IP degrees in accordance with IEC 60529 / EN 60529

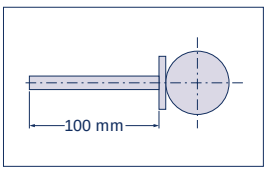
Degrees of protection provided by enclosures for electrical equipment against solid foreign objects, against water and against access to hazardous parts.

Characteristic numerals	IP	0 - 6	0 - 8	(A - D)*
International Protection				
Degree of protection against access to hazardous parts and against solid foreign objects (0 to 6)				
Degree of protection against ingress of water (0 to 8)				
Degree of protection against access to hazardous parts				

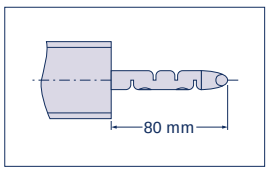
*) Additional letter, used when the degree of protection of persons against access to hazardous parts is higher than the degree of protection against ingress of solid foreign objects.

Access test probes

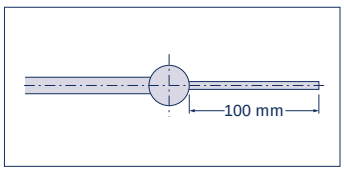
Access probes for the tests for protection of persons against access to hazardous parts



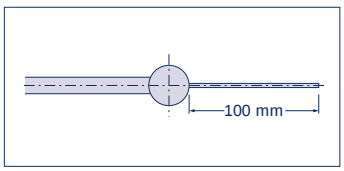
A.
Metal test sphere, ø 50 mm, on handle and guard of insulating material, ø 10 mm, (L = 100 mm).
Test force = 50 N.



B.
Jointed metal test finger, ø 12 mm (L = 80 mm), fitted on handle of insulating material with stop face (ø 50 x 20 mm).
Test force 10 N.



C.
Metal test rod, ø 2.5 mm, (L = 100 mm) with edges free from burrs. Mounted on stop face sphere, ø 35 mm of insulating material with insulated handle, ø 10 mm (L = 100 mm).
Test force 3 N.



D.
Metal test wire, ø 1 mm, (L = 100 mm) with edges free from burrs. Mounted on stop face sphere,ø 35 mm of insulating material with insulated handle, ø 10 mm, (L = 100 mm).
Test force 1 N.

IP degrees in accordance with IEC 60529 / EN 60529

1st numeral: Protection against contact and against solid foreign objects.	**IP numeral**
0 Non-protected	IP **0**X(X)
1 Protected against solid foreign objects of ≥ 50 mm ø	IP **1**X(X)
2 Protected against solid foreign objects of ≥ 12.5 mm ø	IP **2**X(X)
3 Protected against solid foreign objects of ≥ 2.5 mm ø	IP **3**X(X)
4 Protected against solid foreign objects of ≥ 1.0 mm ø	IP **4**X(X)
5 Protected against ingress of dust (dust-protected)	IP **5**X(X)
6 Protected against ingress of dust by underpressure (dust-tight)	IP **6**X(X)

2nd numeral: Protection against ingress of water.	**IP numeral**
0 Non-protected	IP X**0**(X)
1 Protected against vertically falling water drops	IP X**1**(X)
2 Protected against vertically falling water drops when enclosure tilted up to 15°	IP X**2**(X)
3 Protected against spraying water	IP X**3**(X)
4 Protected against splashing water	IP X**4**(X)
5 Protected against water jets	IP X**5**(X)
6 Protected against powerful water jets	IP X**6**(X)
7 Protected against the effects of temporary immersion in water	IPX**7**(X)
8 Protected against the effects of continuous immersion in water	IPX**8**(X)

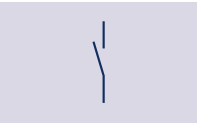
Additional letter Protection against solid foreign objects is higher than 1st numeral	**IP additional letter**
A Protected against access with the back of the hand	IP XX **A**
B Protected against access with a finger	IP XX **B**
C Protected against access with a tool	IP XX **C**
D Protected against access with a wire	IP XX **D**

Electrotechnical symbols

⎓	DC current/voltage
∿	AC current/voltage
≂	AC/DC current/voltage
3N∿50Hz	3-phase current with neutral conductor 50 Hz
V	Voltmeter
A	Ammeter
kWh	kWh-meter
	Transformer
	Wire, conductor
	Neutral (N)
	Protective earth (PE)
	(Main) earth conductor (E) Functional earth (E)

	Combined protective earth and neutral (PEN)
	Three phases, protective earth and neutral
	Removable terminal
	Removable earth terminal
N	Removable neutral terminal
	Make contact
	Break contact
	Changeover contact
	Contactor
	Fuse
	Fuse (bold line shows feeding side)
	2-pole group switch

Electrotechnical symbols

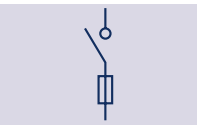

Switch (general)

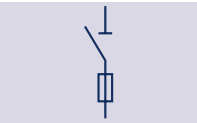
Disconnector[1)]

