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High voltage AC circuit breakers

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Electrical Manufacturers' Association (JEMA)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS C 4603**:1990), which has been technically revised.

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High voltage AC circuit breakers

1 Scope

This Japanese Industrial Standard specifies the requirements for high-voltage indoor AC circuit breakers to be used in high-voltage receiving installations of 3.3 kV or 6.6 kV in the nominal voltage at 50 Hz or 60 Hz in the frequency (hereafter referred to as the circuit breakers).

This Standard shall apply to the circuit breakers of 3.6 kV in the rated voltage and 16 kA or under in the rated breaking current, and those of 7.2 kV in the rated voltage and 12.5 kA or under in the rated breaking current.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS C 3307 *600 V Polyvinyl chloride insulated wires*

JIS C 3315 *Rubber insulated lead wires for electric machinery and apparatus*

JIS C 3316 *Polyvinyl chloride insulated wires for electrical apparatus*

JIS C 3317 *600 V Grade heat-resistant polyvinyl chloride insulated wires*

JIS C 3612 *600V Flame retardant polyethylene insulated wires*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1 Terms and definitions concerning types and ratings of circuit breakers

3.1.1

AC circuit breaker

device used in an AC circuit, capable of switching an electric circuit under a normal state and also under an abnormal state particularly short-circuit state

3.1.2

vacuum circuit breaker

circuit breaker in which an electric circuit is switched in vacuum

3.1.3

gas circuit breaker

circuit breaker in which an electric circuit is switched in such an insert gas as sulfur hexafluoride (SF₆)

3.1.4

rated voltage

upper limit of the service circuit voltage applicable to a circuit breaker under a specified condition

It is expressed by the r.m.s. value of line voltage.

3.1.5

rated withstand voltage

limit of the voltage applicable to a circuit breaker for a specified time without any abnormality

3.1.6

rated frequency

frequency for which a circuit breaker is designed to comply with the specified conditions

3.1.7

rated current

limit of the current that a circuit breaker can carry continuously with a temperature rise not exceeding the specified value up to the maximum permissible temperature, at the rated voltage and the rated frequency

3.1.8

rated short-time withstand current

limit of the current that a circuit breaker can carry for a specified time without any abnormality

3.1.9

rated breaking current

limit of the breaking current corresponding to the lagging power factor that a circuit breaker can break under a specified standard operating duty and an operating state, at all the ratings under the specified circuit conditions

It is expressed by the r.m.s. value of AC component.

3.1.10

rated transient recovery voltage

limit of the prospective transient recovery voltage that a circuit breaker can carry at the breaking the current not more than the rated breaking current

The rated transient recovery voltage is expressed by the stipulated value of parameter which determines the prospective transient recovery voltage by the two-parameter method.

3.1.11**rated making current**

limit of making current that a circuit breaker can make under a specified standard operating duty and an operating state, at all the ratings under the specified circuit conditions

The rated making current is expressed by the maximum instantaneous value at the first cycle of the making current.

3.1.12**reference breaking time**

limit of breaking time in the case where the rated breaking current is broken under a specified standard operating duty and an operating state at all the ratings under the specified circuit conditions

It is also called the rated breaking time. The reference breaking time is expressed by the number of cycles based on the rated frequency.

3.1.13**reference pole opening time**

limit of pole opening time when a circuit breaker is tripped under the conditions of Table 1 at no load

It is also called the rated pole opening time. For a circuit breaker having a particular delay device for pole opening, the value when the delay time has been adjusted to the minimum shall be used.

Table 1 Tripping conditions

Type of tripping		Tripping condition
Voltage tripping		When a rated opening control voltage is applied.
Capacitor tripping		When the tripping coil is excited at the rated input voltage of capacitor release.
Overcurrent tripping	Instantons excitation method	When a current equal to 300 % of the standard value of rated tripping current is applied.
	Continuous excitation method	
Undervoltage tripping		When the power supply of release held at the rated voltage is disconnected.

3.1.14**rated operation voltage**

operation voltage value based on which an operating device of circuit breaker is designed

The rated operation voltage is expressed by the terminal voltage at the maximum current during operation.

