

b) If the double-throw switch is provided with a mechanical means to reduce the likelihood of the load switching from the normal source of supply to an alternate source of supply in one continuous motion, testing in accordance with 7.3.1.4 shall be permitted.

No Text on This Page

c) If the double-throw switch is constructed such that the movable contact of the normal supply is not in motion at the same time as the movable contact of the alternate supply, testing in accordance with 7.3.1.4 shall be permitted.

7.3.1.6 A cycle for a double throw-switch for use as optional standby systems in accordance Annex A, Ref. No. 1, is defined as making and breaking the required test current on both sets of contacts.

7.3.2 Test conditions

7.3.2.1 A switch shall be mounted as in actual service with the door or cover and any other openings closed. The line terminals shall be connected to a supply circuit, and the load terminals shall be connected to the necessary resistance or impedance.

7.3.2.2 A deadfront switch shall be mounted in a panelboard or on a representative chassis, provided spacings from live parts in the switch to the main bus structure and to grounded chassis metal are representative of those in the complete panelboard.

7.3.2.3 A switch intended for use on dc circuits and a switch not specially marked for alternating current only shall be tested with direct current, with a noninductive resistance load, and with the device so connected that the enclosure will be positive in potential with respect to the nearest arcing point.

7.3.2.4 The open-circuit voltage shall not be less than 100 percent of the rated voltage of the switch, and the closed-circuit voltage shall not be less than 90 percent of the rated voltage of the switch or the normal-frequency recovery voltage shall be equal to the rated voltage of the device.

7.3.2.5 A switch intended for ac circuits only shall be tested with alternating current with an inductive load. The test shall be made on a circuit having a maximum frequency of 60 Hz. Resistance and reactance components of the load shall not be connected in parallel, except that an air-core reactor in any phase may be shunted by resistance, the loss in which is approximately 1 percent of the total power consumption in that phase. The shunting resistance used with an air-core reactor may be calculated from the following formula:

$$R_{SH} = 100[(1/PF) - PF]E/I$$

in which PF is the power factor, E is the closed-circuit phase voltage, and I is the phase current.

7.3.2.6 A switch intended for use on circuits having one conductor grounded shall be tested with the enclosure connected through a 30 ampere non-delay, non-renewable-type cartridge fuse to the grounded conductor. If an enclosed switch is intended for use on other types of circuits, the enclosure shall be connected through a similar fuse to the live pole least likely to strike to ground.

7.3.2.7 A 2-wire and a 3-wire switch intended for use on either 3-wire dc or single-phase ac circuits with grounded neutral shall be tested on a 3-wire dc circuit with grounded neutral, with the switch connected to the outside conductors of the circuit, and with the enclosure grounded as indicated in 7.3.2.6. If the switch is intended for use with alternating current only, it shall be tested with alternating current in a similar manner and in accordance with 7.3.2.5.

7.3.2.8 A 3-wire switch without a solid neutral intended for use on ac circuits other than that described in 7.3.2.7 and a 4-wire switch having a solid neutral shall be tested on a 3-phase circuit with a 3-phase balanced load.

7.3.2.9 A 4-wire switch without a solid neutral and a 5-wire switch shall be tested on a single-phase circuit with connections to adjacent poles, one pole being that nearest the enclosure. If the spacings between the poles differ, an additional test shall be made with connections to the pair of poles having the least separation.

7.3.2.10 A switch marked for isolating use only and rated at more than 1 200 A at 250 V or less shall be subjected to the overload test with a current of 1 800 A. A switch marked for isolation use only and rated at more than 600 A at more than 250 V shall be subjected to the overload test with current 900 A. See 9.2.12.

