

UL 489 test procedure

Standard tests

For electronic trip circuit breakers and uncompensated thermal-magnetic circuit breakers rated 40°C, the test sequences are as shown in the table:

Test	Sequence		
	X	Y	Z
200% calibration at 25°C (77°F)	■	■	■
135% calibration at 25°C (77°F)	■		
Calibration of adjustable instantaneous trip	■		
Overload	■		
Tungsten lamp load	①		
100% calibration at 40°C (104°F)	②		
Temperature and 100% calibration at 25°C (77°F)	■		
Endurance		■	
200% calibration at 25°C (77°F) repeated		■	
135% calibration at 25°C (77°F) repeated		■	
Interrupting ability (Y sequence)		■	
Interrupting ability (Z sequence)			■
200% trip out at 25°C (77°F)		■	■
Dielectric voltage withstand	■	■	■

① Applies only to circuit breakers rated 50 A or less, and 125 or 125/250 V or less.

② Applies only to thermal-magnetic breakers rated 40°C.

Standard specifications

Temperature

The temperature rise at the circuit breaker and at its terminals does not exceed specified limits when connected with specified cables or bus bars (see below) and at its rated current.

Examples of specified wires and bus

■ 75°C copper wire

Rating	Number	Size
100 A	1	#1 AWG (60°C)
	1	#3 AWG
250 A	1	250 kcmil
400 A	2	3/0 AWG
600 A	2	350 kcmil
800 A	3	300 kcmil
1000 A	3	400 kcmil
1200 A	4	350 kcmil

■ Copper busbar

Rating	Number	Size
1600 A	2	1/4 x 3
2000 A	2	1/4 x 4
2500 A	2	1/4 x 5
	4	1/4 x 2 - 1/2
3000 A	4	1/4 x 4

(1200 A or less: 1000 A / in²)

Calibration

200% calibration at 25°C

The circuit breaker must trip within time limits which depend on the rating from three minutes for a 30 A rated circuit breaker, up to 30 minutes over 2000 A.

135% calibration at 25°C

The circuit breaker must trip within two hours (for circuit breakers rated more than 50 A).

Calibration of adjustable instantaneous trip

The circuit breaker must trip within the range of 80-120% of the maximum marked tripping current and 75-125% of the minimum marked tripping current.

Overload

■ Up to 1600 A: 50 operations at 600% of rated current;

■ 2000 and 2500 A: 25 operations at 600% of rated current;

■ 3000 to 6000 A: three operations at 600% followed by 25 operations at 200% of rated current.

The power factor shall be from 0.45 to 0.50 lagging.

Endurance

The circuit breaker must complete an endurance test:

■ Operations at rated current and rated voltage;

■ Followed by no load operation.

The power factor shall be 0.75 to 0.80 lagging.

Examples

Frame size	Number of cycles of operations		
	With current	Without current	Total
100 A	6,000	4,000	10,000
225 A	4,000	4,000	8,000
400 A	1,000	5,000	6,000
600 A	1,000	5,000	6,000
800 A	500	3,000	3,500
1200 A	500	2,000	2,500
1600 A	500	2,000	2,500
2000 A	500	2,000	2,500
2500 A	500	2,000	2,500
3000 A	400	1,100	1,500

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Interrupting ability

Interrupting ability (Y sequence)

After endurance tests and calibrations are repeated, the circuit breaker completes an opening (O) followed by a close-open operation (O-t-CO), with specified current.

Examples for 3-pole breakers

Frame rating	RMS Sym. Amperes (3-pole O-and-CO)
100 A ①	3,000
225 A	3,000
400 A	5,000
600 A	6,000
800 A	10,000
1200 A	14,000
1600 A	20,000
2000 A	25,000
3000 A	35,000

① Above 250 V.

Interrupting ability (Z sequence)

A 3-pole circuit breaker rated 240, 480 or 600 V has to complete an opening operation (O) and a close-open operation (O-and-CO) on each pole, at rated voltage, followed by an opening operation (O) using all 3 poles.

