53.3 Parameters

53.3.1 For all equipment

53.3.1.1 The equipment is to be subjected to the number and type of operations in accordance with Table 53.5 and shall comply with Table 56.1. Successive operations are to be conducted by closing the circuit on the equipment ("O" operation) by means of any appropriate switching device, using random closing.

53.3.1.2 The test circuit is to be capable of delivering the current specified in Table 53.3 or Table 53.4 for a given horsepower or full load current rating.

Table 53.3
Short circuit test current values for devices rated 600 volts or less

Maximum horsepower rating, hp[c]	Number of Phases	Equivalent motor full load current, amperes maximum							Test current[a]	Power factor
		110 – 120 V	200 V	208 V	220 – 240 V	380 – 415 V	440 – 480 V	550 – 600 V		
0 – 1	1	16[b]	9.2[b]	8.8[b]	8.0[b]	5.1[b]	4.0[b]	3.2[b]	1000	0.7 – 0.8
over 1 – 2	1	24[b]	13.8[b]	13.2[b]	12.0[b]	7.7	6.0	4.8	5000	0.7 – 0.8
over 2 – 50	1	–	–	–	216	139	108	86	5000	0.7 – 0.8
0 – 1	3	8.4[b]	4.8[b]	4.6[b]	4.2[b]	2.3[b]	2.1[b]	1.7[b]	1,000	0.7 – 0.8
over 1 – 2	3	13.6[b]	7.8[b]	7.5[b]	6.8[b]	4.3	3.4	2.7	5,000	0.7 – 0.8
over 2 – 50	3	260	150	143	130	83	65	52	5,000	0.7 – 0.8
over 50 – 200	3	–	552	528	480	320	240	192	10,000	0.7 – 0.8
over 200 – 400	3	–	–	–	954	636	477	382	18,000	0.25 – 0.30
over 400 – 500	3	–	–	–	1180	786	590	472	30,000	0.20 or less
over 500 – 600	3	–	–	–	10,000 LRA	–	5,000 LRA	4,000 LRA	30,000	0.20 or less
over 600 – 900	3	–	–	–	15,000 LRA	–	7,500 LRA	6,000 LRA	42,000	0.20 or less
over 900 – 1600	3	–	–	–	26,800 LRA	–	13,400 LRA	10,720 LRA	85,000	0.20 or less
over 1600	3	–	–	–	more than 26,800 LRA	–	more than 13,400 LRA	more than 10,720 LRA	100,000	0.20 or less

NOTE – LRA is Locked Rotor Amperes.

[a] Symmetrical rms amperes.

[b] Applies only to overload relays, starters, combination motor controllers, and equipment provided with an overload relay.

[c] For equipment that is not rated in horsepower, the test current shall correspond to the smallest equivalent motor current in the table that is equal to or greater than the rated current of the equipment at the voltage(s) involved.

Table 53.4
Short circuit test values for devices rated 601 – 1500 volts

Full load current, amperes	Test current, symmetrical rms amperes	Power factor
0 – 50	5,000	0.7 – 0.8
51 – 200	10,000	0.7– 0.8
201 – 400	18,000	0.25 – 0.3
401 – 600	30,000	0.20 or less
601 – 850	42,000	0.20 or less
851 – 1500	85,000	0.20 or less
1501 or more	100,000	0.20 or less

53.3.1.3 Fuses and circuit breakers used as main devices need not be mounted in an enclosure. The conductor between the branch circuit protection and the motor control device shall be included in the 4 foot (1.2 m) length as described in 52.3.2.

53.3.2 Provided with fuses – equipment rated 200 hp or less

53.3.2.1 Short circuit tests with fuses on a device having a rating not greater than 200 horsepower (150 kW) are to be in accordance with (a), (b), or (c), as follows:

a) On a single-phase circuit with two poles and one current element in the circuit – three test operations for each current element selected;

b) If rated single-phase only and provided with two current elements – three test operations for each current element selected on a single-phase circuit with two poles and two current elements in the circuit; or

c) If rated 3-phase – two test operations for each current element selected on a 3-phase circuit with three poles and three current elements.

