Reclosers
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Comparison of recloser and breaker standards

Powering Business Worldwide

Introduction

Automatic circuit reclosers and high-voltage circuit breakers provide alternate means for distribution circuit protection.

To aid in the evaluation and application of these devices, the ratings and standards of reclosers and breakers are compared here.

For clarity and conciseness, only those parts of the standards and ratings are selected that are of most significance in the application and comparison of reclosers and breakers, or those items that have been a source of confusion in the past.

The recloser standards used is ANSI/IEEE C37.60 - 1981 and C37.61 - 1973.

Circuit breaker standards used for this comparison are C37.04-1979, C37.06 - 1987 and C37.09 - 1979.

General comparison

Perhaps the most significant difference between a recloser and a breaker is that the recloser was designed as a selfcontrolled device. Standards have been established and capabilities determined within the characteristics of the integral control scheme of the recloser.

Because a breaker was designed for use with a separate relay/control scheme, a breaker must be defined and rated for a wide variety of relay/control sequences. Thus, the breaker standard recognizes, and the breaker must be built to permit, a range of permissible values for:

- Maximum tripping delay
- Reclosing interval
- Short-time current

As pertains to a recloser, these capabilities are defined by the recloser's predetermined time-current characteristics and reclosing settings.

Definitions

Following are the definitions taken from ANSI/IEEE C37.100 - 1981. "IEEE Standard Definition for Power Switchgear".

Recloser

Automatic Circuit Recloser. *A self-controlled device for automatically interrupting and reclosing an alternating-current circuit, with a predetermined sequence of opening and reclosing followed by resetting, hold closed, or lockout.*

Breaker

Circuit Breaker. *A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also, making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short circuit.*

Ratings

Difference in design and application show up readily when comparing the ratings.

Rated interrupting current

Recloser

A recloser is rated on the basis of the maximum symmetric fault current it is designed to interrupt. This current remains a constant for the complete operating-voltage range, except for some recloser ratings where the interrupting current is increased at some lower voltage as shown in Example 1 below.

Example 1.

Type WE recloser

Operating voltage (kV)	Rated interrupting current (amp)
2.4 to 4.8	12,000
above 4.8 to 15.5	10,000

Breaker

Historically, circuit breakers have been rated on a constant MVA basis, with a K factor used to determine the minimum voltage for the "constant MVA rating". See Example 2.

Example 2.

Breaker rated 500 MVA

A breaker rated 500 MVA nominal, with a rated short-circuit current of 18kA at 15.5 kV, K Voltage Range Factor of 1.29.

The K factor established the minimum voltage for "constant MVA" as:

$$\frac{15.5\ \text{kV}}{1.29} = 12\ \text{kV}$$

The "Symmetrical Current Interrupting Capability" at 12kV would be:

$$18\text{KA} \times \frac{15.5\text{kV}}{12.0\text{KV}} = 23.25\ \text{kA}$$

For voltages lower than 12kV, the interrupting current capability is constant at 23.25 kA.

The revised breakers standards have abandoned the "constant MVA" rating approach. The K factor is now 1.0, meaning that the interrupting current is constant for any operating voltage. This is equivalent to the rating method used for reclosers, per C37.60 - 1981.

Table 1. Typical breaker ratings taken from Table 2 C37.06-1987.

Rated max. voltage kV, RMS	Rated voltage range factor K	Rated cont. current at 60H_3 Amp, RMS	Maximum symmetric interrupting Capability kA, RMS
15.5	1.0	600, 1200	12.5
15.5	1.0	1200, 2000	20.0
25.8	1.0	1200, 2000	12.5
25.8	1.0	1200, 2000	25.0

Duty cycle

The term "duty cycle" has been used to mean different things for reclosers and breakers.

Recloser

"Duty cycle" is a standardized test sequence to which a recloser is subjected to establish its minimum life and rated interrupting current.

A recloser duty cycle (Standard Operating Duty) establishes the capability of a recloser to interrupt a relatively large number of faults, tested at three separate current values.