7.4 Endurance test

7.4.1 The same switch previously subjected to the overload test shall perform successfully when operated:

- a) For the number of cycles and rate of speed indicated in Table 19,
- b) Making and breaking 100 percent of its rated current. Switches for isolating use only, rated at more than 1 200 A at 250 V or less, and switches rated at more than 600 A at more than 250 V may be operated without current, if the switch is marked in accordance with 9.2.12,
- c) With the test potential as described in 7.3.2.4 for an ac switch and within 5 percent of the rated voltage of the switch if direct current is used, and
- d) With a power (factor for an ac switch) of 0.75 – 0.80 maximum.

There shall not be any electrical or mechanical malfunction of the device or welding of the contacts. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.4.2 For a switch having both ampere and horsepower or kilowatt horsepower ratings, the endurance test for the horsepower- or kilowatt-rated sample need not be conducted if represented by the endurance test for the general-use rating.

Table 19
Endurance test cycles

Switch rating in amperes	Number of cycles of operation per minute ^a	Number of cycles of operation		
		With current	Without current	Total
100 and less	6	6 000	4 000	10 000
200	5	6 000	2 000	8 000
400	4	1 000	5 000	6 000
600	3	1 000	4 000	5 000
800	2	500 ^b	3 000	3 500
1 200	1	500 ^b	2 000	2 500
1 600 – 2 500	1	500	2 000	2 500 ^c
3 000 – 4 000	1 ^d	400	1 100	1 500 ^c

^a The indicated number of cycles of operation per minute applies only to that part of the test made with current. When no current is used, the switch may be operated at any convenient speed.

^b For a switch marked "For isolating use only" (see 9.2.12) the switch is not operated with current in the endurance test.

^c For switches rated over 1 200 A at 250 V or less and marked in accordance with 9.2.12, the total number of operations is 1000 without current.

^d Rate of operation: 1 cycle per minute for first ten operations; thereafter in groups of five (at 1 cycle per minute) with an interval between groups that is agreeable to all concerned.

7.4.3 For horsepower- or kilowatt-rated switches, the endurance test shall be made with whichever is greater – the rated current of the device or the current selected from the appropriate full-load motor-running currents stated in Table 20 and 21. A fused motor-circuit switch shall be tested at 125 percent of the current given in Table 20 and Table 21. See also 9.2.4.

7.4.4 The current for the common wire of a 2-phase, 3-wire system is 1.414 times the value in Table 20 for a 2-phase, 4-wire system.

7.4.5 The endurance test of a double-throw switch shall be made with the connections that are shown by the overload test to be the most severe (see 7.3.1.4).

7.4.6 In determining if a switch complies with the requirements in 7.4, test conditions shall be as described in 7.3.2.

Table 20
Endurance-test currents in amperes for alternating-current switches

Switch rating in		120 V ^a			240 V			480 V			600 V		
kW	hp	1φ	2φ	3φ	1φ	2φ	3φ	1φ	2φ	3φ	1φ	2φ	3φ
		4-Wire			4-Wire			4-Wire			4-Wire		
0.125	1/6	4.4	—	—	2.2	—	—	—	—	—	—	—	—
0.187	1/4	5.8	—	—	2.9	—	—	—	—	—	—	—	—
0.248	1/3	7.2	—	—	3.6	—	—	—	—	—	—	—	—
0.373	1/2	9.8	4.0	4.4	4.9	2.0	2.2	—	1.0	1.1	—	0.8	0.9
0.560	3/4	13.8	4.8	6.4	6.9	2.4	3.2	3.5	1.2	1.6	2.8	1.0	1.3
0.746	1	16	6.4	8.4	8	3.2	4.2	4.0	1.6	2.1	3.2	1.3	1.7
1.119	1-1/2	20	9.0	12	10	4.5	6	5.0	2.3	3	4.0	1.8	2.4
1.492	2	24	11.8	13.6	12	5.9	6.8	6.0	3.0	3.4	4.8	2.4	2.7
2.238	3	34	16.6	19.2	17	8.3	9.6	8.5	4.2	4.8	6.8	3.3	3.9
3.73	5	56	26.4	30.4	28	13.2	15.2	14.	6.6	7.6	11.2	5.3	6.1
5.60	7-1/2	80	38	44	40	19	22	21	9	11	16	8	9

Table 20 Continued on Next Page

This is a preview. Click here to purchase the full publication.

