

JIS

JAPANESE INDUSTRIAL STANDARD

**High-Voltage
Current-Limiting Fuses**

JIS C 4604—1988

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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J I S

High-Voltage Current-Limiting Fuses

C 4604-1988

1. Scope

This Japanese Industrial Standard specifies high-voltage current-limiting fuses intended for use in three-phase electric lines of nominal voltages 3.3 kV or 6.6 kV, hereinafter referred to as the "fuses".

- Remarks 1. In the case of application to a single-phase circuit, the rated voltage of a fuse shall be not less than the maximum line voltage of the circuit in which the fuse serves, and the fuse shall be used on each pole of the circuit.
2. This Standard is not applicable to fuses for high-voltage cut-out switch.

2. Definitions

For the main terms used in this Standard the definitions in JIS C 0201 apply, and the rest of the terms shall be as follows:

- (1) disconnecting fuse A fuse assembly of such construction that the fuse-link can be opened and closed like the blade of a vertical disconnecting switch so that a disconnected distance equal to that of a disconnecting switch can be obtained when it is opened.
- (2) rated voltage The upper limit value (r.m.s. value) of circuit voltage at which a fuse can serve under specified conditions.
- (3) rated withstand voltage The limit of voltage to which a fuse can withstand under specified conditions. This is the generic name of withstand voltages to the earth, between main circuits of different polarity, and between terminals of same polarity at open state of a disconnecting fuse.

Remark: This rated withstand voltage is sometimes expressed in the insulation level (No.).

- (4) rated current The limit of the current (r.m.s. value) which can be passed continuously through a fuse under specified conditions within a temperature rise of a specified limit.
- (5) rated frequency The frequency employed as the basis of designing a fuse.

Applicable Standards:

JIS C 0201-Glossary of Terms for Fuses

JIS C 4620-Cubicle Type High Voltage Power Receiving Units

JIS Z 8721-Specification of Colours According to Their Three Attributes

Corresponding International Standard:

IEC 282-1 High-voltage fuses. Part 1: Current-limiting fuses

- (6) rated breaking current The upper limit value of prospective current that a fuse is capable of breaking under specified conditions.
- (7) time-current characteristics A curve which expresses the relationship between the permissible time, pre-arcing time or operating time and the prospective current of a fuse when a current is passed through the fuse under specified conditions.
- (8) repeated overcurrent characteristics The combination of current, duration of current and number of times of current application to which a fuse can withstand repeatedly under specified conditions.
- (9) maximum operating $I^2 t$ The maximum value of $I^2 t$ integrated over the operating time in the current-limiting zone.
- (10) arc voltage The voltage which appears across terminals of a fuse during the arcing time.
- (11) prospective transient recovery voltage The transient recovery voltage which appears when the sinusoidal a.c. current of a circuit is broken at a point in the circuit, without producing arc at its natural zero value and without giving effects on the characteristics of transient phenomena of the circuit.
- (12) peak value of transient recovery voltage The largest one of the several maximum values in a transient recovery voltage waveform.
- (13) time to peak transient recovery voltage The time from initiation of transient recovery voltage to the peak value of transient recovery voltage.
- (14) virtual time to peak transient recovery voltage The time to peak transient recovery voltage which is obtained from the oscillogram of transient recovery voltage waveform [see 7.10 (2) (f)].
- (15) rate of rise of transient recovery voltage The rate of rise of transient recovery voltage in respect with time.
- (16) virtual rate of rise of transient recovery voltage The rate of rise of transient recovery voltage obtained from the oscillogram of transient recovery voltage waveform [see 7.10 (2) (f)].
- (17) delay time of transient recovery voltage The time which expresses a delay of initial increment on a transient recovery voltage waveform, and is obtained from the oscillogram of the transient recovery voltage waveform [see 7.10 (2) (f)].
- (18) short-circuit power factor The cosine of the angle of phase difference between fundamental a.c. component of short-circuit current and fundamental a.c. component of power frequency recovery voltage at breaking of the current.
- (19) making phase angle The phase angle of power supply voltage at initiation of the current.
- (20) phase angle at initiation of arcing The phase angle of power supply voltage at the instant of arc generation due to fusion of fuse element.

3. Service Conditions

3.1 Normal Service Conditions The normal service conditions shall be the conditions given below, and fuses shall be used under these conditions, unless otherwise specified.