3.1.15**rated opening control voltage**

voltage based on which a release of circuit breaker is designed

The rated opening control voltage is expressed by the terminal voltage.

3.1.16**rated closing control voltage**

voltage based on which a closing device of circuit breaker is designed

The rated closing control voltage is expressed by the terminal voltage.

3.1.17**rated opening control current**

reference current value (r.m.s. value) for designing a release

3.2 Terms and definitions concerning poles and contacts**3.2.1****pole**

switching part in each conductor of an electric circuit

There are single-pole, double-pole, triple-pole or multi-pole according to the number of phases which can be switched simultaneously.

3.2.2**main contact**

contact provided in the main conductive part to carry the current of main circuit at closed position

3.2.3**arc contact**

contact provided to draw the arc due to breaking or making, in order to prevent the main contact from arcing

3.2.4**movable contact**

contact attached to the movable part in the conductive part configuring the circuit

3.2.5**fixed contact**

contact attached to the fixed part in the conductive part configuring the circuit

3.3 Terms and definitions concerning operations and controls**3.3.1**

operating device

mechanism which handles and transmits the energy directly operating the movable contacts of circuit breaker

3.3.2

operation voltage

voltage applied to terminals of a solenoid, motor, etc. of the operating device

3.3.3

electrical operation

operation by means of an electric energy

3.3.4

spring operation

operation by means of an energy stored in a spring

3.3.5

manual spring operation

spring operation in which the energy is stored manually

3.3.6

motor-driven spring operation

spring operation in which the energy is stored by motor

3.3.7

solenoid operation

operation in which the energy necessary for closing the circuit is supplied by a solenoid

3.3.8

control device

device which controls the energy of circuit breaker operation by receiving and selecting commands or signals from the outside of the circuit breaker

3.3.9

control voltage

voltage applied across the terminals of control device

3.3.10

overcurrent tripping

tripping method of circuit breaker by the secondary current of transformer connected with the main circuit of circuit breaker

The tripping method that is always excited by the secondary current of transformer

is defined as the continuous excitation method, and that excited only at the instant of operation through a protective relay is defined as the instantaneous excitation method.

3.3.11

undervoltage tripping

tripping method of circuit breaker by the voltage drop applied to the undervoltage release

The tripping method in which the trip coil is directly connected with the control power supply is defined as the direct method, and that connected with the control power supply via a protective relay is defined as the indirect method.

3.3.12

capacitor tripping

tripping method of circuit breaker by the energy of the charged capacitor

3.3.13

trip-free

operation that a circuit breaker can be tripped by the activation of release when the main circuit carries a current accidentally by the contact of contacts or the arc between them, even if the closing command is maintained

Also, after completion of the trip, the closing device does not close the circuit breaker again even if the closing command is still being applied to the closing device, and the closing operation is performed when the closing command is once cancelled and then given again.

3.3.14

power supply for capacitor tripping

power supply necessary for tripping, composed of a capacitor, rectifier and others

3.3.15

capacity of overcurrent release

product of the applied current to trip coil and the terminal voltage

In the instantaneous excitation method, it is defined as the capacity corresponding to the standard value of opening control current. In the continuous excitation method, it is defined as the capacity corresponding to the rated opening control current.

3.3.16

capacity of undervoltage release

product of the voltage and the current under such a state that the tripping mechanism remains unoperated at the rated voltage

3.4 Terms and definitions concerning operations

3.4.1

operating duty

a series of operations in which making, breaking or making immediately followed by breaking are performed with a definite interval

3.4.2**standard operating duty**

operating duty based on which the breaking performance, making performance, etc. of a circuit breaker are determined

3.4.3**test operating duty**

operating duty imposed on a circuit breaker on the occasion of the short-circuit test (see 10.8) of circuit breaker

3.4.4**operating characteristics curve**

curve indicating the relation between the travel distance of movable contact and the time at the switching operation of circuit breaker

3.4.5**switching speed**

traveling speed of movable contact on the switching operation of circuit breaker

3.4.6**average switching speed**

average value of switching speed when the moving contact travels about 90 % total traveling distance from the separating position