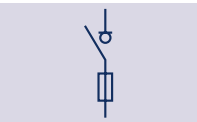
Switch[1)]

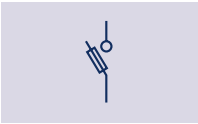
Switch-disconnector[1)]

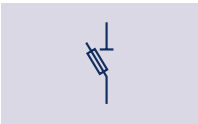
Switch-disconnector, 4-pole


Switch-fuse[1)]


Disconnector-fuse[1)]


Switch-disconnector-fuse[1)]


Fuse-switch[1)]


Fuse-disconnector[1)]

Fuse-switch-disconnector[1)]

Circuit breaker

Circuit breaker suitable for isolation

Under voltage circuit breaker

Circuit breaker with thermal and electromagnetic overcurrent protection

RCBO residual current operated circuit breaker with integral overcurrent protection

RCCB residual current operated circuit breaker without overcurrent protection

[1)] For definitions see abstract from IEC 60947-3.

Definitions of switches, disconnectors, switch-disconnectors and fuse-combination units

Switch
A mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit.

Disconnector*)
A mechanical switching device which, in the open position, complies with the requirements specified for the isolating function.

Switch-disconnector
A switch which, in the open position, satisfies the isolating requirements specified for a disconnector.

Fuse-combination unit (general term for fuse switching devices)
A combination of a mechanical switching device and one or more fuses in a composite unit, assembled by the manufacturer or in accordance with his instructions.

Switch-fuse
A switch in which one or more poles have a fuse in series in a composite unit.

Disconnector-fuse
A disconnector in which one or more poles have a fuse in series in a composite unit.

Switch-disconnector-fuse
A switch-disconnector in which one or more poles have a fuse in series in a composite unit.

Fuse-switch
A switch in which a fuse-link or a fuse-carrier with fuse-link forms the moving contact.

Fuse-disconnector
A disconnector in which a fuse-link or fuse-carrier with fuse-link forms the moving contact.

Fuse-switch-disconnector
A switch-disconnector in which a fuse-link or a fuse-carrier with fuse-link forms the moving contact.

making and breaking current		isolating		making, breaking and isolating	
switch		disconnector		switch-disconnector	
switch-fuse		disconnector-fuse		switch-disconnector-fuse	
fuse-switch		fuse-disconnector		fuse-switch-disconnector	

*) A disconnector is capable of opening and closing a circuit when either a negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for a specified time currents under abnormal conditions such as those of short circuit.
Note: This definition differs from IEV 441-15-05 by referring to isolating function instead of isolating distance.

Excerpt from IEC 60947-3, EN 60947-3

Test sequence

1. General performance characteristics (TS I)

1.1 Temperature-rise
1.2 Dielectric properties
1.3 Making and breaking capacities
1.4 Dielectric verification
1.5 Leakage current
1.6 Temperature-rise verification
1.7 Strength of actuator mechanism

2. Operational performance capability (TS II)

2.1 Operational performance
2.2 Dielectric verification
2.3 Leakage current
2.4 Temperature-rise verification

3. Short-circuit performance capability (TS III)

3.1 Short-time withstand current
3.2 Short-circuit making capacity
3.3 Dielectric verification
3.4 Leakage current
3.5 Temperature-rise verification

4. Conditional short-circuit current (TS IV)

4.1 Fuse protected short-circuit withstand
4.2 Fuse protected short-circuit making
4.3 Dielectric verification
4.4 Leakage current
4.5 Temperature-rise verification

5. Overload performance capability (TS V)

5.1 Overload test
5.2 Dielectric verification
5.3 Leakage current
5.4 Temperature-rise verification

Explanatory remarks

Making and breaking capacities (1.3).

For example: 63 A equipment of utilization category AC-23A shall make 5 make cycles of 10 x I_e at p.f. 0.45, and 5 break cycles of 8 x at I_e at p.f. 0.45. The test voltage is 1.05 x U_e.

Temperature-rise verification (1.6).

After the making and breaking capacity tests the terminals shall not exceed 80 K temperature-rise at the rated operational current I_e.

Operational performance (2.1).

The electrical and mechanical durability is verified for frequent (category A) and not frequent (category B) switching. As an example, the number of operating cycles without current of 250 A equipment shall be 7,000 in category A and 1,400 in category B.
With current (I_e) this shall be 1,000 and 200 operating cycles respectively.

Conventional enclosed thermal current (I_{the})
The conventional enclosed thermal current is the value of current stated by the manufacturer to be used for the temperature-rise tests of the equipment when mounted in a specified enclosure. The value of the conventional enclosed thermal current shall be at least equal to the maximum value of the rated operational current of the enclosed equipment in eight-hour duty.
If the equipment is normally intended for use in unspecified enclosures, the test is not mandatory if the test for conventional free air thermal current (I_{th}) has been made. In this case, the manufacturer shall be prepared to give guidance on the value of enclosed thermal current or the derating factor.