- (1) Fuses are used in a place where the ambient temperature does not exceed the range of -20°C to $+40^{\circ}\text{C}$.
- (2) Fuses are used in a place where the altitude does not exceed 1000 m.

3.2 Special Service Conditions The special service conditions mean the service conditions given below, and these conditions shall be specified especially. When fuses are used in a place where -

- (1) The ambient temperature and/or altitude differ from those specified in 3.1.
- (2) Fuses are severely subjected to a sea breeze.
- (3) It is always humid.
- (4) Excessive vapour or oil vapour exists.
- (5) Explosive, inflammable or other harmful gas exists, or a risk due to the above gas is anticipated.
- (6) Excessive dust exists.
- (7) Fuses receive abnormal vibration or shock.
- (8) Excessive snow or ice exists.
- (9) Special conditions are required.

4. Ratings

4.1 Rated Voltage The rated voltage shall have the values given in Table 1.

Table 1. Rated Voltage

Unit: kV	
Nominal voltage	Rated voltage
3.3	3.6
6.6	7.2

4.2 Rated Withstand Voltage The rated withstand voltage and the insulation level shall have the values given in Table 2.

Table 2. Withstand Voltage and Insulation Level

Unit: kV

Rated voltage	Class of insulation level	Withstand voltage between terminals of main circuit and between main circuit terminals together and earth		Withstand voltage across main-circuit terminals of same phase	
		Lightning impulse (standard waveform) dry	Power frequency dry (1 min) wet (10 s)	Lightning impulse (standard waveform) dry	Power frequency dry (1 min) wet (10 s)
3.6	No. 3 A	45	16	52	19
	No. 3 B	30	10	35	
7.2	No. 6 A	60	22	70	25
	No. 6 B	45	16	52	

- Remarks 1. The withstand voltage across main-circuit terminals of same phase is applicable to disconnecting fuses.
2. Only dry state applies to indoor fuses, and both of dry and wet states applies to outdoor fuses.
3. When the withstand voltage of fuses used in a place exceeding 1000 m in altitude is tested in a place of normal altitude, Appendix 1 shall be complied with.

4.3 Rated Frequency The rated frequency shall be 50 Hz, 60 Hz or 50/60 Hz.

4.4 Rated Current The rated current shall be selected from the values of Table 3 and the values of R 10 series of Table 4.

Table 3. Rated Current

Unit: A

Rated current									
1	1.5	3	5	7.5	10	15	20	30	40
50	60	75	100	150	200	250	300	400	

Table 4. Rated Current (R 10 Series)

Unit: A

Rated current (R 10 series)									
1	1.25	1.6	2	2.5	3.15	4	5	6.3	8

Remarks 1. The value of Table 4 multiplied by 10^n (n is an integer) is also acceptable as the standard value.

2. A value exceeding 400 A shall be selected from the R-10 series of Table 4.

4.5 Rated Breaking Current The rated breaking current shall be selected from the values given in Table 5.

Table 5. Rated Breaking Current

Rated voltage kV	Rated breaking current kA	Three-phase rupturing capacity (Informative reference value) MVA
3.6	16	100
	25	160
	40	250
7.2	12.5	160
	20	250
	31.5	390
	40	500

4.6 Minimum Breaking Current The minimum breaking current shall have the value specified by the manufacturer, and the operating time corresponding to the current shall be clearly stated.

5. Performances

5.1 Resistance between Terminals and between Fuse-link Contacts These resistance shall fall within the ranges previously established by the manufacturer when tested as specified in 7.2.

5.2 No-voltage Switching Property When a disconnecting fuse is tested as specified in 7.3, the fuse shall be operated smoothly with less shock, and shall show no trouble such as loosening of fastened part at any portion. Further, the fuse shall comply with the provision of 5.1.

5.3 Temperature Rise When the test is carried out as specified in 7.4, the temperature rise at each part shall not exceed the appropriate value of Table 6, and the specimen shall comply with the provision of 5.1. For fuses intended for used in a place where the ambient temperature exceeds 40°C, the value given in Table 6 subtracted by the ambient temperature in excess of 40°C shall be considered as the limit of temperature rise.