3.4.7**initial separating speed**

average speed when the moving contact travels about 20 % total traveling distance from the separating position

3.5 Terms and definitions concerning time**3.5.1****pole opening time**

interval of time from the instant of energizing of the release of circuit breaker in closed position to the instant when the arc contact at all of the poles (if no arc contact is provided, the main contact) separates (see Figure 1)

3.5.2**arc time**

interval of time from the instant of arcing of the pole first arced to the instant when the main currents of all the poles are broken

If defined on a particular pole, the arc time means the interval from the instant of arcing of the said pole to the instant when the main current of the pole is broken (see Figure 1).

3.5.3

breaking time

interval of time from the instant of energizing of the release of circuit breaker in closed position to the instant when the main currents of all the poles are broken (see Figure 1)

3.5.4

pole closing time

interval of time from the instant of energizing of the closed circuit control device of circuit breaker in open position to the instant when the arc contact at all of the poles (if no arc contact is provided, the main contact) contacts (see Figure 1)

3.5.5

making time

interval of time from the instant of energizing of the closed circuit control device of circuit breaker in open position to the instant when the current begins to flow in the main circuit (see Figure 1)

3.5.6

charge time

interval of time from the charging start of the capacitor of capacitor release power supply to the instant when the control voltage which can trip the circuit breaker is attained

3.5.7

transient recovery voltage delay time

interval of time obtained by the stipulated method (see 10.8 and Annex C), expressing the delay in the initial uprising part in the transient recovery voltage waveform

3.5.8

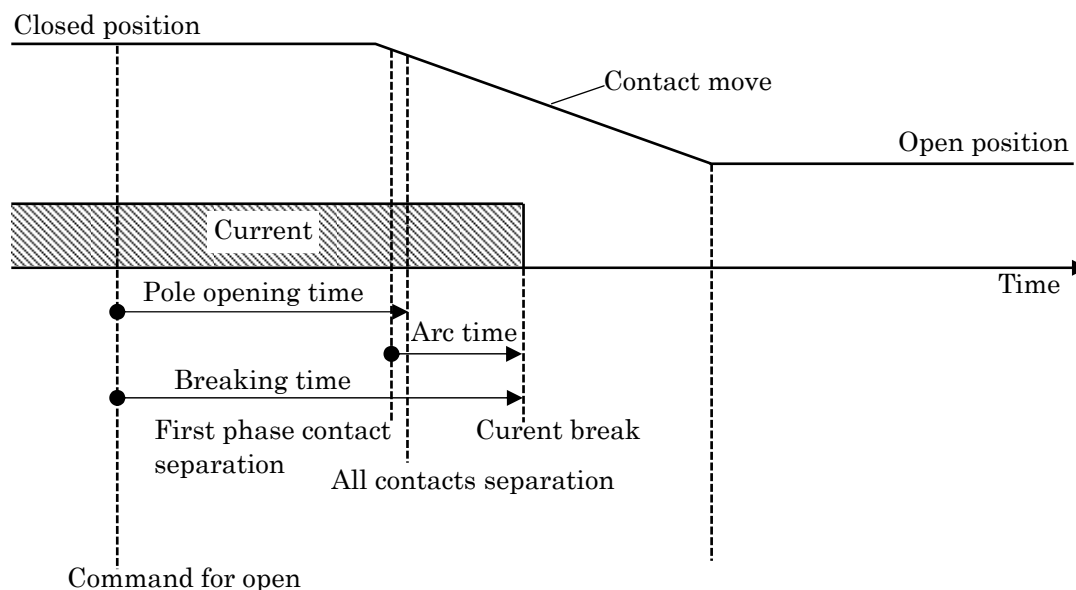
peak time of transient recovery voltage waveform

interval of time from the appear of transient recovery voltage on the pole to the instant when the peak value of transient voltage is attained

