General

The choice of connectors entails more than just considering factors such as functionality, the number of contacts, current and voltage ratings. It is equally important to take account of where the connectors are to be used and the prevailing ambient conditions. This in turn means that, dependent on the conditions under which they are to be installed and pursuant to the relevant standards, different voltage and current ratings may apply for the same connectors.

The most important influencing factors and the corresponding electrical characteristics of the associated connectors are illustrated here in greater detail.

Overvoltage category

The overvoltage category is dependent on the mains voltage and the location at which the equipment is installed. It describes the maximum overvoltage resistance of a device in the event of a power supply system fault, e. g. in the event of a lightening strike.

The overvoltage category affects the dimensioning of components in that it determines the clearance air gap. Pursuant to the relevant standards, there are 4 overvoltage categories.

Equipment for industrial use, such as fall HARTING heavy duty Han connector, fall into Overvoltage Category III.

Extract from DIN VDE 0110-1 and IEC 60 664-1, Para. 2.2.2.1.1

Equipment of overvoltage category IV is for use at the origin of the installation.

Note 1: Examples of such equipment are electricity meters and primary overcurrent protection equipment.

Equipment of overvoltage category III is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements.

Note 2: Examples of such equipment are switches in the fixed installation and equipment for industrial use with permanent connection to the fixed installation.

Equipment of overvoltage category II is energy-consuming equipment to be supplied from the fixed installation.

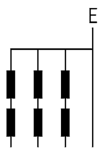
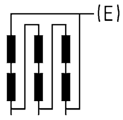
Note 3: Examples of such equipment are appliances, portable tools and other household equipment with similar loads.

If such equipment is subjected to special requirements with regard to reliability and availability, overvoltage category III applies.

Equipment of overvoltage category I is equipment for connection to circuits in which measures are taken to limit transient overvoltages to an appropriately low level.

Note: Examples are protected electronic circuits.

Rated impulse voltages (Table B2 of DIN EN 60 664-1)

Voltage line-to-neutral derived from nominal voltages A.C. or D.C. up to and including	Nominal voltages presently used in the world (= Rated insulation voltage of equipment)				Rated impulse voltage for equipment			
	Three-phase 4-wire systems with earthed neutral	Three-phase 3-wire systems earthed or unearthed	Single-phase 2-wire systems A.C. or D.C.	Single-phase 3-wire systems A.C. or D.C.	Overvoltage category			
					I	II	III	IV
					Special protected levels	Level for electrical equipment (household and others)	Level for distribution supply systems	Input level
V	V	V	V	V	V	V	V	V
50			12.5 24 25 30 42 48	30 ... 60	330	500	800	1500
100	66/115	66	60		500	800	1500	2500
150	120/208* 127/220	115, 120 127	100** 110, 220	100 ... 200** 110 ... 220 120 .. 240	800	1500	2500	4000
300	220/380, 230/400 240/415, 260/440 277/480	200**, 220 230, 240 260, 277	220	220 ... 440	1500	2500	4000	6000
600	347/600, 380/660 400/690, 417/720 480/830	347, 380, 400 415, 440, 480 500, 577, 600	480	480 ... 960	2500	4000	6000	8000
1000		660 690, 720 830, 1000	1000		4000	6000	8000	12 000

* ... Practice in the U.S.A and in Canada
** ... Practice in Japan

Pollution degree

The dimensioning of operating equipment is dependent on environmental conditions. Any pollution or contamination may give rise to conductivity that, in combination with moisture, may affect the insulating properties of the surface on which it is deposited. The pollution degree influences the design of components in terms of the creepage distance.

The pollution degree is defined for exposed, unprotected insulation on the basis of environmental conditions.

HARTING heavy duty Han connectors are designed as standard for Pollution Degree 3.

Pollution degree 1
in air-conditioned or clean, dry rooms, such as computer and measuring instrument rooms, for example.

Pollution degree 2
in residential, sales and other business premises, precision engineering workshops, laboratories, testing bays, rooms used for medical purposes. As a result of occasional moisture condensation, it is to be anticipated that pollution/contamination may be temporarily conductive.

Pollution degree 3
in industrial, commercial and agricultural premises, unheated storage premises, workshops or boiler rooms, also for the electrical components of assembly or mounting equipment and machine tools.

Pollution degree 4
in outdoor or exterior areas such as equipment mounted on the roofs of locomotives or tramcars.