Table 6. Temperature Rise Limit

Unit: °C

Measurement place and classification			Temperature rise limit	Maximum permissible temperature
Fuse-link contact	Pressurized by spring	Copper or brass contact	35	75
		Silver contact	65	105
		Tin contact	55	95
	Clamped by bolt	Copper or brass contact	50	90
		Silver or tin contact	65	105
Terminal		Copper or brass contact	50	90
		Silver or tin contact	65	105
Insulating part of fuse-link		Class A	65	105
		Class E	80	120
		Class B	90	130
		Class F	115	155
		Class H	140	180
		Class C	A value exceeding 140	A value exceeding 180

Remarks 1. The limit of reference ambient temperature is 40°C.

2. When the temperature test of fuses intended for use in a place exceeding 1000 m in altitude is carried out in a place of normal altitude or when such fuses are used with the rated current corrected, Appendix 1 shall be complied with.

5.4 Watt Loss The watt loss shall not exceed the value declared by the manufacturer when tested in accordance with 7.5.

5.5 Withstand Voltage When a fuse is subjected to the test of 7.6, the fuse shall not cause earth fault or flashover, and shall not show abnormality at any part.

5.6 Pre-arcing Time-Current Characteristics When the test is carried out as specified in 7.7, individual pre-arcing time-current characteristic shall not deviate from the curve declared by the manufacturer by more than $\pm 20\%$ on the current coordinate and shall satisfy the specification of Table 7.

The pre-arcing time-current characteristics shall be clearly stated by means of the average value based on virtual time.

5.7 Permissible Time-Current Characteristic When the test is carried out as specified in 7.8, this characteristic shall satisfy the requirements given below.

The permissible time-current characteristic shall be clearly stated based on the minimum value of permissible time.

- (1) A current corresponding to 60 s on the permissible time-current characteristic curve is passed for 60 s, this operation is repeated three times, and then the pre-arcing time at 60 s fusing current shall fall within a range of $\pm 20\%$ on current coordinate of the pre-arcing time-current characteristic.
- (2) The fuse shall not cause fusion when such a current application is repeated 100 times that a current corresponding to 60 s on the permissible time-current characteristic curve is passed for 60 s.

5.8 Repeated Overcurrent Characteristic When the test is carried out as specified in 7.9, this characteristic shall be as specified in Table 8.

Table 7. Pre-arcing Time-Current Characteristic

Unit: A

Class of fuse	Pre-arcing time-current characteristic				
	Non-fusing current	I_{f7200}/I_n	I_{f60}/I_n		$I_{f0.1}/I_n$
G (General)	No fusion shall occur within 2 h, due to a current of 1.3 times rated current	$I_{f7200}/I_n \leq 2$	—	$2 \leq I_{f10}/I_n \leq 5$	$7 \left(\frac{I_n}{100} \right)^{0.25} \leq I_{f0.1}/I_n \leq 20 \left(\frac{I_n}{100} \right)^{0.25}$
T (for transformer)		—	—	$2.5 \leq I_{f10}/I_n \leq 10$	$12 \leq I_{f0.1}/I_n \leq 25$
M (for motor)		—	—	$6 \leq I_{f10}/I_n \leq 10$	$15 \leq I_{f0.1}/I_n \leq 35$
C (for capacitor)	No fusion shall occur within 2 h, due to a current of 2 times rated current.	—	$I_{f60}/I_n \leq 10$	—	—

Remarks 1. I_{f7200} : 2 h fusing current (mean value)
 I_{f60} : 60 s fusing current (mean value)
 I_{f10} : 10 s fusing current (mean value)
 $I_{f0.1}$: 0.1 s fusing current (mean value)
 I_n : rated current

2. The calculated values of $7 \left(\frac{I_n}{100} \right)^{0.25}$ and $20 \left(\frac{I_n}{100} \right)^{0.25}$ for type G fuse are given in Appendix 2.

3. The high-voltage current-limiting fuses for the cubicle of JIS C 4620, and the fuses for high-voltage load disconnecting cubicle (types PF and S) shall be the fuses of type G.
4. The pre-arcing time-current characteristic of fuses for instrument transformers shall be that of type T.

