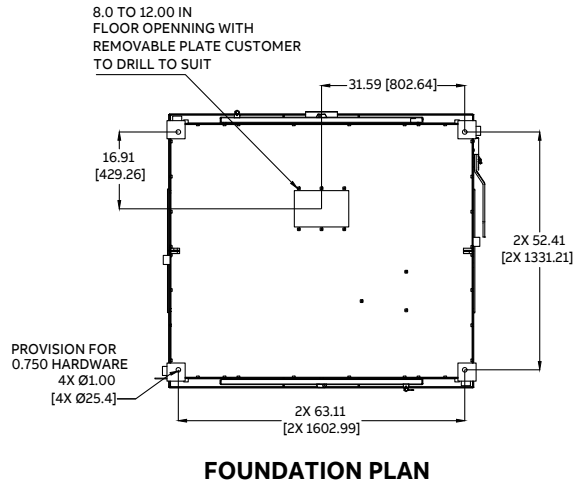
SIDE VIEW

Outline drawings

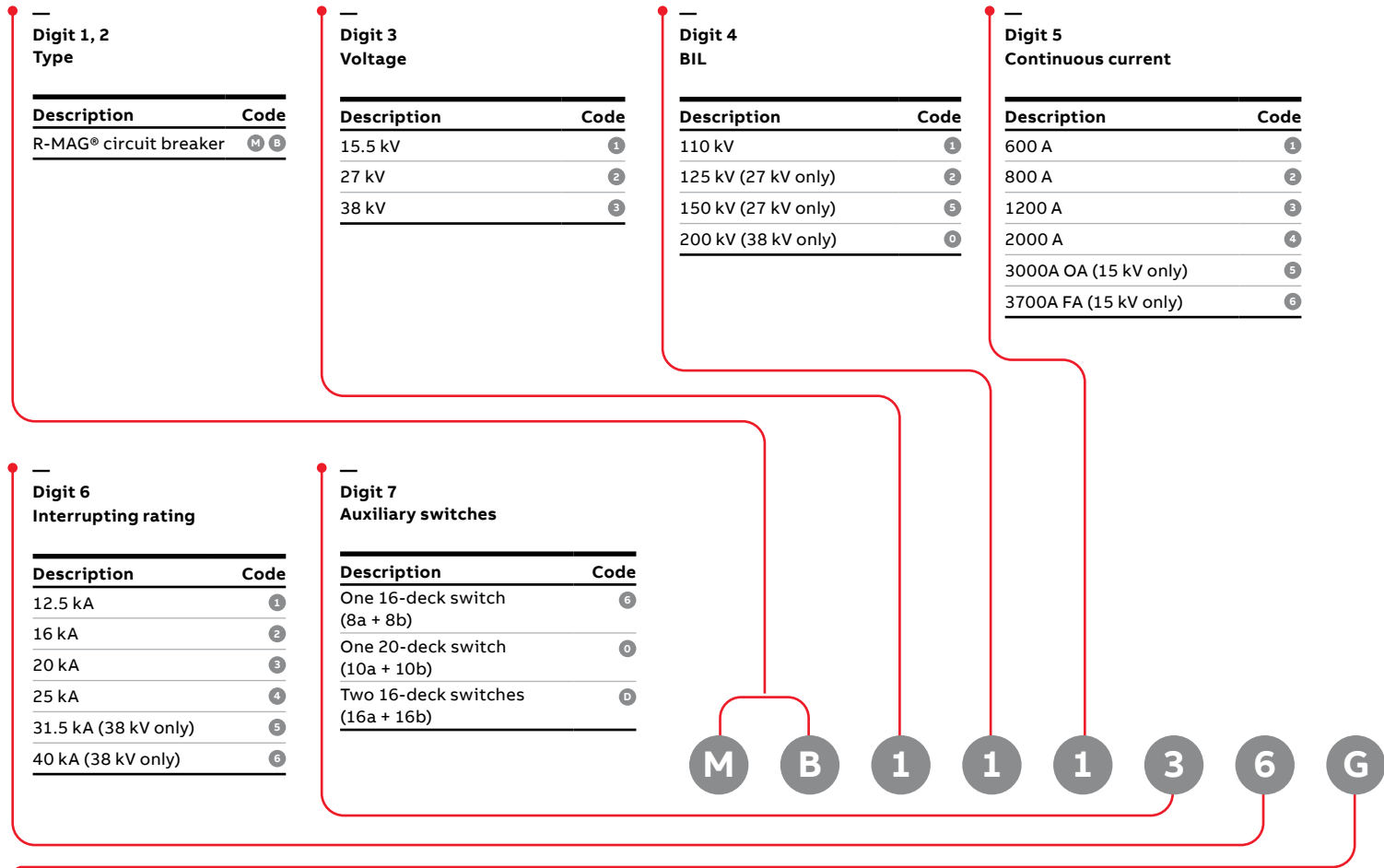
17 R-MAG® circuit breaker
27 kV 1200 A/2000 A