Extract from DIN EN 60 664-1 (VDE 0110-1), Para. 4.6.2

Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

Pollution degree 2: Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be excepted.

Pollution degree 3: Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.

Pollution degree 4: Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

Special ruling for connectors

Subject to compliance with certain preconditions, the standard for connectors permits a lower pollution degree than that which applies to the installation as a whole. This means that in a pollution degree 3 environment, connectors may be used which are electrically rated for pollution degree 2.
The basis for this is contained in DIN EN 61 984, Para. 6.19.2.3.

Extract form DIN EN 61 984, Para. 6.19.2.3

For a connector with a degree of protection IP 54 or higher according to IEC 60 529 the insulating parts inside the enclosure may be dimensioned for a lower pollution degree.

This also applies to mated connectors where enclosure is ensured by the connector housing and which may only be disengaged for test and maintenance purposes.

The conditions fulfills,

- a connector which is protected to at least IP 54 as per IEC 60 529,
- a connector which is installed in a housing and which as described in the standard is disconnected for testing and maintenance purposes only,
- a connector which is installed in a housing and which when disconnected is protected by a cap or cover to at least IP 54,
- a connector located inside a switching cabinet to at least IP 54.

These conditions do not extend to connectors which when disconnected remain exposed to the industrial atmosphere for an indefinite period.

It should be noted that pollution can affect a connector from the inside of an installation outwards.

Typical applications in which to choose pollution degree 2 connectors:

- A connector serving a drive motor which is disconnected only for the purpose of replacing a defective motor, even when the plant or system otherwise calls for pollution degree 3.
- Connectors serving a machine of modular design which are disconnected for transport purposes only and enable rapid erection and reliable commissioning. In transit, protective covers or adequate packing must be provided to ensure that the connectors are not affected by pollution/contamination.
- Connectors located inside a switching cabinet to IP 54. In such cases, it is even possible to dispense with the IP 54 housings of the connectors themselves.

Specifying electrical data

Electrical data for connectors are specified as per DIN EN 61 984.

This example identifies a connector suitable for use in an unearthed power system or earthed delta circuit (see page 00.22, Table B2 of DIN EN 60 664-1):

16 A 500 V 6 kV 3

Working current
Working voltage
Rated impulse voltage
Pollution degree

This example identifies a connector suitable exclusively for use in earthed power systems (see page 00.22, Table B2 of DIN EN 60 664-1):

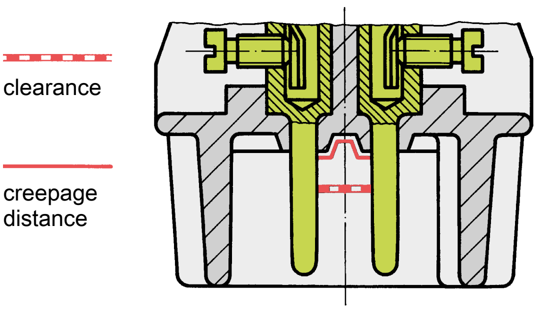
10 A 230/400 V 4 kV 3

Working current
Working voltage conductor – ground
Working voltage conductor – conductor
Rated impulse voltage
Pollution degree

Other terms explained

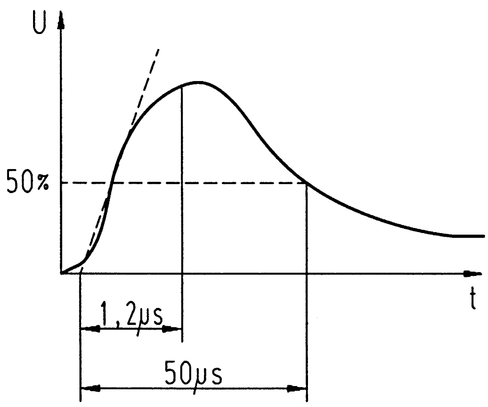
Clearance air gap
The shortest distance through the air between two conductive elements (see DIN EN 60664-1 (VDE 0110-1), Para. 3.2). The air gaps are determined by the surge voltage withstand level.

Creepage distance
Shortest distance on the surface of an solid insulating material between two conductive elements (see DIN EN 60664-1 (VDE 0110-1), Para. 3.3). The creepage distances are dependent on the rated voltage, the pollution degree and the characteristics of the insulating material.



Working voltage
Fixed voltage value on which operating and performance data are based. More than one value for rated voltage or rated voltage range may be specified for the same connector.