In Example 3, the Type VSA12 recloser duty cycle is a total of 232 operations consisting of 88-112-32 interruptions at the specified currents.

Example 3.

Type WE (oil interrupters) and Type VSA12 (vacuum interrupters) duty cycle.

Current in % of interr. current	Type WE		Type VSA12	
	Minimum X/R	No. of unit operations	Minimum X/R	No. of unit operations
15-20	3	28	4	44 (88)*
45-55	7	20	8	56 (112)*
90-100	14	10	15	16 (32)*
Total Operations		58		116 (232)

* Number in parentheses is actual duty cycle as established by test. The smaller number - 116- is "half-life". Recloser standards allow the manufacturer to test only to "half-life" because of the expense and time required for a test of the duty cycle of a vacuum recloser.

The entire operating duty is performed with the recloser adjusted to give the maximum permissible number of unit operations before lock-out, with the minimum reclosing intervals for which the recloser is designed. Eaton Cooper Power series reclosers are tested for a sequence of O+INSTANTANEOUS+CO+2s+CO+2s+CO.

Breaker

The "Rated Standard Operating Duty" (Standard Duty Cycle) of a circuit breaker shall be two unit operations with a 15 second interval between operations (CO+15s+CO). (C37.04-5.6).

In addition, the breaker must be capable of a "number of operations in which the sum of the currents interrupted does not exceed 400 percent of the required asymmetrical interrupting capability of the breaker at its operating voltage", for fault currents between its rated continuous current and 85 percent of its required asymmetrical interrupting capability at its operating voltage. (C37.04- 5.10.3.3.1).

Note: The 400 percent value relates to oil circuit breakers. ANSI/IEEE 37.04g-1986 specifies a duty of 800 percent for "hermetically sealed" interrupting units. This would include vacuun interruption and sealed SF6 interrupter units.

Additional interrupting duty at the rated continuous current is specified in Standard C37.06, Table 8. For example, a 600- or 1200-amp breaker is required to close and interrupt the rated continuous current for 100 operations.

The "life" of a breaker before maintenance (the equivalent of a recloser duty cycle) is specified in ANSI Standard C37.04 which includes a method for determining breaker life for currents between rated continuous current and 85% of the required asymmetrical capability.

Comparison of duty cycle ratings: recloser vs breaker

To see how these ratings compare in establishing the recloser or breaker life before maintenance, below is a comparison of the Type VSA20A recloser duty cycle and life and a breaker rated 20kA, 15kV, calculating total operations available at currents 50% and 100% of the maximum symmetric current rating:

Recloser

Example 4.

VSA20 & VSA20A, rated 20,000 amps symmetric at 14.4kV operating voltage with a duty cycle of:

Current in % of interrupting current	X/R	No. of unit operations
15-20	4	88
45-55	8	112
90-100	16	32
		232

The total number of unit operations for 50% and 100% faultcurrent levels are calculated in accordance with Appendix C of ANSI C37.61 - 1973 (*Guide for the Application, Operation, and Maintenance of Automatic Circuit Reclosers*):

$(4{,}000 \text{ amps})^{1.5} = 25.3 \times 10^4$; x 88 operations = 22.26×10^6

$(10{,}000 \text{ amps})^{1.5} = 100 \times 10^4$; x 112 operations = 112.00×10^6

$(20{,}000 \text{ amps})^{1.5} = 282.4 \times 10^4$; x 32 operations = 90.37×10^6

Total duty factor = 224.63×10^6

No. of unit operations at 10,000 amps (50%) =

$$\frac{224.63 \times 10^6}{100 \times 10^4} = 224 \text{ operations}$$

No. of unit operations at 20,000 amps (100%) =

$$\frac{224.63 \times 10^6}{282.4 \times 10^4} = 79 \text{ operations}$$

Breaker

Example 5.