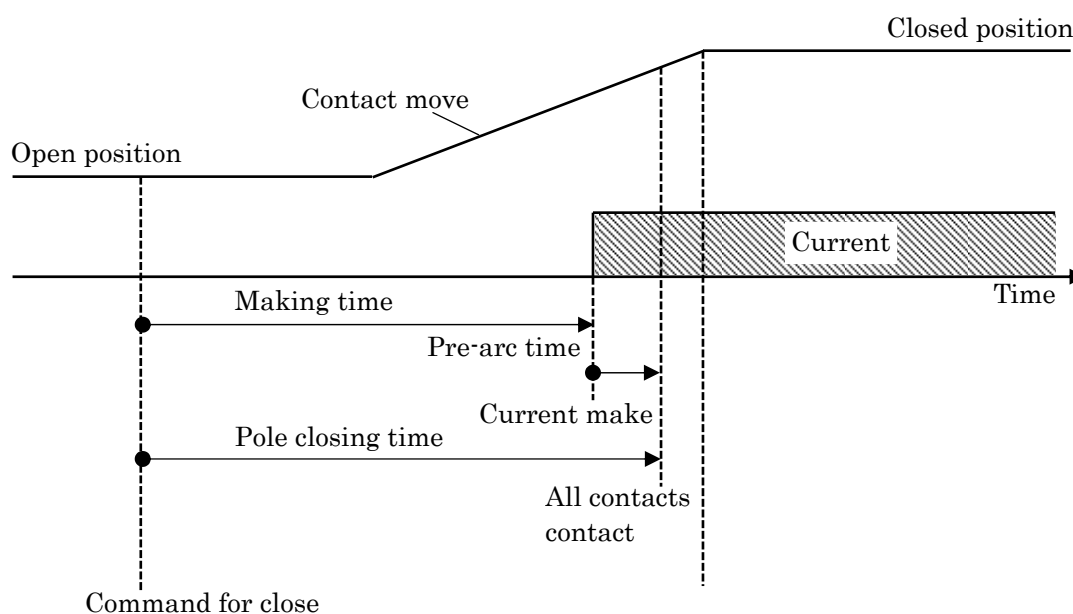
3.5.9

stipulated peak time of transient recovery voltage waveform

peak time of transient recovery voltage waveform obtained by the stipulated method (see 10.8 and Annex C)



a) Opening operation



b) Closing operation

NOTE This diagram is created referring to Figure 1 of JEC-2300.

Figure 1 Times and terms concerning switching

3.6 Terms and definitions concerning breaking and making

3.6.1

small leading current breaking

breaking of capacitive small current

3.6.2

small delay current breaking

breaking of inductive small current

3.6.3

breaking of ground fault on different phases

breaking of short-circuit current which flows under the state that different phases cause ground fault in both sides of a circuit breaker, by the said circuit breaker

3.6.4

short-circuit test

test to check the short-circuit breaking performance and the short-circuit making performance of circuit breaker

3.6.5

direct short-circuit test

short-circuit test in which the breaking current, making current, transient recovery voltage and commercial cycle recovery voltage all together are supplied from the same power supply

The single-phase test of a three-phase circuit breaker is defined as the single-phase direct short-circuit test.

3.6.6

test frequency

frequency of voltage or current applied to the testing of circuit breaker

3.6.7

short-circuit power factor

cosine of phase difference angle between AC component fundamental wave of the short-circuit current and AC component fundamental wave of commercial cycle recovery voltage at the time of breaking

The power factor of three-phase circuit is expressed by the average of respective phases.

3.6.8

unbalance factor

percentage of negative-phase-sequence component to positive-phase-sequence component, when a multi-phase voltage wave or a multi-phase current wave is deemed as a sine wave

3.7 Terms and definitions concerning voltage

3.7.1

applied voltage

voltage being applied to a circuit breaker immediately before application of the current

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in testing

Unless otherwise specified, it is expressed by the line voltage (r.m.s. value). In the case of a three-phase circuit, it is expressed by the average of respective line voltages.

3.7.2

recovery voltage

voltage which appears across both terminals of a pole of circuit breaker immediately after breaking of the current, composed of the transient recovery voltage and the commercial cycle recovery voltage.