Rated impulse voltage
The rated impulse voltage is determined on the basis of the overvoltage category and the nominal power supply voltage. This level in turn directly determines the test voltage for testing the overvoltage resistance of the connector (Waveform voltage in 1.2/50 µs as per IEC 60060-1).



Working current
Fixed current, preferably at an ambient temperature of 40 °C, which the connector can carry on a permanent basis (without interruption), passing simultaneously through all contacts which are in turn connected to the largest possible conductors, without exceeding the upper temperature limit.
The dependence of the rated current on ambient temperature is illustrated in the respective derating diagrams.

Transient overvoltages
Short-term overvoltage lasting a few milliseconds or less, oscillatory or non-oscillatory, generally heavily damped (see DIN EN 60664-1 (VDE 0110-1, Para. 3.7.2). An overvoltage may occur as a result of switching activities, a defect or lightening surge, or may be intentionally created as a necessary function of the equipment or component.

Power-frequency withstand voltage
A power-frequency overvoltage (50/60 Hz).
Applied for a duration of one minute when testing dielectric strength.
For test voltages in association with surge voltage withstand levels, see extract from Table 8, DIN EN 61984.

Test voltages (Extract from Table 8, DIN EN 61984)

Impulse withstand voltage kV (1.2/50 µs) at an altitude of 2000 m	RMS withstand voltage kV (50/60 Hz)
0.5	0.37
0.8	0.50
1.5	0.84
2.5	1.39
4	2.21
6	3.31
8	4.26
12	6.6

CTI (Comparative Tracking Index)
This figure gives an indication of the conductivity of insulating materials and affects the specified creepage distances. The influence of the CTI value on the creepage distance is as follows: the higher the index value, the shorter the creepage distance. The CTI is used to divide plastics into insulation groups.
Breakdown of insulation groups:

I	600 ≤ CTI
II	400 ≤ CTI < 600
IIIa	175 ≤ CTI < 400
IIIb	100 ≤ CTI < 175

Protection levels as per IEC 60529
The protection level describes the leak-proof character of housing, e. g. for electrical equipment. It ranges from IP 00 to IP 68. HARTING heavy duty Han connectors feature a standard protection level of IP 65 (see page 00.5, table based on DIN EN 60529, IEC 60529).

Derating diagram as per DIN EN 60512-5-2
These diagrams are used to illustrate the maximum current carrying capacity of components. The illustration follows a curve which shows the current in relation to ambient temperature. Current carrying capacity is limited by the thermal characteristics of contacts and insulating elements which have an upper temperature limit which should not be exceeded.

Current carrying capacity

Current carrying capacity

The current carrying capacity is determined in tests which are conducted on the basis of the DIN EN 60512-5-2. The current carrying capacity is limited by the thermal properties of materials which are used for inserts as well as by the insulating materials. These components have a limiting temperature which should not be exceeded.

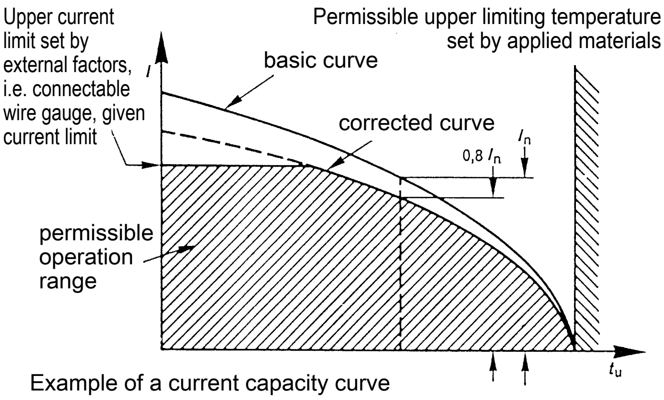
The relationship between the current, the temperature rise (loss at the contact resistance) and the ambient temperature of the connector is represented by a curve. On a linear coordinate system the current lies on the vertical line (ordinate) and the ambient temperature on the horizontal line (abscissa) which ends at the upper limiting temperature.

In another measurement the self-heating (Δt) at different currents is determined.

At least 3 points are determined which are connected to a parabolic curve, the basic curve.