Table 20 Continued

Switch rating in		120 V ^a			240 V			480 V			600 V		
kW	hp	1 ϕ	2 ϕ	3 ϕ	1 ϕ	2 ϕ	3 ϕ	1 ϕ	2 ϕ	3 ϕ	1 ϕ	2 ϕ	3 ϕ
		4-Wire			4-Wire			4-Wire			4-Wire		
7.46	10	100	48	56	50	24	28	26	12	14	20	10	11
11.19	15	135	72	84	68	36	42	34	18	21	27	14	17
14.92	20	—	94	108	88	47	54	44	23	27	25	19	22
18.65	25	—	118	136	110	59	68	55	29	34	44	24	27
22.38	30	—	138	160	136	69	80	68	35	40	54	28	32
22.84	40	—	180	208	176	90	104	88	45	52	70	36	41
37.30	50	—	226	260	216	113	130	108	56	65	86	45	52
44.76	60	—	—	—	—	—	154	—	—	77	—	—	62
55.95	75	—	—	—	—	—	192	—	—	96	—	—	77
74.60	100	—	—	—	—	—	248	—	—	124	—	—	99
93.25	125	—	—	—	—	—	312	—	—	156	—	—	125
111.9	150	—	—	—	—	—	360	—	—	180	—	—	144
149.2	200	—	—	—	—	—	480	—	—	240	—	—	192
186.5	250	—	—	—	—	—	—	—	—	302	—	—	242
223.8	300	—	—	—	—	—	—	—	—	361	—	—	289
261.1	350	—	—	—	—	—	—	—	—	414	—	—	336
298.4	400	—	—	—	—	—	—	—	—	477	—	—	382
335.7	450	—	—	—	—	—	—	—	—	515	—	—	412
373.0	500	—	—	—	—	—	—	—	—	590	—	—	472

^a For 127 V ratings, the test is conducted at rated voltage with the currents in this column.

Table 21
Endurance-test currents in amperes for direct-current switches

Switch rating		125 V	250 V	600 V
kW	hp			
0.373	1/2	5.4	2.7	—
0.56	3/4	7.6	3.8	—
0.746	1	9.4	4.7	1.8
1.119	1-1/2	13.2	6.6	2.6
1.462	2	17	8.5	3.4
2.238	3	25	12.2	5.0
3.73	5	40	20	8.3
5.60	7-1/2	58	29	12
7.46	10	76	38	16
11.19	15	112	55	23
14.92	20	148	72	31
18.65	25	—	89	89
22.38	30	—	106	46
29.84	40	—	140	61
37.30	50	—	173	75

7.5 Dielectric voltage-withstand test

7.5.1 A single-throw switch (with fuses, if any, in place) shall withstand for 1 minute without breakdown the application of a 60 Hz essentially sinusoidal voltage of 1 000 V plus twice the maximum rated voltage:

- a) Between live parts and the enclosure with the switch closed,
- b) Between terminals of opposite polarity with the switch closed, and
- c) Between the line and load terminals with the switch open.

7.5.2 A double-throw switch for use in optional standby systems in accordance with Annex A, Ref. No. 1, shall have the potential voltage applied:

- a) Between live parts and the enclosure with the contact alternately closed to each supply source,
- b) Between terminals of opposite polarity with the contacts closed,
- c) Between live parts of different circuits, and
- d) Between terminals of the normal source and the alternate source with the switch in both normal and alternate positions.

7.5.3 To determine if a switch complies with the requirements in Clause 7.5, Dielectric voltage-withstand test, the device shall be stressed by means of a 500 VA or larger transformer, the output voltage of which can be varied. The applied voltage shall be increased from zero until the required test value is reached and held at that value for 1 minute. The increase in the applied voltage shall be at a substantially uniform rate and as rapid as is consistent with its value being correctly indicated by the voltmeter. A transformer less than 500 VA shall be permitted if the output voltage is measured directly.