53.3.2.2 The poles – contacts – referred to in 53.3.2.1 may be omitted from the circuit after a sufficient number of tests have been conducted to determine that subsequent malfunction or breakdown of the equipment due to contact arcing is unlikely. Consideration is to be given to contact arcing while testing the intermediate as well as the higher-rated current elements.

53.3.3 Provided with circuit breaker – equipment rated 200 hp or less

53.3.3.1 Short circuit tests on a device having a maximum rating of 200 horsepower (150 kW) or less with an inverse-time or instantaneous-trip circuit breaker are to consist of:

a) Two operations on a 3-phase circuit with three poles and three overload relays in the circuit for a device having three or more poles.

b) For a product rated single phase only:

1) Two poles and two overload relays are to be used if overload relays are provided in each conductor to the motor and

2) Two poles and one overload relay are to be used for other arrangements.

53.3.4 For equipment rated over 200 hp

53.3.4.1 Short-circuit tests on a device having a maximum rating in excess of 200 horsepower (150 kW) are to consist of one test operation on a 3-phase circuit, with three poles and three overload relays in the circuit. The tests are to be performed with protective devices selected in accordance with either note (h) or (i) of Table 53.1 or 53.1.3.1 (a) or (b). If an inverse-time circuit breaker is adjustable, it is to be set at the maximum tripping time unless the product is marked to indicate a limit of protection. A product not provided with three overload relays is to be tested with three poles and two overload relays in the circuit.

Exception: The test may be performed for a period of time at least equivalent to the opening time of the protective device specified on the motor control device at the required level of test current.

53.3.4.2 The number of test operations for each current element selected is to be as specified in Table 53.5.

Table 53.5
Required number of test operations

Rating		Number of poles for a device	Number of current elements[a]	Type of branch circuit protection and number of poles provided		Number of operations[b]
Horsepower	(kW)			Fuse	Circuit breaker	
0 – 200	(0 – 149)	1 phase, single pole	1	1	single pole inverse-time	3 "O" operations
		1 phase, 2 poles	2	2	2 pole inverse-time	3 "O" operations
		3 phase, 3 poles	3	3	3 pole inverse-time	2 "O" operations
201 – 1600	(150 – 1193)	3 phase, 3 poles	3	3	3 pole inverse-time	1 "O" operation

[a] Applies to devices provided with or incorporating a thermal overload relay. See 53.3.2.1, 53.3.3.1, and 53.3.4.1.

[b] Number of operations for each current element selected, when device is provided with or incorporates thermal overload relays.

54 High-Available Fault Current Circuits (Optional)

54.1 General

54.1.1 The optional requirements in this section cover combination motor controllers and motor control devices with or without overload relays for use on circuits having available short circuit currents in excess of the minimum levels specified in Table 53.3, and not more than 200,000 amperes rms symmetrical. For other than a combination motor controller with integral protective devices, the specific type of protective device shall be specified for the product and marked as specified in 70.3. The test current levels shall be one of the values given in Table 54.1.

Table 54.1
High Available Fault Current – Short Circuit Test current values rms symmetrical or dc amperes

7,500	25,000	65,000
10,000	30,000	85,000
14,000	35,000	100,000
18,000	42,000	125,000
20,000	50,000	150,000
22,000	–	200,000

54.1.2 Combination motor controllers and motor control devices with or without overload relays shall additionally comply with Section 53, Standard Fault Current Circuits, which is able to be conducted on a separate set of samples.

54.2 Sample selection

54.2.1 Overload relay

54.2.1.1 Samples for the test are to be selected among motor control devices employing the largest and smallest size current element that may be used with the protective device specified for the motor control device.

54.2.1.2 The maximum number of current elements that can be accommodated by the device are to be in place during each test. Three-phase tests are considered to cover single-phase tests for a device of the same design.