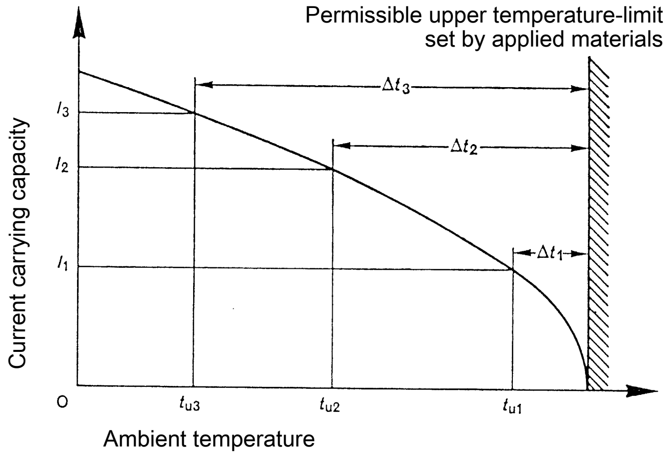
The corrected current carrying capacity curve is derived from this basic curve. The reasons for the correction are external factors that bring an additional limitation to the current carrying capacity, i.e. connectable wire gauge or an unequal dispersion of current.

The derating diagrams pictured as curve have been primarily determined with tin-plated cables as well as with physical cross sections close to the respective ISO-cable cross section.



Example of a current capacity curve

Definition: The rated current is the continuous, not interrupted current a connector can take when simultaneous power on all contacts is given, without exceeding the maximum temperature.



Example of a current carrying curve

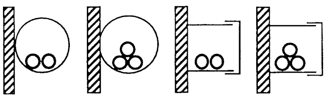
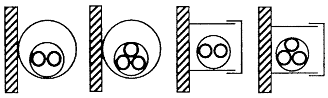
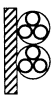
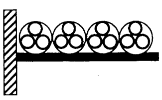
Acc. to DIN EN 61984 the sum of ambient temperature and the temperature rise of a connector shall not exceed the upper limiting temperature. The limiting temperature is valid for a complete connector, that means insert plus housing.

As a result the insert gives the limit for the temperature of a complete connector and thus housings as well.

In practice it is not usual to load all terminals simultaneously with the maximum current. In such a case single contacts can be loaded with a higher current as permitted by the current capacity curve, if less than 20 % of the whole is loaded.

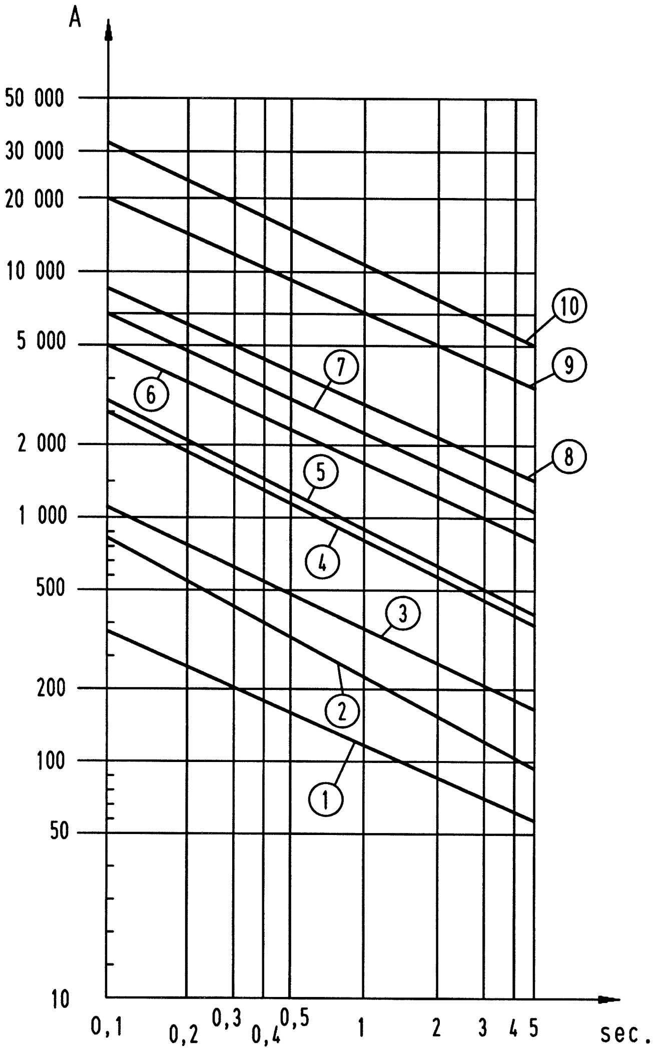
However, for these cases there are no universal rules. The limits have to be determined individually from case to case. It is recommended to proceed in accordance with the relevant rules of the DIN EN 60512-5-2.