7.6 Clamped joint test

7.6.1 A clamped joint between two insulators (reference 6.6.1.18) shall be tested using two samples:

- a) The clamped joint on the first sample shall be opened up to produce a space 3.2 mm (1/8 inch) wide. This may be accomplished by loosening the clamping means or by drilling a 3.2 mm (1/8 inch) diameter hole at the joint between the insulators at a point of minimum spacing between the metal parts on the opposite sides of the joint. The drilled hole shall not decrease spacings between the opposite polarity parts as measured through the crack between the insulators. The 60 Hz dielectric breakdown voltage through this hole shall then be determined by applying a gradually increasing voltage (500 V per second) until breakdown occurs.
- b) The second sample, with the clamped joint intact, shall be subjected to a gradually increasing 60 Hz voltage until 110 percent of the breakdown voltage of item (a) has been reached. If the breakdown voltage of item (a) is less than 4 600 V rms, the voltage to be applied to the second sample shall be further increased to 5 000 V rms and held for 1 second. There shall be no electrical breakdown of the second sample.

7.7 Close-open test

7.7.1 Switches rated higher than 10 000 amperes short-circuit current shall comply with the Close-open test requirements in 7.7.2 – 7.7.6.

7.7.2 A deadfront switch shall be mounted and connected to the test circuit in the same manner as for the overload test as specified in 7.3.2.2.

7.7.3 The test conditions shall be as follows:

- a) A previously untested sample shall be used.
- b) The line terminals of an ac rated switch shall be connected to the power supply circuit and the load terminals of the switch to an inductive load. The connections for a dc rated switch shall be as specified in 7.3.2.3.
- c) The test circuit shall be as follows:
 - i) For ac rated switches, the power factor of the load shall be 0.45 – 0.50.
 - ii) For dc rated switches, testing shall be on a dc circuit with a time constant not less than 0.003 s. The time constant shall be measured on the oscillogram of the test current where the value is 63.2% of the maximum current.
- d) The current shall be 600% of the rated current of the device.
- e) A shunting resistance as described in 7.3.2.5 shall be permitted.
- f) The open-circuit test voltage shall not be less than 100% of the rated voltage of the device.
- g) The closed-circuit test voltage shall not be less than 90% of the rated voltage of the device, or the normal-frequency recovery voltage shall be equal to the rated voltage of the device.
- h) A ground fuse as described in 7.3.2.6 shall be used.
- i) A polyphase switch or a dc rated switch shall be subjected to 3 operations. A switch intended for use on single-phase ac circuits only shall be subjected to 5 operations.
- j) The time between operations is not specified.
- k) Servicing the blades and jaws before each operation shall be permitted. Servicing is considered to be filing, lubricating, deburring, and the like. There shall not be any disassembly of the device to accomplish the servicing. Servicing shall not include replacement of any part.

7.7.4 At the conclusion of the test, the switch shall be in operating condition. The ground fuse shall not have opened. Burning or pitting of the contacts shall be considered to be acceptable, but line-to-line breakdown shall be considered to be unacceptable.

7.7.5 Upon completion of the test, the test sample shall not be serviced in any manner before conducting the dielectric voltage-withstand test. After completion of the dielectric voltage-withstand test, servicing the switch prior to the short-circuit withstand test shall be permitted.

7.7.6 The dielectric voltage-withstand test described in 7.5 shall be conducted following the close-open test.

7.8 Short-circuit withstand test

7.8.1 The following switches shall be subjected to the tests outlined in 7.8 – 7.9:

- a) Switches rated higher than 10 000 A short circuit current rating,
- b) Unfused switches, having a 5 000, 7 500, or a 10 000 A short-circuit current rating and marked for use with overcurrent protective devices having a continuous current rating greater than that of the switch,
- c) Fused motor-circuit switches incorporating fuseholders of a current rating greater than that of the switch, and
- d) Switches with design technologies other than the knife-blade design and a short-circuit current rating of 10 kA or less.