54.2.2 Protective devices

54.2.2.1 For a motor control device or overload relay intended to be used with circuit breakers, the protective devices used for the test are to be sized in accordance with 53.1.3.1 and are to be selected as follows:

a) A circuit breaker installed within a combination motor control device is considered to be representative of all other breakers of the same manufacturer, rating, and frame construction. The interrupting rating of the circuit breaker is to be at least the marked short-circuit current rating of the motor control device.

Exception: A circuit breaker with a lower interrupting rating is able to be used when the combination is evaluated and subjected to the appropriate requirements of the Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, UL 489.

b) For noncombination controllers, the circuit breaker to be used is to be selected from commercially available units of the molded-case type having essentially the same characteristics with respect to let-through (I^2t) and peak let-through current (I_p) and current-limiting features.

c) For circuit breakers with current limiters provided as part of the control device, the current limiter shall be selected such that when tested on a single-phase circuit, the peak let-through current and a clearing I^2t are not less than the maximum value established for the current limiter intended to be used with the motor control device being tested.

d) For instantaneous circuit breaker, they shall be adjusted to their maximum setting and no more than 13 times the full load current or 17 times the full load current for controllers marked for use with high-efficiency Design B motors.

Exception: Combination motor controller self-protecting control devices are provided with integral short-circuit and ground-fault protection.

54.2.2.2 For a motor control device or overload relay intended to be used with fuses, the protective devices used for the test are to be sized in accordance with 53.1.2.1 and are to be selected as follows:

a) Fuses specified for branch-circuit protection for motor control devices rated over 10,000 amperes shall be limited to high-interrupting capacity, current-limiting types – for example, Class CC, G, J, L, R, and T.

Exception: A motor control device rated 50 horsepower (37 kW) or less and tested at 10,000 amperes, is able to specify Class H or K fuses for motor-branch-circuit protection.

b) A motor control device that is required to be used with RK1 or RK5 fuses is to be tested with fuses having I^2t and I_p characteristics for Class RK5 fuses. All references to Class R fuses are intended to mean fuses with energy let-through (I^2t), characteristics of Class RK5 fuses.

Exception: A motor control device that is marked to restrict its use to RK1 fuses is able to be tested with fuses having energy let-through characteristics of a Class RK1 fuse.

c) A Class CC, G, J, L, R, or T fuse, or motor short-circuit protector is to be selected such that, when tested on a single-phase circuit, the peak let-through current and clearing I^2t are not less than the maximum value established for the fuse – see the UL 248 series of standards – or motor short-circuit protector rating that is intended to be used with the controller being tested. For a fuse with I_p and I^2t limits established for several different short-circuit current levels, the test fuse is to be selected to have at least the maximum values of the current corresponding to the marked short-circuit current rating of the motor control device.

Exception No. 1: A test limiter is able to be used in place of the fuses.

Exception No. 2: Combination motor controller self-protecting control devices are provided with integral short-circuit and ground-fault protection.

54.3 Procedure

54.3.1 A combination motor controller or motor control device with or without overload relays shall be tested according to the requirements in this section and shall additionally comply with Section 52, Short Circuit Test – General. The terminals of the test circuit described in 52.3.1 are to be connected together by a copper bar, and the test circuit is to be calibrated as described in Section 57, Calibration of Test Circuits, at the maximum available short circuit current for which the motor control device is rated.

54.3.2 The test circuit is to have the characteristics specified in Table 54.2.

Table 54.2
High-capacity short circuit test values for devices rated 600 V or less

Test current, amperes[a]	Power factor[b]
10,000 amperes or less	0.70 – 0.80
10,001 – 20,000	0.25 – 0.30
Greater than 20, 000	0.15 – 0.20

[a] Symmetrical rms amperes

[b] Lower power factor circuits than specified may be used.