Conventional free air thermal current (I_{th})
The conventional free air thermal current is the maximum value of test current to be used for temperature-rise tests of unenclosed equipment in free air.
The value of the conventional free air thermal current shall be at least equal to the maximum value of the rated operational current of the unenclosed equipment in eight-hour duty.
Free air is understood to be air under normal indoor conditions reasonably free from draughts and external radiation.

Rated frequency
The supply frequency for which an equipment is designed and to which the other characteristic values correspond.

Rated impulse withstand voltage (U_{imp})
The peak value of an impulse voltage of prescribed form and polarity which the equipment is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.
The rated impulse withstand voltage of an equipment shall be equal to or higher than the values stated for the transient overvoltages occurring in the circuit in which the equipment is fitted.

Rated insulation voltage (U_i)
The rated insulation voltage of an equipment is the value of voltage to which dielectric tests and creepage distances are referred.
In no case shall the maximum value of the rated operational voltage exceed that of the rated insulation voltage.

Rated operational current (I_e) or rated operational power
A rated operational current of an equipment is stated by the manufacturer and takes into account the rated operational voltage, the rated frequency, the rated duty, the utilization category and the type of protective enclosure, if appropriate.
In the case of equipment for direct switching of individual motors, the indication of a rated operational current may be replaced or supplemented by an indication of the maximum rated power output, at the rated operational voltage considered, of the motor for which the equipment is intended. The manufacturer shall be prepared to state the relationship assumed between the operational current and the operational power, if any.

Rated operational voltage (U_e)
A rated operational voltage of an equipment is a value of voltage which, combined with a rated operational current, determines the application of the equipment and to which the relevant tests and the utilization categories are referred.
For single-pole equipment, the rated operational voltage is generally stated as the voltage across the pole. For multipole equipment, it is generally stated as the voltage between phases.

Rated short-circuit making capacity (I_{cm})
The rated short-circuit making capacity of a switch or a switch-disconnector is the value of short-circuit making capacity assigned to the equipment by the manufacturer for the rated operational voltage, at rated frequency (if any) and at specified power-factor (or time-constant). It is expressed as the maximum prospective peak current.

Rated short-time withstand current (I_{cw})

The rated short-time withstand current of a switch, a disconnector or a switch-disconnector is the value of short-time withstand current, assigned by the manufacturer, that the equipment can carry without any damage under the relevant test conditions.

The value of the rated short-time withstand current shall be not less than twelve times the maximum rated operational current and, unless otherwise stated by the manufacturer, the duration of the current shall be 1 s.

Rated uninterrupted current (I_u)

The rated uninterrupted current of an equipment is a value of current, stated by the manufacturer, which the equipment can carry in uninterrupted duty.

Rated conditional short-circuit current

The rated conditional short-circuit current of an equipment is the value of prospective current, stated by the manufacturer, which the equipment, protected by a short-circuit protective device specified by the manufacturer, can withstand satisfactorily for the operating time of this device under the specified test conditions.

The details of the specified short-circuit protective device shall be stated by the manufacturer.

Notes:

1. For a.c. the rated conditional short-circuit current is expressed by the r.m.s. value of the a.c. component.
2. The short-circuit protective device may either form an integral part of the equipment or be a separate unit.

Outer diameter of underground LV multi-core armoured cable

copper cross section (mm^2)	outer diameter in mm 2-core cables	3-core cables	4-core cables	5-core cables
1.5	12.6	13.0	13.8	14.7
2.5	13.4	13.9	14.7	15.7
4	14.3	14.9	15.8	17.0
6	15.4	16.0	17.2	18.4
10	20.2	21.0	22.1	24.1
16	22.2	23.2	24.9	26.9
25	26.0	27.0	29.5	-
35	27.0	28.2	30.7	-
50	30.0	26.9	30.9	-
70	34.0	31.4	35.6	-
95	38.2	35.2	39.6	-
120	-	39.0	43.2	-
150	-	42.5	47.6	-
185	-	46.6	54.1	-
240	-	54.0	60.3	-
300	-	57.8	-	-

Outer diameter of aboveground LV multi-core armoured cable

copper cross section (mm^2)	outer diameter in mm 1-core cables	2-core cables	3-core cables	4-core cables	5-core cables
1.5	-	9.7	10.1	10.8	11.7
2.5	-	10.4	10.9	11.7	12.7
4	-	11.3	11.9	12.8	14.0
6	7.0	12.5	13.1	14.2	15.4
10	8.4	16.0	16.8	17.9	20.0
16	9.4	18.0	19.0	20.7	22.7
25	11.1	21.8	22.8	24.9	27.4
35	12.3	23.2	24.2	26.5	29.4
50	13.8	25.8	24.3	27.9	33.7
70	15.8	29.6	28.6	32.6	38.8
95	17.9	-	32.2	36.4	44.3
120	19.7	-	35.8	39.8	-
150	21.8	-	39.5	44.6	-
185	24.1	-	43.6	49.7	-
240	27.1	-	49.6	56.1	-
300	30.0	-	-	-	-
400	33.6	-	-	-	-

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