Examples of 3-pole circuit breakers

Frame rating	RMS Sym. Amperes	
	Each pole O-and-CO	Common O
100 to 800 A	8,660	10,000
1000 to 1200 A	12,120	14,000
1600 A	14,000	20,000
2000 A	14,000	25,000
3000 A	25,000	35,000

Dielectric

After testing, the circuit breaker must withstand for one minute a voltage of 1000 V plus twice the rated voltage between:

- Line and load terminals with circuit breaker in open, tripped and off positions;
- Terminals of opposite polarity with circuit breaker closed;
- Live parts and the overall enclosure with circuit breaker open and closed.

Optional tests

■ High available fault current

Circuit breakers having passed all the standard tests may have the UL Listing label applied at higher values than the standard.

Test sequence is as follows:

- 200% calibration,
 - Interrupting capacity: an opening operation followed by a close-open operation (O-and-CO) on all poles are performed on the circuit breaker.
- The power factor over 20000 A shall be 0.15 to 0.2 lagging:
- Trip out at 250%,
 - Dielectric at twice the rated test voltage.

■ 100% rated

Circuit breakers having passed all the standard tests may have the UL Listing label applied to use the circuit breaker in an enclosure when carrying 100% of its maximum rating.

The circuit breaker is submitted to additional temperature tests performed as standard tests, except that the circuit breaker is installed in an enclosure.

The dimensions and possible ventilations shall be recorded and shall be marked on the circuit breaker.

Tests on accessories

Shunt trip and undervoltage trip

These devices are submitted to temperature, overvoltage, operation, endurance and dielectric tests.

■ Overvoltage test

The device must be capable of withstanding 110% of its rated voltage continuously without damage (this test does not apply to a shunt trip with an "a" contact connected in series).

■ Operation

The shunt trip must operate at 75% of its rated voltage (except shunt trip devices for use with ground-fault protection shall operate at 55%).

The undervoltage trip must trip the circuit breaker when the voltage is less than 35% and may trip the circuit breaker between 35 and 70% of its rated voltage and shall pick-up and seal when the voltage is at 85% or more of its rated voltage.

■ Endurance

The device must be capable of performing successfully for 10% of the number of "with current" operations of the circuit breaker.

Auxiliary and alarm switches

Auxiliary and alarm switches must be submitted to temperature, overload, endurance and dielectric tests.

■ Overload test

The test consists of fifty operations making and breaking 150% of rated current at rated voltage, with a 75-80% power factor in ac and non-inductive load in dc.

■ Endurance

The switch must make and break its rated current at rated voltage, with a 75-80% power factor in ac, and non-inductive load in dc for 100% of the number of operations "with current" for auxiliary switches, and 10% of this number for alarm switches.

Motor operator

The motor operator shall perform the number of "without current" operations indicated for the circuit breaker endurance tests. The first 25 operations shall be conducted at 85% of the motor operator voltage rating.

The circuit breaker is to be tripped during these tests.

The next 25 operations shall be conducted at 110% of the motor operator voltage rating. The balance shall be completed at rated voltage without tripping the circuit breaker.

IEC 947-2 test procedure

Standard tests

Consisting of seven parts, the IEC 947 Standard applies to all low-voltage equipment designed for industrial application.

Three documents are to be consulted for circuit breakers and switches.

- IEC 947-1: general regulations;
- IEC 947-2: circuit breakers;
- IEC 947-3: switches.

Two categories of devices

The IEC 947-1 standard defines two categories of devices.

Category A

Devices not specifically designed to carry out chronometric selectivity.

Category B

Devices specifically designed to carry out chronometric selectivity. These circuit breakers possess a compulsory additional characteristic: short-time withstand (I_{cw}).

Breaking capacity

■ Ultimate breaking capacity: I_{cu}

I_{cu} is the value to be taken into account when calculating an installation.

The rule remains: $I_{cu} > I_{cc}$ (maximum fault current of the installation).