54.3.3 For the short-circuit-closing test (“CO” shot), each switching device of the motor control device is closed on the test circuit. This requires separate tests for each switching device, as specified in Table 54.3: one in which the disconnecting means, when provided, is closed on the circuit, and a second in which the contactor is closed on the circuit. Complete physical closure of the switching contacts is not required to be established. When complete physical closure of the switching contact is established, the closing test on the disconnecting means is able to cover the withstand test (“O” shot) on the motor control device and the closing test on the motor control device is able to cover the withstand test on the disconnecting means. To determine whether complete physical closure of the contacts has occurred, the oscillogram of the short circuit current and voltage traces are reviewed between circuit initiation and current interruption by the protective device. A smooth sinusoidal waveform in this area of the trace is an indication of complete physical closure.

Table 54.3
Required number of test operations

Disconnecting means provided	Type of test	Number of test operations
Yes	Disconnecting means closed on the circuit ("CO" shot)	1[a,b]
Yes	Motor control device closed on the circuit ("CO" shot)	1[a]
Yes	Circuit closed on equipment ("O" shot)	1
No	Motor control device closed on the circuit ("CO" shot)	1
No	Circuit closed on equipment ("O" shot)	1[c]

[a] If complete physical closure of the switching contact is established during closing tests ("CO" shots), the withstand test ("O" shot) is not required.

[b] When a motor control device and its control circuit are supplied from the same source (common control), the closing test on the disconnect switch is not required.

[c] When a stand-alone overload relay is subjected to this test, the overload relay shall be subjected to two “O” shots closing the circuit on the equipment under test.

54.3.4 The equipment is to be subjected to the number and type of operations in accordance with Table 54.3 and shall comply with Table 56.1. Successive operations on a motor control device or overload relay without a disconnecting means are to be conducted by alternating closing the equipment on the circuit ("CO" operation) and closing the circuit on the equipment ("O" shot), using random closing.

54.3.5 When closing the circuit on the equipment ("O" shot), the disconnecting means, when provided, and the motor control device are to be in the fully closed position. When manual motor control devices are to be closed onto the test circuit ("CO" shot), they are to be operated in a manner that would normally be anticipated in service (i.e., in a continuous, uniform movement of the operating handle from the "off" to the "on" position).

55 Group Installation (Optional)

55.1 General

55.1.1 A motor control device or overload relay intended for group installation at standard fault currents shall be tested in accordance with 55.2 and 55.3 and shall also comply with the short circuit test requirements in Section 53, Standard Fault Current Circuits, conducted on a separate set of samples. A motor control device or overload relay intended for group installation at high fault currents shall be tested in accordance with 55.2, 55.3, and 55.4. All devices for group installation according to 55.1.2 shall be marked in accordance with 70.4. All devices for group installation as described in 55.1.3 shall be marked in accordance with 70.5 and 70.6.

55.1.2 The requirements in this section cover a motor control device or overload relay:

a) For use on circuits having available short circuit currents at standard fault levels or at high fault levels; and

b) Protected by a circuit breaker or fuse(s), intended to provide branch circuit protection for two or more motors, or one or more motors and other loads. The protective device(s) shall be selected in accordance with 53.1, except the current rating of the protective device is not limited to those values specified in Table 53.1 or Table 53.2. The maximum size of the branch circuit protective device shall not exceed the ampere rating calculated from the following formula:

$$Amperes = [9.6 \times (maximum\ wire\ size)] - [2.2 \times (minimum\ motor\ FLA)]$$

in which:

Maximum wire size is the ampacity from Table 45.3 of the largest conductor size for which the device terminals have been evaluated; and

Minimum motor FLA is the smallest rated FLA (or equivalent FLA from horsepower rating per Table 47.2) marked on the device.

55.1.3 When intended for installation on the load side of a manual motor controller that has been previously found suitable for tap conductor protection, a motor controller is able to be evaluated to group installation requirements in this section while installed on the load side of the specified manual motor controller. No additional overcurrent protective devices are included in the test circuit.

55.2 Sample selection

55.2.1 A sample of a motor control device, three samples of an overload relay current element, or one sample of a three phase overload relay that complies in all other respects with requirements in this standard shall be subjected to short circuit tests. The device is to be connected in series with either:

a) A nonrenewable cartridge fuse(s) or an inverse-time circuit breaker of the maximum standard rating with which the motor control device or element is intended to be used and not more than specified in 55.1.2(b); or

b) A manual motor controller suitable for tap conductor protection as in 55.1.3.