Table 8. Repeated Overcurrent Characteristic

Class of fuse	Repeated overcurrent characteristic
G (General)	—
T (for transformer)	When a current equal to 10 times rated current is passed for 0.1 s, 100 times repeatedly, no fusion shall occur.
M (for motor)	When a current equal to 5 times rated current is passed for 10 s, 10000 times repeatedly, no fusion shall occur.
C (for capacitor)	When a current equal to 70 times rated current is passed for 0.002 s, 100 times repeatedly, no fusion shall occur.

Remark: If a number of times of repetition more than that in Table 8 is necessary, it should be agreed between the user and manufacturer.

5.9 Breaking Performance When the test is carried out as specified in 7.10, the specimen shall comply with the following requirements:

- (1) Neither explosion of fuse-link shall occur, nor welding damage etc. shall be found on the reusable part after operation. However, damage, fissures, etc. which are not detrimental to service caused on the part not intended to be reused, are permissible.
- (2) The cut-off current, operating $I^2 t$ and pre-arcing $I^2 t$ shall not exceed the relevant values declared by the manufacturer.
- (3) The switching voltage shall not exceed the relevant value given in Table 9.

Table 9. Switching Voltage

Unit: kV	
Rated voltage	Switching voltage (peak value)
3.6	12
7.2	23

- (4) Any high temperature gas shall not blow and from the fuse. However, discharge of a small amount of high temperature gas from the indicator or striker is permitted.
- (5) The indicator or striker, if provided, shall operate normally.

6. Construction

6.1 Construction in General Fuses shall have sufficient durability electrically and mechanically, and shall be so constructed that the maintenance inspection is made safely and easily.

Further, disconnecting fuses shall be operated smoothly and reliably, with small shock, at the time of switching.

6.2 Coating and Plating The part on which rusting is anticipated shall be coated after sufficient rust prevention has been made.

For the part to be plated, the plating shall be carried out after sufficient pretreatment.

6.3 Color of Coating The color of coating of indoor fuses shall be expressed by the hue, value and chroma as specified in JIS Z 8721, and it shall, as a rule, be 5 Y 7/1.

7. Test Procedures

7.1 Construction Test In the construction test, the items specified in 6. and 10. shall be examined.

7.2 Resistance Test In the resistance test, the resistances between terminals and between fuse-link contacts shall be measured by d.c. voltage drop method.

7.3 No-voltage Switching Test The no-voltage switching test shall be carried out on disconnecting fuses under a state as in practical service as possible, in such a way that the specimen is closed and opened 50 times (5 times in acceptance inspection) at no-voltage and then the conditions of various parts are examined.

After the above test, the test of 7.2 shall be carried out.

7.4 Temperature Test The temperature test shall be carried out in a place free of ventilating effect, on the contact parts, terminals and fuse-link.

The fuse to be tested (specimen) shall be mounted as in practical service as possible.

- (1) Test Voltage, Current and Frequency The test voltage may be less than the rated voltage. The test current shall be the rated current and the test frequency shall be 48 to 62 Hz. However, the test current for fuses of type C shall be 1.5 times the rated current.
- (2) Ambient Temperature The test shall be carried out at ordinary temperature (5 to 35°C), unless otherwise specified and the ambient temperature shall not exceed 40°C in any case.

The ambient temperature shall be determined in such a way that thermometers each immersed in oil of about 0.5 l are placed in at least three places at a high equal to the center of conductive part of specimen and at a distance 1 to 2 m, and the average value of the readings of these thermometers is taken.

If there is change in the ambient temperature during this temperature test, the average value of the temperatures in the last 1/4 of the total test period shall be considered as the ambient temperature.

- (3) Connecting Conductor The appropriate copper wires or bars given in Table 10 shall be connected to both ends of the specimen.

Table 10. Connecting Conductor

Rated current A	Connecting conductor	
	Sectional area mm ²	Length m
Up to and including 25	20 to 30	1 min.
Over 25 up to and including 60	40 to 60	
Over 60 up to and including 100	80 to 100	
Over 100 up to and including 200	120 to 160	
Over 200 up to and including 400	250 to 350	
Over 400 up to and including 600	500 to 600	
Over 630 up to and including 1000	800 to 1000	

- (4) Measurement of Temperature Rise The measurement of temperature rise shall be made by thermometer method. The temperature sensitive part of one of mercury thermometer, alcohol thermometer, non-embedding type resistance thermometer or thermoelectric thermometer shall be brought in contact with the surface of accessible part from outside where the temperature is estimated to be the maximum, and covered with an appropriate amount of putty or the like.