18 R-MAG® circuit breaker
38 kV 1200 A/2000 A



Selection guide



Digit 8 Current transformers 1-3-5 (also available in CSA and 50 Hz ratings)

Ratio	Accuracy	Thermal rating factor	1 set	2 sets
600/5	C100	TR 1.33	A	B
1200/5	C200	TR 2.00	C	D
1200/5	C200	TR 1.33	E	F
1200/5	C400	TR 1.33	G	H
1200/5	C200	TR 2.00	-	I
1200/5	C400	-	-	-
2000/5	C400	TR 1.33	J	K
1200/5	C400	TR 2.00	L	M
1200/5	C400	TR 2.00	-	O
2000/5	-	-	-	-
3000/5	C400	TR 1.33	P	Q
1200/5	C400	TR 1.50	R	S
2000/5	C400	TR 2.00	T	U
2000/5	C800	TR 2.00	V	W
600/5	C200	TR 2.00	X	-
600/5	C400	TR 2.00	Y	-
SPECIAL	-	-	Z	-
NONE	-	-	N	-

Digit 9
Current transformers 2-4-6

Ratio	Accuracy	Thermal rating factor	1 set	2 sets
600/5	C100	TR 1.33	A	B
1200/5	C200	TR 2.00	C	D
1200/5	C200	TR 1.33	E	F
1200/5	C400	TR 1.33	G	H
1200/5	C200	TR 2.00	-	I
1200/5	C400			
2000/5	C400	TR 1.33	J	K
1200/5	C400	TR 2.00	L	M
1200/5	C400			
2000/5	C400	TR 2.00	-	O
3000/5	C400	TR 1.33	P	Q
1200/5	C400	TR 1.50	R	S
2000/5	C400	TR 2.00	T	U
2000/5	C800	TR 2.00	V	W
600/5	C200	TR 2.00	X	-
600/5	C400	TR 2.00	Y	-
SPECIAL			Z	
NONE			N	

Digit 10
R-MAG® circuit breaker enclosure

Description	Code
Mild steel	N
Stainless steel	T
Mild steel + arc resistant	A
Stainless steel + arc resistant	B
Mild steel + NEMA 4	C
Stainless steel + NEMA 4	D

Digit 11
Control voltage, R-MAG circuit breaker actuator control

Description	Code
Low voltage actuator controller (20.4–52.8 V AC or 16.8–75 V DC)	L
High voltage actuator controller (85–264 V AC or 77–280 V DC)	H

Digit 12
Auxiliary power

Description	Code
120 V AC (must use high voltage actuator controller)	1
240 V AC (must use high voltage actuator controller)	2
48 V DC (must use low voltage actuator controller)	4
125 V DC (must use high voltage actuator controller)	5

Digit 13
Circuit protection

Description	Code
Molded case circuit breaker (MCB)	A
Knife switch	K
Pull-out fuse block	P
Standard (MCB for HTR and AUX, knife SW for control)	S
Special	Z

Digit 14
Control

Description	Code
Basic (no relay on circuit breaker)	B
Microprocessor	M

Digit 15
Panel configuration

Description	Code
Standard control switch, open/close indicating lights and local/remote toggle switch	L
Panel with standard control switch and open/close indicating lights	S
Special	Z
No panel	N

Digit 16
Bushing terminal

Description	Code
Clamp	C
4-hole NEMA pad	4
Threaded stud only	S
Special terminal	Z



Note: Not all combinations of options are available for all ratings. Please consult your ABB sales representative for more information.