55.2.2 Samples of overload relays shall be selected in accordance with 53.2 for standard fault ratings.

55.2.3 Samples of overload relays are to be selected in accordance with 54.2.1.1 for high fault ratings.

55.3 Group installation for standard fault circuit ratings

55.3.1 A motor control device or overload relay having short circuit ratings at levels specified in Table 53.3 shall comply with Table 56.1 when subjected to a short circuit test described in 55.3.2.

55.3.2 The requirements in 53.3 are to be applied, and the test circuit is to be calibrated as described in Section 57, Calibration of Test Circuits, at the standard available short circuit current for which the motor control device or overload relay is rated.

55.4 Group installation for high capacity short circuit ratings

55.4.1 A motor control device or overload relay having short circuit ratings in excess of the levels specified in Table 53.3 shall comply with Table 56.1 when subjected to a short circuit test described in 55.4.2.

55.4.2 The requirements in 54.3 are to be applied and the test circuit is to be calibrated as described in Section 57, Calibration of Test Circuits, at the maximum available short circuit current for which the motor control device or overload relay is rated.

56 Standard and High Fault Acceptance Criteria

56.1 After the protective device or the motor control device has cleared the fault, an overload relay, industrial control equipment incorporating an overload relay, a starter, a combination motor controller, or a motor control device shall comply with Table 56.1.

Table 56.1
Maximum damage criteria

Product	Damage criteria reference
Motor control device	a – i
Starter, industrial control equipment incorporating an overload relay	a – k

All devices

a) The solid AWG wire connected between the live pole and the enclosure shall not open.

b) The door or cover shall not be blown open, and it shall be possible to open the door or cover. When deformation of the enclosure occurs, all resulting openings in the enclosure shall comply with 7.17.1 for accessibility of live parts under normal operating conditions.

c) There shall be no damage to a conductor or terminal connector and no conductor shall pull out of a terminal connector. There shall be no damage to bus bars, their insulators and connectors, including stab-in assemblies, and there shall be no evidence of shifting or pullout of bus bars from their mounting means or at terminals.

d) There shall be no breakage or cracking of insulating bases to the extent that the integrity of the mounting of live parts is impaired.

e) Discharge of parts or any risk of a fire shall not occur.

Motor control devices

f) The load switching function of the motor control device is able to be inoperative at the conclusion of the test. The contacts of the motor control device are able to weld or completely disintegrate.

g) *Deleted*

h) *Deleted*

i) *Deleted*

Overload relays

j) When burnout of the current element of a mechanical overload relay occurs, the device shall be marked as specified in 72.7 and the test shall be repeated with the minimum resistance element in the smallest size or construction that does not burn out.

k) *Deleted*

Combination motor controllers

l) *Deleted*

m) *Deleted*

n) *Deleted*

57 Calibration of Test Circuits

57.1 Circuit characteristics

57.1.1 Equipment rated for direct current is to be tested using a direct current electrical source; alternating-current equipment is to be tested on a 60-hertz essentially sinusoidal current electrical source. The open-circuit voltage of the test circuit is to be 100 to 105 percent of the voltage rating of the overload relay, except that the voltage may exceed 105 percent of the rated voltage with the concurrence of those concerned. The test circuit is to be capable of delivering the specified current when the system is short-circuited at the testing terminals to which the device under test is to be connected, and this is to be verified by means of an oscillograph.

57.1.2 For available fault current circuits, air core type reactors are to be employed in the line to obtain the power factor in accordance with Table 53.5. The reactors may be connected in parallel, but no reactor is to be connected in parallel with a resistor; except that a reactor in any phase may be shunted by a resistor if the power consumed by the resistor is in the range between 0.55 – 0.65 percent of the reactive volt-amperes in the reactor in that phase. The minimum value of the shunting resistance used with a reactor having negligible resistance is to be calculated from the equation:

$$R = 167\frac{E}{I}$$

in which E is the phase voltage across the reactor with phase current I flowing as determined by oscillographic measurement during the short circuit calibration or by proportion from meter measurements at some lower current.