For a 20 kA, 15kV breaker, calculated in accordance with C37.04, the number of unit operations for 50% and 100% is:

At 14.4kV, the symmetrical current interrupting capability is 20,000 amps.

Assuming a maximum S factor of 1.4 (S factor for asymmetric capability multiplier based on a circuit X/R ratio of 15, equivalent to the maximum X/R ratio of recloser test requirements), the asymmetrical interrupting capability is:

20,000 x 1.4 = 28,000 Amps

And, according to C37.04 (oil) and C37.04g-1986 (vacuum and SF_6

28,000 x 400% = 112,000 Amps (oil)

28,000 x 800% = 224,000 Amps (vacuum/ SF_6)

At 10,000 amps (50% of 20,000), the number of unit operations is:

$$\frac{112{,}000}{10{,}000} = 11.2 \text{ (oil)}$$

$$\frac{224{,}000}{10{,}000} = 22.4 \text{ (vacuum/ } SF_6\text{)}$$

At 20,000 amps, the number of unit operations is:

$$\frac{112{,}000}{20{,}000} = 5.6 \text{ (oil)}$$

$$\frac{224{,}000}{20{,}000} = 11.2 \text{ (vacuum/} SF_6\text{)}$$

Comparison of device life before maintenance at 50% and 100% of rated interrupting current:

50% Maximum Interrupting:

Recloser: 224 operations

Breaker: 11.2 (22.4) operations

100% Maximum Interrupting:

Recloser: 79 operations

Breaker: 5.6 (11.2) operations

Note: Exercise discretion in using this comparison because it compares device life as defined by standards. Actual device life may be greater than the numbers calculated which would, of course, affect any "real world" comparison.

Derating of rated interrupting current for reclosing duty

Recloser

A recloser is capable of its full interrupting rating for a complete four-operation sequence, based on the sequence used to determine the Standard Operating Duty. Reclosers, therefore, do not require derating.

Breaker

A breaker is subject to derating (reduction) of its rated interrupting current for an operating sequence "having either more operations or a shorter time interval between operations than the standard CO+15s+CO duty cycle". (C37.04 - 5.10.2.6).

Example 6.

Derating (per C37.04 - 5.10.2.6)

Select a breaker rated 15.5kV, 20,000 ampere interrupting rating. The 20,000 ampere rating applies for a sequence of CO+15s+CO.

Derate for a typical "breaker" sequence of:
O + 0s + CO + 15s + CO + 45s + CO

The derating factor D = 9.9% (*)
Therefore, the rated interrupting current is:

20,000 x .901 = 18,020 Amps.

Derate for a recloser sequence of:

O +0s + CO + 2s + CO + 2s +CO

The derating factor D = 15.6% (*)

Therefore, the rated interrupting current is:

20,000 x .844 = 16,880 Amps.

* Calculations of derating factors is included in Appendix A.

A recloser with a rated interrupting current of 20,000 Amps will maintain the rated interrupting current of 20,000 Amps for either of these sequences with no derating involved.

Required asymmetrical interrupting capability

Recloser

When applied within the maximum symmetric fault current rating and the maximum X/R ratio, a recloser is capable of interrupting any degree of asymmetrical current that can occur.

Example 7.

Assume a Type VSA20 recloser rated 20,000 Amps symmetric, maximum X/R of 16, is applied on a circuit with this fault available. The maximum asymmetric current that the circuit can deliver is 20,000 x 1.53 (ratio of asymmetric to symmetric current for circuit X/R of 16) = 30,600 Amps (first major loop of current).

Breaker

The breaker requiring asymmetrical interrupting capability is determined by multiplying the symmetric interrupting capability by a factor S; the value of S shall be 1.4, 1.3, 1.2, 1.1, or 1.0. For breakers having primary arcing contact parting times of 1, 1.5, 2, 3, 4, or more cycles, respectively. (C37.04 - 5.10.2.2).

Required closing-latching-carrying-interrupting capabilities (C37.04-4-4.5.2.4)

Breaker

A breaker is required to close and latch any current which does not exceed 1.6Kx rated short-circuit current.