3.7.3

commercial cycle recovery voltage

recovery voltage of commercial frequency which appears successively to the transient recovery voltage

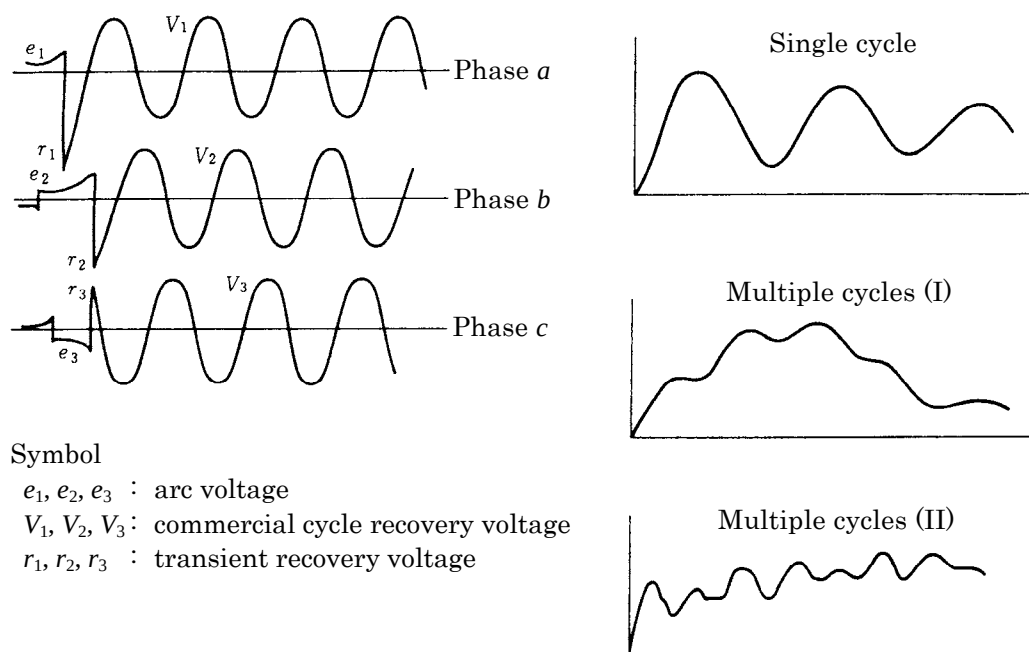
Unless otherwise specified, it is expressed by the r.m.s. value. In some cases, it is expressed by the value converted to the line voltage [see Figure 2 a)].

3.7.4

transient recovery voltage

recovery voltage which appears in the transient period immediately after breaking of the current [see Figure 2 a)]

There are transient recovery voltages having the transient component of single cycle only and having the transient component of multiple cycles [see Figure 2 b)].



a) Waveform of terminal voltage b) Transient recovery voltage (enlarged)

Figure 2 Transient recovery voltage

3.7.5

prospective transient recovery voltage

transient recovery voltage generated when AC sine wave current in an electric circuit is broken at one point of the circuit without generating any arc at its natural zero value, and also there is no influence on the characteristics of transient phenomenon of the circuit

In the case of a three-phase circuit, it is expressed by the value across terminals of the same phase firstly broken.

3.7.6

peak value of transient recovery voltage waveform

maximum value among the peak values in the transient recovery voltage waveform

3.7.7

rate of rise of transient recovery voltage

rising rate of transient recovery voltage in relation to time

3.7.8

stipulated rate of rise of transient recovery voltage

rate of rise of transient recovery voltage, expressed by $\text{kV}/\mu\text{s}$, obtained by the stipulated method (10.8 and Annex C) in a transient recovery voltage including only the transient component of single cycle

3.7.9

frequency of transient recovery voltage

frequency obtained by the stipulated method (10.8 and Annex C)

3.7.10

reset voltage

minimum terminal voltage (r.m.s. value) when an undervoltage release is reset

3.7.11

input voltage

r.m.s. value of AC voltage being applied to the input side terminal of a capacitor release power supply

3.7.12

two-parameter method

method by which the transient recovery voltage waveform having solely the transient component of single cycle is expressed by two parameters of the peak value and the rate of rise (or peak time)

3.8 Terms and definitions concerning current