Current carrying capacity of copper wires

	Diameter [mm²] of single wires in a three-phase system	0.75	1	1.5	2.5	4	6	10	16	25	35
	Type of installation										
B1	 Conductors/single core cables in conduit and cable trunking systems	8.6	10.3	13.5	18.3	24	31	44	59	77	96
B2	 Cables in conduit and cable trunking systems	8.5	10.1	13.1	17.4	23	30	40	54	70	86
C	 Cables on walls	9.8	11.7	15.2	21	28	36	50	66	84	104
E	 Cables on open cable trays	10.4	12.4	16.1	22	30	37	52	70	88	110
	Depiction in accordance with DIN EN 60 204-1 for PVC-insulated copper wires in an ambient temperature of + 40 °C under permanent operating conditions.										
	For different conditions and temperatures, installations, insulation materials or conductors the relevant corrections have to be carried out.										

Transient current carrying capacity

A transient current in circuits can be generated by switching operations such as the starting of a motor or a short circuit in a faulty installation. This can cause thermal stress at the contact. These short and very high increases cannot be dissipated quickly and therefore a local heating effect at the contact is the result. Contact design is an important feature when transient currents are encountered. HARTING contacts are machined from solid material and are therefore relatively unaffected by short overloads when compared to stamped and formed designs. For guidance please see the table below.



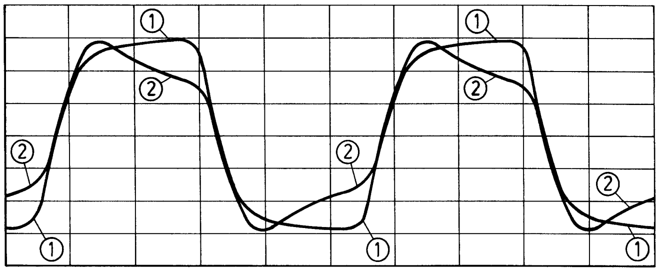
①	Han D®	I_N = 10 A
②	Han® 3 A / 4 A	I_N = 10 A
③	Han A® / Han E®, Han® ES, EE, Q 5/0	I_N = 16 A
④	Han® 6 HsB	I_N = 35 A
⑤	Han® C/K axial	I_N = 40 A
⑥	Han® K 4/8, Han® 70 A Modul	I_N = 80 A
⑦	Han® K 6/6	I_N = 100 A
⑧	Han® K 3/0	I_N = 200 A
⑨	Han® HC-Modular 350	I_N = 350 A
⑩	Han® HC-Modular 650	I_N = 650 A

Short circuit carrying capacity

Low currents and voltages

HARTING's standard contacts have a silver plated surface. This precious metal has excellent conductive properties. In the course of a contact's lifetime, the silver surface generates a black oxide layer due to its affinity to sulphur. This layer is smooth and very thin and is partly interrupted when the contacts are mated and unmated, thus guaranteeing very low contact resistances. In the case of very low currents or voltages small changes to the transmitted signal may be encountered. This is illustrated below where an artifically aged contact representing a twenty year life is compared with a new contact.

In systems where such a change to the transmitted signal could lead to faulty functions and also in extremely aggressive environments, HARTING recommend the use of gold plated contacts.

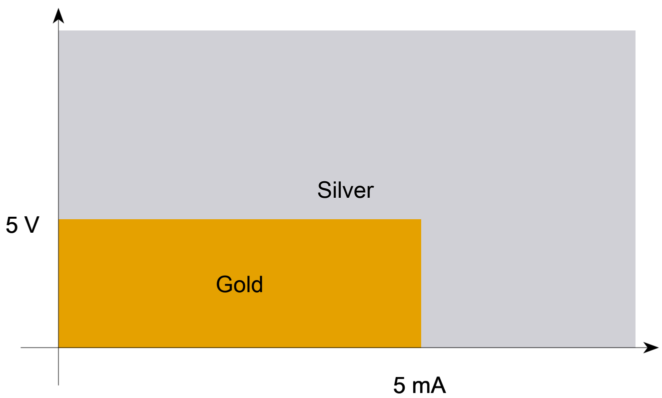


Changes to the transmitted signal after artifical ageing

① new contact

② after ageing

Below is a table derived from actual experiences.



Recommendation