A breaker is required to carry a short circuit current for any time up to permissible tripping delay.

Recloser

Recloser standards define a "Rated Symmetrical Making Current": "The rated symmetrical making current shall be the same value as the rated symmetrical interrupting current, with maximum symmetry corresponding to the X/R ratio". This rating establishes the capability to close in on any symmetric or asymmetric current within the interrupting rating of the recloser.

Required short-time current carrying capability

Breaker

This rating establishes the breaker capability to close in on and carry the maximum fault current for a duration of three seconds.

Recloser

Recloser standards do not include any short-time requirements. A short-time current capability is established during testing of the Standard Operating Duty (duty cycle), where the recloser must withstand the maximum time delay curve with the maximum available minimum trip value as part of the recloser operating sequence.

While not required by standards some reclosers are tested to establish a short-time current rating.

Continuous current

Breaker

Breaker standard list 600- and 1200-amp continuous current ratings (plus higher ratings such as 2000 and 3000 Amps, beyond recloser ratings).

Recloser

Recloser current rating originated with the series-coil type of recloser, utilizing coil ratings of 25, 35, 50, 70, 100, 140, 200, 280, 400 and 560 Amps. Each succeeding rating is approximately 1.4 (or √2) times larger than the previous value. Higher ratings of 800 and 1120 Amps are extensions of this number series. Essentially, the 560 and 1120 Amp ratings are equivalent to 600 and 1200 Amp breaker ratings. Several of the larger rated reclosers have continuous current ratings of 800 or 1200 Amps.

Load current switching capability

Both reclosers and breakers are required to have capability of interrupting load currents.

Rated capacitor current switching

Breaker

Capacitance Switching Current ratings are specified in C37.06, Table 2A.

Recloser

No ratings are specified in standards. However, some reclosers have been tested and are rated for Capacitance Current Switching in accordance with C37.06.

Rated line charging current switching

Breaker

Breakers have an "Overhead Line Current" rating.

Recloser

Reclosers have a "Cable Charging Interrupting Current" rating.

Ratings for both reclosers and breakers are 2 Amps at 15.5kV; and 5 Amps at 25.8kV (breakers), 27.0kV (reclosers), and 38.0 kV.

Rated excitation current switching

Breaker

"Under study in the IEEE Switchgear Committee." (C37.04 - 5.17)

Recloser

Reclosers have a "Transformer Magnetizing Current Interruption" rating. The interrupting rating is equal to $3\frac{1}{2}$% of the continuous current rating of the recloser.

Reclosing interval – time

Recloser

The reclosing *interval* is "The open-circuit time between an automatic opening and the succeeding automatic reclosure." (C37.100)

This is the actual "dead" time (no current flow) of the circuit since the recloser control determines the interval between opening and reclosure.

See Appendix B, Figure 1.

Breaker

The reclosing *time* is "The interval between the time when the actuating quantity of the release (trip) circuit reaches the operating value (the breaker being in the closed position) and the re-establishment of the circuit on the primary arcing contacts on the reclosing stroke. (C37.100).

On a reclosing sequence, the actual "dead" time will depend on the reclosing time sequence as set up on the reclosing relay. For an "Instantaneous" reclosing, the circuit "dead" time will be the breaker "reclosing time", less the breaker interrupting time. Subsequent "dead" times are essentially determined by the reclosing relay settings, less the overcurrent relay time delay.

See Appendix B, Figure 2.

Various breaker specification considerations

Beyond the basic comparison of standards and ratings, customer specifications frequently call for features that have become somewhat standard for breakers. Because of differences in design and construction, it is impossible and often not worth the customer's expense - to completely satisfy some of these requirements in reclosers:

1. Ten stage auxiliary switch

   This is frequently specified in customer specifications. Reclosers can be equipped with a three-stage auxiliary switch as an accessory and, where required, a total of five stages can be provided. This has generally been satisfactory.