Technical data

Rated maximum voltage	Units					R-MAG® circuit breaker		
	kV	15.5	15.5	15.5	27	27	38	38
			800/1250	800/1250/2000/		1250/	1250/	1250/
Continuous current	A	800/1250	2000	3000 ⁽¹⁾ /3700 ⁽²⁾	1250	2000	2000	2000
Operating temperature		-50 °C and 70 °C per IEC 62271-1003						
Voltage range factor K	1	1	1	1	1	1	1	1
Short circuit interrupting current (at contact part) kA, RMS, Sym	kA	12.5	20	25	12.5	25	31.5	40
Frequency	Hz	50/60	50/60	50/60	50/60	50/60	50/60	50/60
Power frequency withstand dry 60 Hz for 1 min	kV	50	50	50	60	60	80	80
Power frequency withstand wet 60 Hz for 10 sec	kV	45	45	45	50	50	75	75
Lightning impulse withstand (BIL)	kV	110	110	110	125/150	125/150	200	200
Operating duty (standard duty cycle)	cycles	Exceeds ANSI standard O-0.3 sec-CO-3 min-CO						
Maximum interrupting time	cycles	3	3	3	3	3	3	3.5
Permissible tripping delay Y	sec	2	2	2	2	2	2	2
Closing time	cycles	6	6	6	6	6	6	6
Reclosing time	sec	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Short circuit interrupting current (at contact part) (kA RMS sym.)	kA	12.5	20	25	12.5	25	31.5	40
Close and latch (initial current loop) (kA RMS asym.)	kA	20	32	40	20	40	50.4	-
Close and latch (kA peak)	kA	32.5	52	65	32.5	65	81.9	104
Short time current (3 sec) (kA RMS sym.)	kA	12.5	20	25	12.5	25	31.5	40
Rated duration of short-circuit @ short-time current	sec	3	3	3	3	3	2	2
Transient recovery voltage (kV peak)	kV	29	29	29	51	51	71.7	71.7
Load current switching capability	A	600/800	600/800/	600/800/1250/		1250/	1250/	1250/
		1250	1250/2000	2000/3000	1250	2000	2000	2000
Wire line charging current	A	100	100	100	100	100	100	100
Isolated cable charging current	A	600	600	600	400	400	600	100
Isolated capacitor bank switching current (A RMS)	A	600	600	600	600	600	600	600
Back-to-back shunt capacitor bank switching current (A RMS)	A	600	600	600	600	600	600	600
Transient overvoltage factor						C1*	C1*	-
Transient inrush current (kA peak) back-to-back	kA	20	20	20	20	20	20	-
Transient inrush frequency (Hz) back-to-back	Hz	4240	4240	4240	4240	4240	4240	-
Mechanical endurance		10000	10000	10000		10000	10000	10000
Internal arc resistant		IEEE C37.20.7, Type 2B, 0.5s						
Ingress protection		NEMA 4 as per NEMA 250-2018						

Note: Please find specific R-MAG circuit breaker vacuum bottle curves on the product instruction book.

(1) up to 3000 A standard circuit breaker

(2) 3700 A forced air cooled circuit breaker

(3) above 40 °C circuit breaker derated per ANSI C37.010

(*) Per C37.09a restrike category

Options



Flexitest™ test switches

As the original FT switch with the longest, most successful history, ABB's Flexitest switch sets the benchmark for unmatched quality in the industry. With more than 60 years of experience, ABB is the test switch manufacturer with the largest installed base in North America. ABB's Flexitest switch offers the highest quality and is the original FT — there is no equivalent.



Relion® 615 series relays

The Relion® relay product family offers the widest range of products for the protection, control, measurement and supervision of power systems. To ensure interoperable and future-proof solutions, Relion relays are designed to implement the core values of the IEC 61850 standard. Benefit from ABB's leading-edge technology, global application knowledge and experienced support network.

Additional information

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