57.2 Alternating-current circuits

57.2.1 General

57.2.1.1 The available current capacity of the circuit is to be at least the value required for the short-circuit-current rating of the motor control device. The frequency of the test circuit is to be 60 ±12 hertz for an alternating-current circuits.

57.2.1.2 The available rms symmetrical current is to be determined at the device terminals.

Exception No. 1: For a circuit rated 25,000 amperes or less, the available current may be determined at the test-station terminals.

Exception No. 2: The available current may be determined at the test-station terminals if for a circuit having a maximum available short-circuit current:

> *a) Between 25,001 – 50,000 amperes, the available current is determined to be 5 percent higher than the required test current: or*
>
> *b) Between 50,001 – 200,000 amperes, the available current is determined to be 10 percent higher than the required test current.*

If the available current is determined at the test-station terminal and the physical arrangement in the test station requires leads longer than 8 feet (2.4 m) per terminal, the additional length of leads is to be included in the circuit calibration.

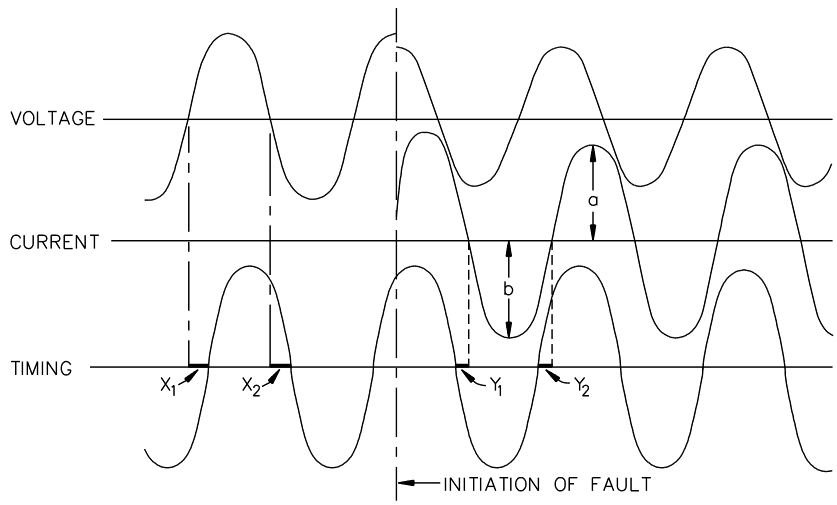
57.2.2 Available current of 10,000 amperes or less

57.2.2.1 For an alternating-current circuit intended to deliver 10,000 amperes or less, the current and power factor are to be determined as follows:

> a) For a 3-phase test circuit, the current is to be determined by averaging the rms values of the first complete cycle of current in each of the three phases; the voltage to neutral is to be used to determine the power factor.
>
> b) For a single-phase test circuit, the current is to be the rms value of the first complete cycle – see Figure 57.1 – when the circuit is closed to produce an essentially symmetrical current waveform. The direct-current component is not to be added to the value obtained when measured as illustrated. In order to obtain the desired symmetrical waveform of a single-phase test circuit, controlled closing is recommended although random closing methods may be used. The power factor is to be determined by referring the open-circuit voltage wave to the two adjacent zero points at the end half of the first complete current cycle by transposition through a suitable timing wave. The power factor is to be computed as an average of the values obtained by using these two current zero points.

Figure 57.1

Determination of current and power factor for circuits of 10,000 amperes and less



$$Current = \frac{a+b}{2} \text{ rms calibration of instrument element}$$

$$Power\ Factor = \frac{Cosine\left[(Y_1 + X_1) \times 180°\right] + Cosine\left[(Y_2 + X_2) \times 180°\right]}{2}$$

Where X_1, X_2, Y_1, and Y_2 values of the power factor are fractions of the 1/2-cycle distance in which they occur.