   Typically, breaker requirements include the use of four stages for control wiring, leaving six stages available for customer use. When an auxiliary switch is provided on reclosers, **all** stages are available for customer use.

2. Bushings.

   Breaker specifications sometimes specify condenser- type or transformer-breaker-interchangeable bushings or bushings "per ANSI C76.1".

   a. Condenser type.

      Recloser bushings are condenser type when the size, use and dielectric requirements dictate. Most recloser bushings are not condenser type. Recloser bushings are designed to be completely adequate with regard to dielectric ratings and performance, size and operation of reclosers.

   b. Transformer-breaker interchangeable.

      Recloser bushings are not transformer-breaker interchangeable. This requirement would dictate a considerably larger bushing for most recloser types and the resulting larger overall recloser size would significantly reduce the savings offered by reclosers. The added cost would be much greater than any possible savings due to interchangeable bushings.

   c. ANSI C76.1.

      This is a standard for outdoor apparatus bushings which defines the electrical characteristics, dimensions, mounting flange size, hole spacing, etc. It helps the bushing manufacturer to make bushings that can be used in different types of apparatus, and allows equipment manufacturers and utilities to buy bushings from different bushing suppliers.

      Recloser bushings are designed and tested for use with - and to meet all requirements of - reclosers. This allows the optimum recloser size and design at the lowest cost to the customer.

3. Bushing current transformers.

   Breaker specifications appear to routinely require two sets of BCT's - one set for overcurrent protection and the other set for customer metering and /or additional relaying.

   Since electronically controlled reclosers are equipped with sensing CT's (1000:1 or 2000:1 ratio) for overcurrent protection (and for metering with the Form 4C microprocessor control), separate CT's are usually not necessary. When the recloser is used with the Form 3A control, one set of additional CT's is usually required for metering. When the Form 4C control is used, the Form 4C control provides both overcurrent protection and demand metering with the standard recloser sensing CT's. Thus, no additional CT's are required.

4. Red-green lights.

   Red-green lights are essentially standard equipment for breakers and can be simply and inexpensively provided for breakers because the control panel is usually mounted as part of the breaker in - or adjacent to-the operating cabinet that contains the auxiliary switches. For remote relay mounting, the interconnecting cable or cables involve many conductors so the additional wiring for the red-green lights are available at minimum expense.

   For a recloser controlled by the Form 4C control, the control provides RECLOSER OPEN and RECLOSER CLOSED indication via the LCD indicators on the front panel.

   For a recloser controlled by the Form 3A control, the control can be provided with red-green lights as an accessory, operated from the recloser auxiliary switch (and connecting cable) or from a control Recloser Status accessory.

5. Cincinnati analyzer.

   This device provides a plot of the opening and closing operations of a breaker. It is of most use with the larger, more complicated mechanisms where many different linkages, levers and bearings are involved.

   Recloser mechanisms, by nature of their smaller size, simpler design, and higher speed, are not adaptable to this type of analyzer. A recloser mechanical failure will generally be in the nature of complete failure to open or close. Prior to this failure, there is generally little - or no - advance indication that would be detected by this type of equipment.

Appendix a: Calculation of derating factors for breakers for reclosing duty

Rated Interrupting Current = 20,000 Amps. For 20,000-Amp interrupting capability, d^1 = 3.3 (C37.06, Figure 2).

Derate for reclosing duty of O + 0s + CO + 15s + CO + 45s + CO

$$\text{Derating factor } D = 3.3\,(2) + 3.3\,\frac{(15\text{-}0)}{15} + 3.3\,\frac{(15\text{-}15)}{15} = 9.9$$

Reclosing capability factor R = 100 - 9.9 = 90.1%

Derate for reclosing duty of O + 0s + CO + 2s + CO + 2s + CO

$$\text{Derating factor } D = 3.3\,(2) + 3.3\,\frac{(15\text{-}0)}{15} + 3.3\,\frac{(15\text{-}2)}{15} + 3.3\,\frac{(15\text{-}2)}{15} = 15.6$$