The temperature rise shall be measured by spending plenty of time so that a constant temperature at the final stage can be confirmed, but if any change exceeding 1°C per 1 h is not observed, the temperature may practically be considered as the final temperature.

- (5) Measurement of Resistance After the measurement of temperature rise the specimen shall be allowed to stand for cooling, and then subjected to the test of 7.2.

7.5 Watt Loss Test The watt loss test shall be carried out under the same conditions as in the temperature test in such a way that 50 %, 100 % and 150 % (only for fuses of type C) of the rated current are passed and the watt loss between both ends of fuse-link is measured after the final temperature is attained at each current.

7.6 Withstand Voltage Test The withstand voltage test consists of power frequency withstand voltage test and lightning impulse withstand voltage test.

- (1) Parts of Application and Conditions of Fuse The parts to which the voltage is applied and the conditions of fuses shall be as given in Table 11.

Table 11. Part of Application and Conditions of Fuse

Part to which voltage is applied	Condition of fuse
Between main circuit terminals of different phase	The fuses are attached on three poles with the minimum distance between phases designated by the manufacturer, and the test is carried out under the open circuit condition.
Between main circuit terminals and the earth	The test is carried out under the closed circuit condition (for a disconnecting fuse, the test is also carried out under open circuit condition).
Between main circuit terminals of same phase	The test is carried out under the open circuit condition on disconnecting fuses.

- (2) Waveform and Frequency of Test Voltage in Power Frequency Withstand Voltage Test The waveform of test voltage shall be sinusoidal as far as possible and the frequency shall be 48 to 62 Hz. If the waveform differs remarkably from a sine wave, the peak value of the test voltage shall be not less than the specified test voltage multiplied by $\sqrt{2}$.
- (3) Number of Tests and Waveform of Test Voltage in Lightning Impulse Withstand Voltage Test The waveform shall be $\pm 1.2/50 \mu s$ (tolerances on waveform are $\pm 30 \%$ in wave-front length and $\pm 20 \%$ in wave-tail length) and three tests shall be carried out in each of positive polarity and negative polarity.
- (4) Test Voltage The test voltage to be applied to each part shall have the appropriate value given in Table 2.
- (5) Application Method of Test Voltage in Power Frequency Withstand Voltage Test In the dry test, a voltage not more than $1/2$ of the test voltage is applied, the voltage is raised to the test voltage as fast as possible, within such an extent that the instantaneous voltage can be indicated by the voltmeter, and then the test voltage is applied continuously for 1 min.
- (6) Wet Test Water shall be sprayed under a constant water pressure so that the water drops are as fine as possible and uniform and the extent of spray is sufficient to cover the specimens. The density of spray shall be as uniform as possible and the angle of spray shall be about 45° to the vertical at almost center of the specimen. The amount of spray shall be about 3 mm per minutes in vertical component.
- The resistivity of sprayed water shall, as a rule, be $10000 \Omega \cdot cm \pm 20 \%$.

7.7 Pre-arcing Time-Current Characteristic Test The pre-arcing time-current characteristic test is carried out to confirm the pre-arcing time-current characteristic specified in 5.6, and the test shall be carried out in a place free from influence of ventilation, on new fuses which are not heated by current in advance, as specified below.

- (1) Ambient Temperature Unless otherwise specified, the test shall be carried out at an ordinary temperature not exceeding 40°C.
- (2) Mounting of Specimen The test shall be carried out on the specimens mounted in the same conditions as in the temperature test of 7.4. The connecting conductor shall be as specified in Table 10.
- (3) Test Voltage, Frequency and Current Waveform The test voltage may be a voltage not exceeding the rated voltage. The test frequency shall be 48 to 62 Hz and the current waveform shall be sinusoidal as far as possible.
- (4) Measurement of Time The measurement of time shall be made by a stopwatch, oscillograph or other adequate instrument.
- (5) Measurement of Flowing Current
 - (a) The measurement of current flowing through the specimen shall be made by an indicating ammeter, oscillograph or other adequate instrument.
 - (b) If the current is not constant due to inclusion of d.c. component or damping of a.c. component, the current shall be converted from the I^2t obtained by the method given in Appendix 3 or the equivalent method.
- (6) Test Current and Number of Tests The current to be passed for test shall have the appropriate value given in Table 12, and the test shall be carried out once for each of the items of the table.