■ Breaking performance during operation: I_{cs}

This characteristic indicates the ability of the device to eliminate short-circuit currents less than I_{cc} and with a greater likelihood of occurring, generally near the application. I_{cs} is expressed in % of I_{cu} (values retained by the standard IEC 25-50-75-100% of I_{cu}).

This test sequence designed to check the I_{cs} performance, groups together on the same device, following the breaking test (O-CO-CO, see page 59), certain checks such as:

- Temperature rise under I_n ;
- Calibration at $1.45 I_n$;
- Leakage current (for devices suitable for disconnection).

The leakage current should not exceed 2 mA under the application voltage (0.5 mA when new).

These checks ensure that the device is able to carry out all its functions after elimination of a fault of I_{cs} value and to be put back in operation; hence the notion of breaking power performance during operation I_{cs} .

Isolation

Function

Recognition and definition of the disconnection capacity for industrial low-voltage equipment

Until recently, circuit breaker standards have established no regulations concerning the isolation function.

Only the installation standards provided some rather vague information.

The IEC 947 standard takes this function into account. In the "general regulations" section, it clearly states:

- The manufacturing regulation,
- The tests to be performed.

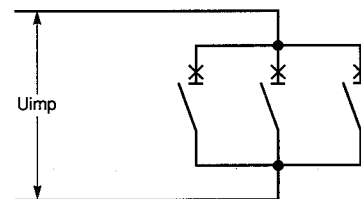
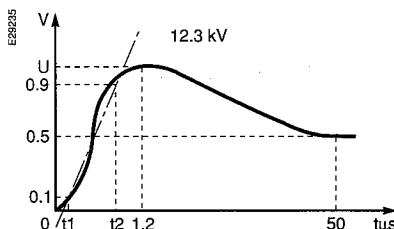
The circuit breaker standard should define the manner in which the tests are to be performed (under study).

The manufacturing regulations state, for example:

- Both the isolation and the inner contact distances (open > 8 mm),
- A device indicating the true position of the contacts (operating handle if representative of the state of all the contacts),
- When a "locked" position is provided, this should only be possible with "open" contacts.

The tests to be performed are as follow:

■ Shock wave voltage strength (U_{imp})



1.2/50 μ s - 12.3 kV plus 25% between open contacts in comparison with devices not fitted with the applied isolation function according to the figure below.

The test is validated if no triggering occurs between the contacts.

■ Measurement of the leakage current

Under 110% of the device application voltage

- Maximum leakage currents proposed per pole:

- 0.5 mA new device,
- 2 mA device after I_{cs} ,
- 6 mA device after I_{cu} or after endurance tests, representative of the "end of service life."

IEC 947-2 test procedure

Test sequences

Sequence	Category of devices	Tests
1 - General characteristics	All circuit breakers	- trip unit control - dielectric properties - mechanical and electrical endurance - overload - dielectric voltage withstand - temperature rise - 145% calibration (3 phases test)
2 - Breaking capacity during operation	All circuit breakers	- breaking capacity during operation (Ot-CO-t-CO) - dielectric voltage withstand - temperature rise - 145% calibration (3 phases test)
3 - Ultimate breaking capacity (I _{cu})	A B if I _{cu} > I _{cw}	- 200% calibration (each pole separately) - ultimate breaking capacity (O-t-CO) - dielectric voltage withstand - 250% calibration (each pole separately)
4 - Admissible short duration current (I _{cw})	B	- 200% calibration (each pole separately) - short-time current withstand - temperature rise - breaking capacity at admissible short-time current (O-t-CO) - dielectric voltage withstand - 200% calibration (each pole separately)
Combined sequence	I _{cw} = I _{cs} replaces sequences 2 and 4 I _{cw} = I _{cs} = I _{cu} replaces sequences 2, 3 and 4	- 200% calibration (each pole separately) - short-time current withstand I_{cw} - breaking capacity at I_{cs} (O-CO-CO) at maximum relay temp. - dielectric voltage withstand - temperature rise - 200% calibration (each pole separately)