Reclosing capability factor R = 100 - 15.6 = 84.4%

Appendix b

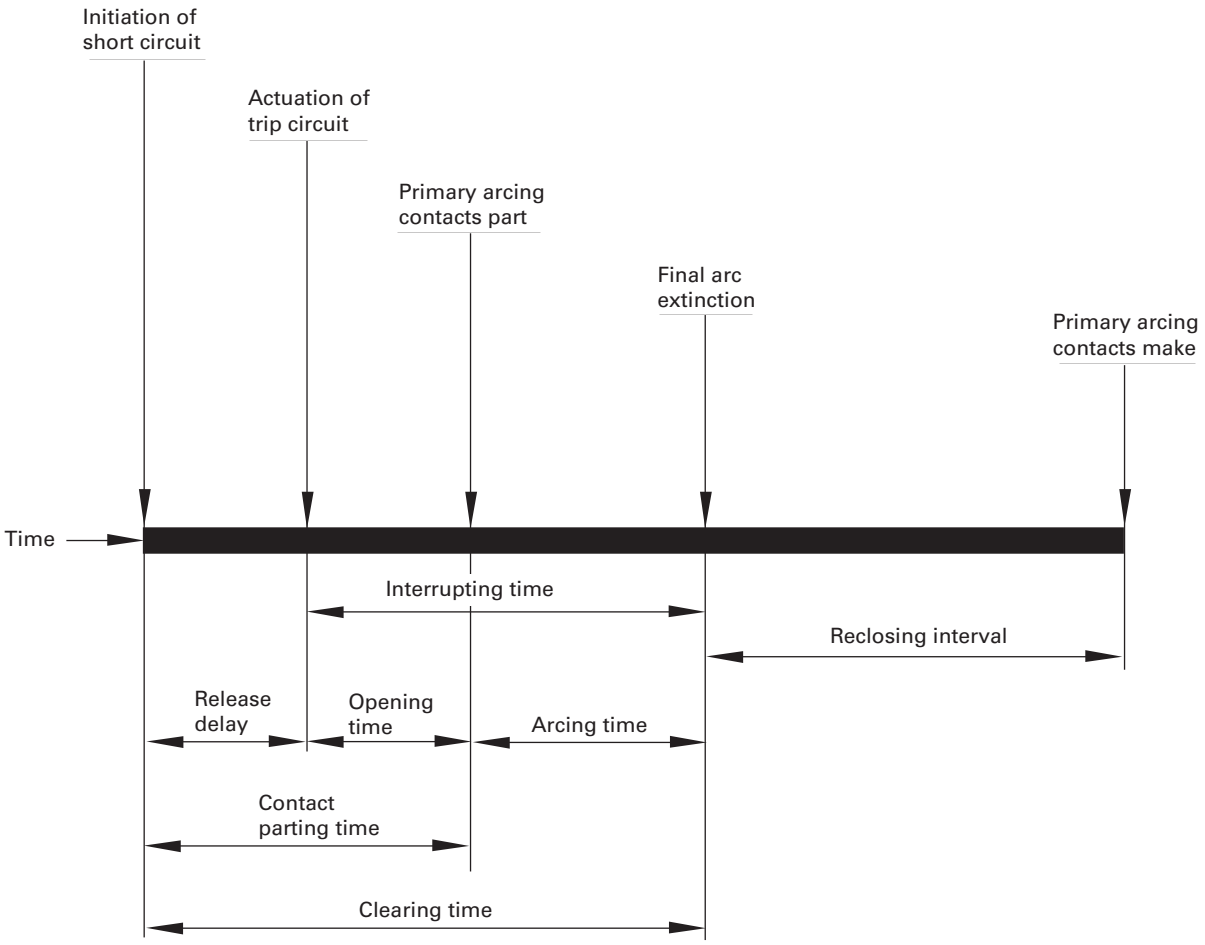

Figure 1. Reclosing interval - recloser