If the current for breaking test is close to the current of Table 12, data obtained in the breaking test may be used.

Table 12. Current to be Passed for Pre-arcing Time-Current Characteristic Test

G (General)	T (for transformer)	M (for motor)	C (for capacitor)
Non-fusing current	Non-fusing current	Non-fusing current	Non-fusing current
Rated current x 2.0	Minimum breaking current		Rated current x 10
10 s fusing current	600 s fusing current	600 s fusing current	600 s fusing current
0.1 s fusing current	10 s fusing current	10 s fusing current	10 s fusing current
0.01 s fusing current	0.1 s fusing current	0.1 s fusing current	0.1 s fusing current
	0.01 s fusing current	0.01 s fusing current	0.01 s fusing current

Note (¹) The test of minimum breaking current is carried out only when the pre-arcing time at the minimum breaking current exceeds 600 s.

Remarks 1. The value of non-fusing current is as specified in Table 7.

2. The fusing current in Table 12 means the current corresponding to the specified time on the pre-arcing time-current characteristic curve, and the actual current to be passed shall be within $\pm 10\%$ from the current.

7.8 Permissible Time-Current Characteristic Test The permissible time-current characteristic test is carried out to confirm the permissible time-current characteristic specified in 5.7, and the test shall be carried out in a place free from influence of ventilation, on new fuses which are not heated by current in advance, as specified below.

- (1) Ambient Temperature Unless otherwise specified, the test shall be carried out at an ordinary temperature not exceeding 40°C.
- (2) Mounting and Number of Specimens The test shall be carried out on the specimens mounted in the same conditions as in the temperature test of 7.4. The connecting conductor shall be as specified in Table 10. The number of specimens shall be three for each class of test, and the test may be made on the specimens connected in series.
- (3) Test Voltage, Frequency and Current Waveform The test voltage may be a voltage not exceeding the rated voltage. The test frequency shall be 48 to 62 Hz and the current waveform shall be sinusoidal as far as possible.
- (4) Duration of Current The duration of current shall be 60 s.
- (5) Current to Be Passed A current corresponding to 60 s on the permissible time-current characteristic curve shall be passed.
- (6) Interval of Current Application The current shall be passed at intervals of 30 min or less.
- (7) Number of Current Applications The number of current applications shall be as follows:
 - (a) Class A Test The current shall be passed three times repeatedly and then the pre-arcing time-current characteristic test shall be carried out at the 60 s fusing current.
 - (b) Class B Test The current shall be passed 100 times repeatedly and existence or non-existence of fusion shall be examined.

7.9 Repeated Overcurrent Characteristic Test The repeated overcurrent characteristic test is carried out to confirm the repeated overcurrent characteristic specified in 5.8, and the test shall be carried out in a place free from influence of ventilation on new fuses which are not heated by current in advance, as specified below.

- (1) Ambient Temperature Unless otherwise specified, the test shall be carried out at an ordinary temperature not exceeding 40°C.

- (2) Mounting and Number of Specimens The test shall be carried out on the specimens mounted in the same conditions as in the temperature test of 7.4. The connecting conductor shall be as specified in Table 10. The number of specimens shall be three, and the test may be made on the specimens connected in series.
- (3) Test Voltage, Frequency and Current Waveform The test voltage may be a voltage not exceeding the rated voltage. The test frequency shall be 48 to 62 Hz and the current waveform shall be sinusoidal as far as possible.
- (4) Duration of Current The duration of current shall be as given in Table 13 in correlation with the type of fuse.
- (5) Current to Be Passed The current appropriate to the type of fuse given in Table 13 shall be passed.
- (6) Number of Current Applications and Interval of Current Application The current shall be passed by the number of current applications appropriate to the type of fuse given in Table 13, at intervals of 30 min or less.

Table 13. Conditions for Repeated Overcurrent Characteristic Test

Type of fuse	Duration of current s	Test current A	Number of current applications time
T (for transformer)	0.1	10 times rated current of fuse	100
M (for motor)	10	5 times rated current of fuse	10000
C ⁽²⁾ (for capacitor)	0.002	70 times rated current of fuse	100

Note (2) If the test with the duration of current and the test current given in Table 13 is difficult, a possible shortest duration of current and a corresponding test current which causes the equivalent thermal effect are chosen and the test may be carried out with the parameters so chosen.