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57.2.3 Available current of more than 10,000 amperes

57.2.3.1 For circuits intended to deliver more than 10,000 amperes, the current and power factor are to be determined in accordance with the requirements in 57.2.3.2 – 57.2.3.6. Instrumentation used to measure test circuits of over 10,000 amperes is to comply with the requirements in 57.4.

57.2.3.2 The rms symmetrical current is to be determined, with the supply terminals short-circuited by measuring the alternating-current component of the wave at an instant 1/2 cycle – on the basis of the test frequency timing wave – after the initiation of the short circuit. The current is to be calculated in accordance with Figure 7 in the Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis, ANSI/IEEE C37.09-1979(R1989).

57.2.3.3 For a 3-phase test circuit, the rms symmetrical current is to be the average of the currents in the three phases. The rms symmetrical current in any one phase is not to be less than 90 percent of the required test current.

57.2.3.4 The test circuit and its transients are to be such that 3 cycles after initiation of the short circuit, the symmetrical alternating component of current will not be less than 90 percent of the symmetrical alternating component of current at the end of the first 1/2 cycle, or the symmetrical alternating component of current at the time at which the overcurrent-protective device will interrupt the test circuit is at least 100 percent of the rating for which the motor control device is being tested. In 3-phase circuits, the symmetrical alternating component of current of all three phases is to be averaged.

57.2.3.5 The power factor is to be determined at an instant 1/2 cycle – on the basis of the test frequency timing wave – after the short circuit occurs. The total asymmetrical rms amperes are to be measured in accordance with 57.2.3.2 and the ratio M_A or M_M is to be calculated as follows:

$$M_A\,(3\ phase) = \frac{Av.\ 3\ phases - Asymmetrical\ \ RMS\ \ Amperes}{Av.\ 3\ Symmetrical\ \ RMS\ \ Amperes}$$

$$M_M\,(1\ phase) = \frac{Asymmetrical\ \ RMS\ \ Amperes}{Symmetrical\ \ RMS\ \ Amperes}$$

Using ratio M_A or M_M, the power factor is to be determined from Table 57.1.

Table 57.1
Short-circuit power factor

Short-circuit power factor, percent	Ratio M_M[a]	Ratio M_A[a]	Short-circuit power factor, percent	Ratio M_M[a]	Ratio M_A[a]
0	1.732	1.394	30	1.130	1.066
1	1.696	1.374	31	1.121	1.062
2	1.665	1.355	32	1.113	1.057
3	1.630	1.336	33	1.105	1.053
4	1.598	1.318	34	1.098	1.049
5	1.568	1.301	35	1.091	1.046
6	1.540	1.285	36	1.084	1.043
7	1.511	1.270	37	1.078	1.039
8	1.485	1.256	38	1.073	1.036
9	1.460	1.241	39	1.068	1.033
10	1.436	1.229	40	1.062	1.031
11	1.413	1.216	41	1.057	1.028
12	1.391	1.204	42	1.053	1.026
13	1.372	1.193	43	1.049	1.024
14	1.350	1.182	44	1.045	1.022
15	1.330	1.171	45	1.041	1.020
16	1.312	1.161	46	1.038	1.019
17	1.294	1.152	47	1.034	1.017
18	1.277	1.143	48	1.031	1.016
19	1.262	1.135	49	1.029	1.014
20	1.247	1.127	50	1.026	1.013
21	1.232	1.119	55	1.015	1.008
22	1.218	1.112	60	1.009	1.004
23	1.205	1.105	65	1.004	1.002
24	1.192	1.099	70	1.002	1.001
25	1.181	1.093	75	1.0008	1.0004
26	1.170	1.087	80	1.0002	1.00005
27	1.159	1.081	85	1.00004	1.00002
28	1.149	1.075	100	1.00000	1.00000
29	1.139	1.070			

[a] See 57.2.3.5.

57.2.3.6 The power factor of a 3-phase circuit may be calculated by using controlled closing so that upon subsequent closings a different phase will be caused to have maximum asymmetrical conditions. The power factor of each phase could then be determined using the method described for single-phase circuits