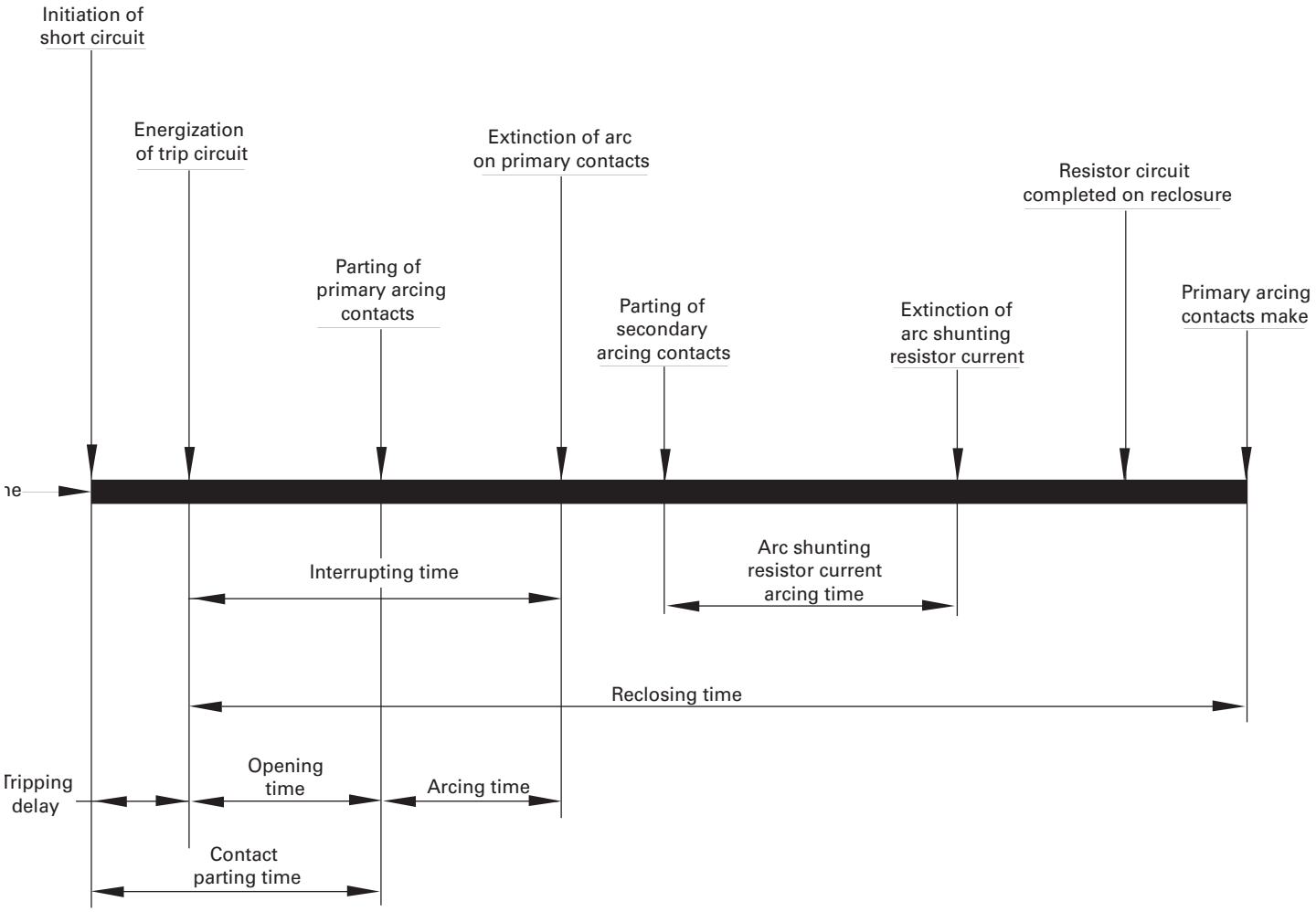

Figure 2. Reclosing time - breaker

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