7.10 Breaking Test The breaking test is carried out to confirm the rated breaking current, minimum breaking current, cut-off characteristic, switching voltage, etc. and the test shall be carried out on new fuses which are not heated by current in advance, as specified below.

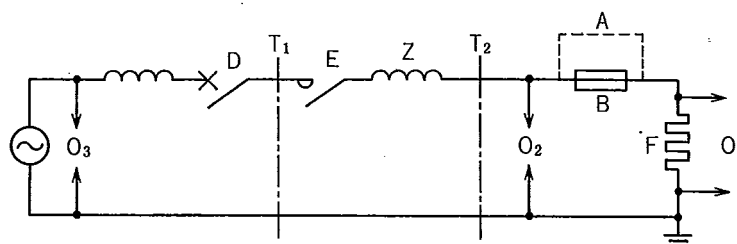
- (1) Conditions of Specimen The fuse shall be assembled completely, installed as in practical service as possible and then subjected to the test.
- (2) Test Circuit and Measuring Method The breaking test shall be carried out every time on one piece of specimen in the single-phase circuit illustrated in Fig. 1.

When a reactor and a resistor are connected in parallel as the circuit element for breaking test in small current region such as minimum breaking current, the parallel resistance shall be not less than 30 times the reactance.

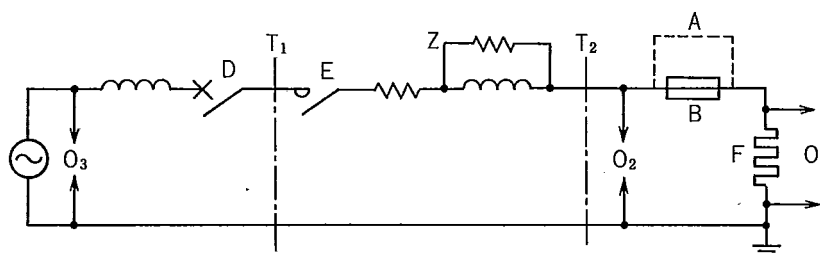
The prospective current, current, voltage, etc. shall be as specified below.

Fig. 1. Breaking Test Circuit

(a) For Large Current Region



(b) For Small Current Region



A: short circuiting conductor of negligible low impedance

B: specimen

D: backup circuit-breaker

E: making switch

F: shunt

O₁: to oscillograph element for current measurement

O₂: to oscillograph element for recovery voltage measurement

O₃: to oscillograph element for power supply voltage measurement

Z: current regulating impedance

T₁, T₂: possible locations of transformer

- (a) Prospective Current In general an oscillograph shall be used for the measurement of prospective current. However, in the measurement of a current region requiring long time for fusion of the fuse such as the minimum breaking current, an indicating ammeter⁽³⁾ may be used.

In the case of breaking test in small current region, the fuse is not necessarily short circuited by a conductor at the time of measuring the prospective current.

The prospective current at an instant corresponding to the instant of initiation of the arcing of specimen in the breaking test, shall be considered as the prospective breaking current. However, if the instant of initiation of arcing is within 0.5 cycle after commencement of short circuit, the current at an instant 0.5 cycle after commencement of short circuit shall be taken as the prospective breaking current (see Fig. 2 and Fig. 3).

- Note (3) Use of an indicating ammeter for measurement of current is permitted only in such a case that the current is held constant in the greater part of the period to fusion, and the indicating ammeter responds the phenomenon so that the pointer can indicate exactly the actual instantaneous current.
- (b) Power Supply Voltage The power supply voltage shall be expressed in the r.m.s. value of line voltage being applied to the power supply side of the specimen before short-circuiting. The distortion factor⁽⁴⁾ of power supply voltage waveform shall not exceed 10 %.
- (c) Recovery Voltage The recovery voltage shall be obtained between the instant of arc extinction in the specimen and the instant after $1/2f$ to $1/f$ s (f is the frequency of recovery voltage) (see Fig. 2 and Fig. 3).
- The distortion factor⁽⁴⁾ of recovery voltage waveform shall not exceed 10 %.

Note (4) The determination method of distortion factor shall be as specified in Appendix 4.