Note: The 5 000 and 7 500 A levels are applicable only to combinations of the switch and a circuit breaker.

7.8.2 Switches that have dc short-circuit current ratings greater than 10 000 A shall be evaluated as follows:

- a) The switch shall be subjected to short-circuit withstand, short-circuit closing and low-level dielectric withstand tests described in 7.7 through 7.10 as required for an ac rating of 600 V at the short-circuit current value of the dc rating to be applied. The ac test circuit current level shall be at least the value of the dc short-circuit current rating to be applied. If the dc rating is 250 V or lower and at the same or lower short-circuit current rating, no dc short-circuit test is required provided that the ac testing is conducted with fuses with suitable current limiting capability and marked in accordance with 9.2.17.
- b) If the dc rating is greater than 250 V, an additional set of short-circuit withstand and short-circuit closing tests shall be conducted at the dc voltage and dc short-circuit current rating. The fuses used in these tests shall be commercially available fuses having appropriate dc voltage, current and interrupting ratings.

Note: The fuses are not required to have specific characteristics of peak current and I^2t let through. The samples used for the additional dc short-circuit tests may be previously untested samples.

7.8.3 For switches rated for 10 000 A and below available fault current a previously untested sample shall be permitted.

7.8.4 For a double-throw switch, the tests specified in 7.8.1 shall be performed on both sets of contacts. If the construction of both sets of contacts are representative of each other, the test need only be conducted on one set.

7.8.5 A circuit capable of providing the maximum short-circuit current for which the switch is rated shall be closed on the sample. The switch shall withstand the designated current until the overcurrent protective device or devices specified in 7.8.7 opens, or, for a switch not marked as requiring a specific overcurrent protective device, for 0.050 s. After the circuit is opened:

- a) The fuse connected to the enclosure shall not have opened,
- b) There shall not be any breakage to the extent that the integrity of the mounting of live parts is impaired,
- c) The door shall be kept by its latch, without bolt or lock installed therein, from being blown open (deformation of the case alone is considered to be acceptable),
- d) The switch shall be capable of being opened manually with the operating handle, and
- e) Fuses (neither end of a bar or tube as described in 7.8.10) shall not be completely ejected from the fuse clips and no fuse (or line end of a bar or tube) shall bridge from a fuse clip to grounded metal.
- f) Cracking or crazing of a viewing window is acceptable but a hole or opening of 6.4 mm or more in any dimension shall not occur.

7.8.6 For the test mentioned in 7.8.5:

- a) The open-circuit voltage of the power-supply circuit shall not be less than the maximum rated voltage of the switch.
- b) The available rms symmetrical short-circuit current or prospective direct current in amperes shall not be less than the short-circuit current rating of the switch.
- c) The circuit shall be as indicated in Figure 2, with any overcurrent protection device on the load side, and shall include the necessary measuring equipment and the fuse-mounting means. A circuit breaker shall be used if specified for use with an unfused switch. Connecting overcurrent protection means on the line side of an unfused switch shall be permitted if the switch is marked as indicated in 9.2.22.
- d) The test circuit requirements shall be as follows:
 - i) For an ac circuit, the power factor of the circuit shall be 0.45 to 0.50 lagging for a circuit of 0 to 10 000 A, except the power factor shall be 0.85 to 0.95 lagging for fuses rated 100 A or less, 0.25 to 0.30 lagging for a circuit of 10 001 to 20 000 A, and 0.15 to 0.20 lagging for circuits over 20 000 A.
 - ii) For a dc circuit, the time constant shall not be less than 0.003 s for 10 000 A or less, and 0.008 s for circuits greater than 10 000 A.
- e) The enclosure of the switch shall be connected through a 30 A nonrenewable, nondelay-type fuse to the pole of the switch considered least likely to arc to the enclosure. The fuse shall have a voltage rating not less than the rating of the switch being tested. This connection shall be