Fig. 2. Prospective Breaking Current and Recovery Voltage at a Moment of Breaking a Large Current

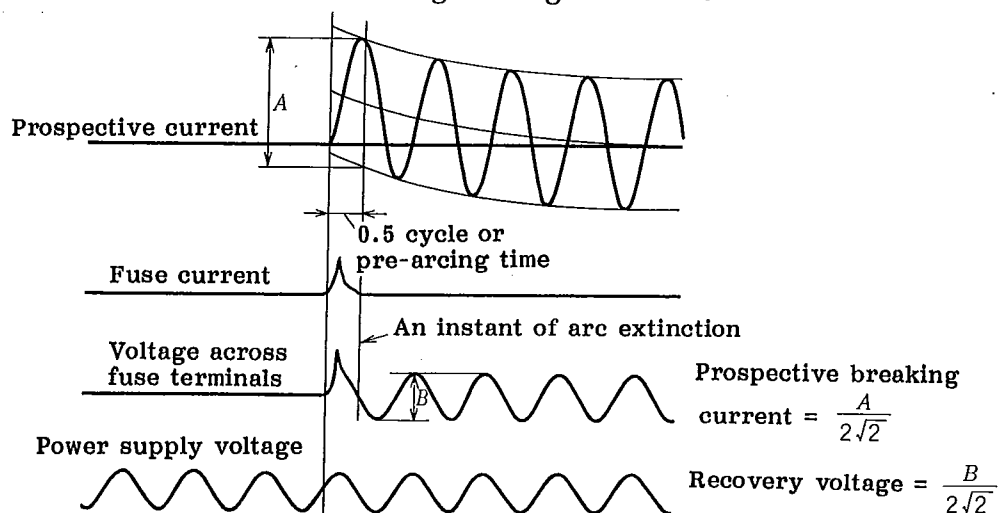
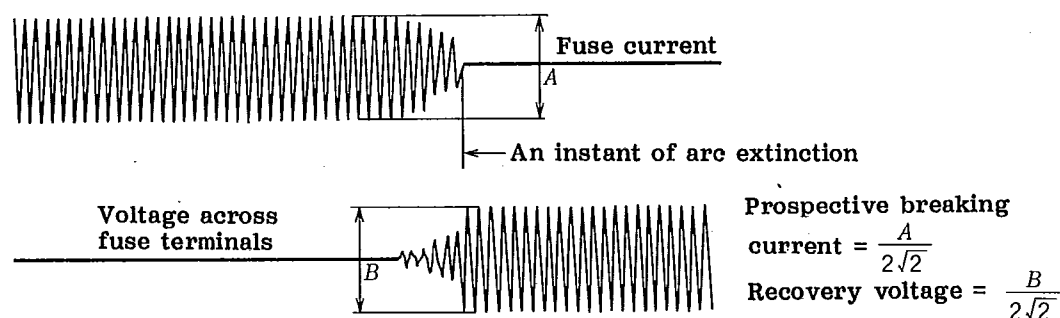


Fig. 3. Prospective Breaking Current and Recovery Voltage at a Moment of Breaking a Small Current



- (d) Short-circuit Power Factor The short-circuit power factor shall be obtained by the methods given in Appendix 5.
- (e) Test Frequency The test frequency shall be 48 to 62 Hz, and the frequency before short circuiting shall be measured.
- (f) Prospective Transient Recovery Voltage of Test Circuit In the test of duty 1 and duty 2, the parameters for waveform of prospective transient recovery voltage of the test circuit shall be obtained from the oscillogram of the voltage by means of the method given in Appendix 6, and recorded. At the measurement of the parameters, a low voltage power supply may be used.
- The waveform shall have characteristic values as close to the standard values given in Table 14 as possible.

Table 14.1. Prospective Transient Recovery Voltage of Test Circuit for Duty 1

Rated voltage (E) kV	Peak value ⁽⁵⁾ (U_c) kV	Virtual rate of rise (U_c/t_b) kV/ μ s	Virtual time to peak value (t_b) μ s	Delay time (t_d) μ s
3.6	6.2	0.16	39	5
7.2	12.3	0.32	39	5

Note ⁽⁵⁾ The formula for calculating U_c in this table are as follows:

$$U_c = 1.4 \times \sqrt{2} \frac{1.5}{\sqrt{3}} E$$