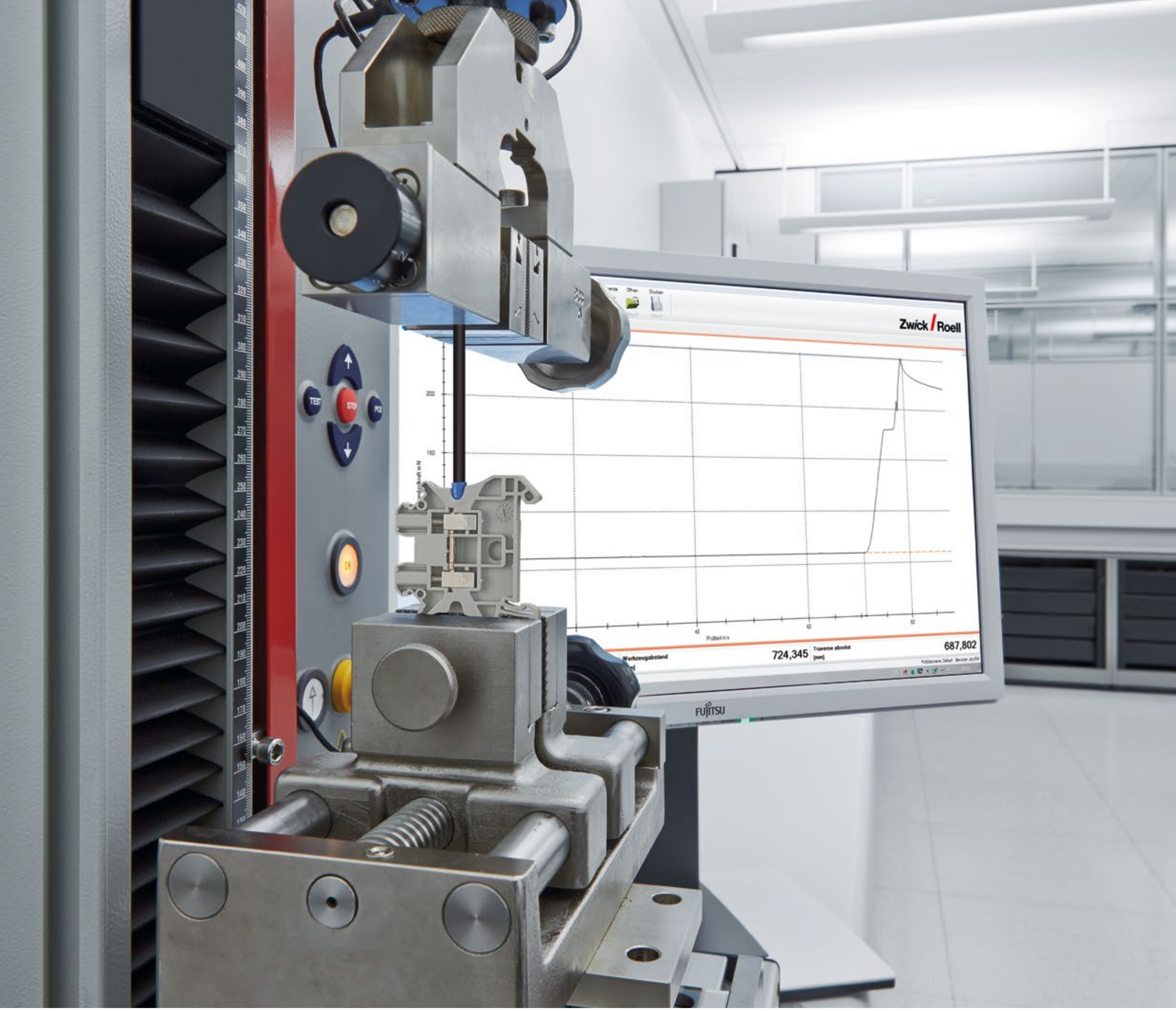
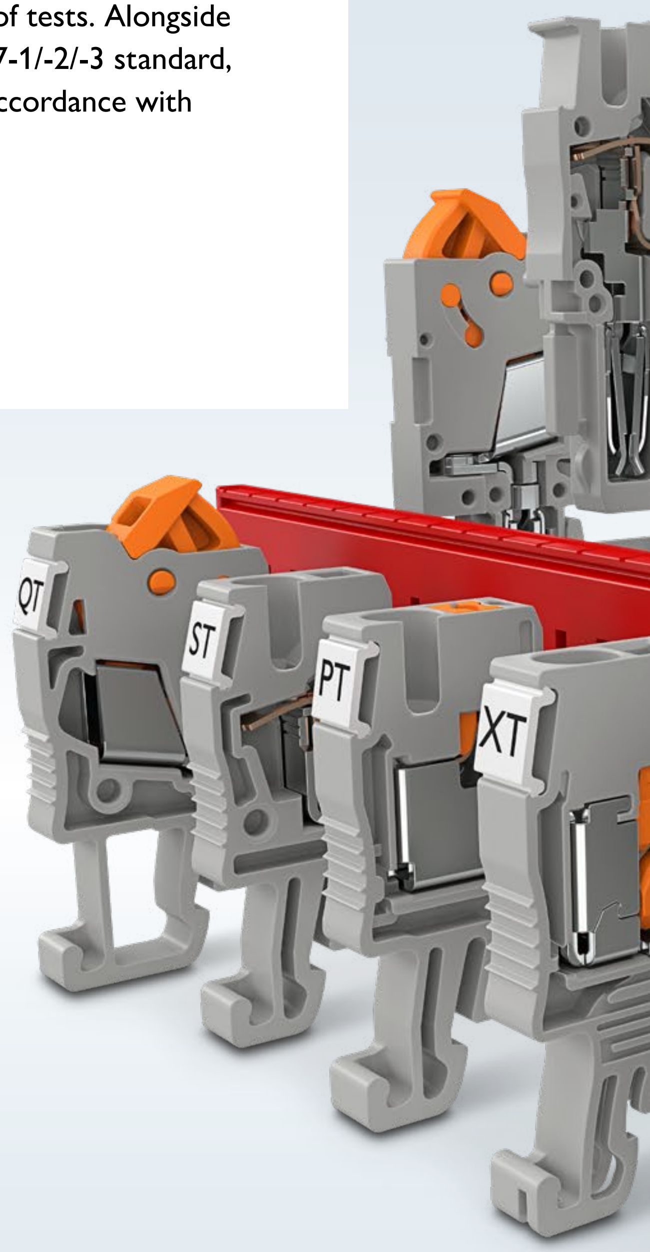


Expertise in connection technology

CLIPLINE quality

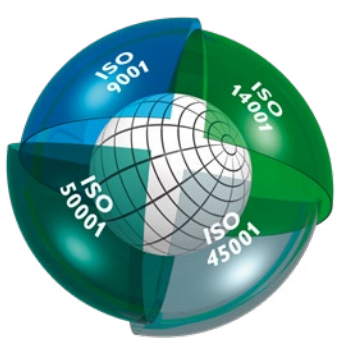
Quality is our top priority

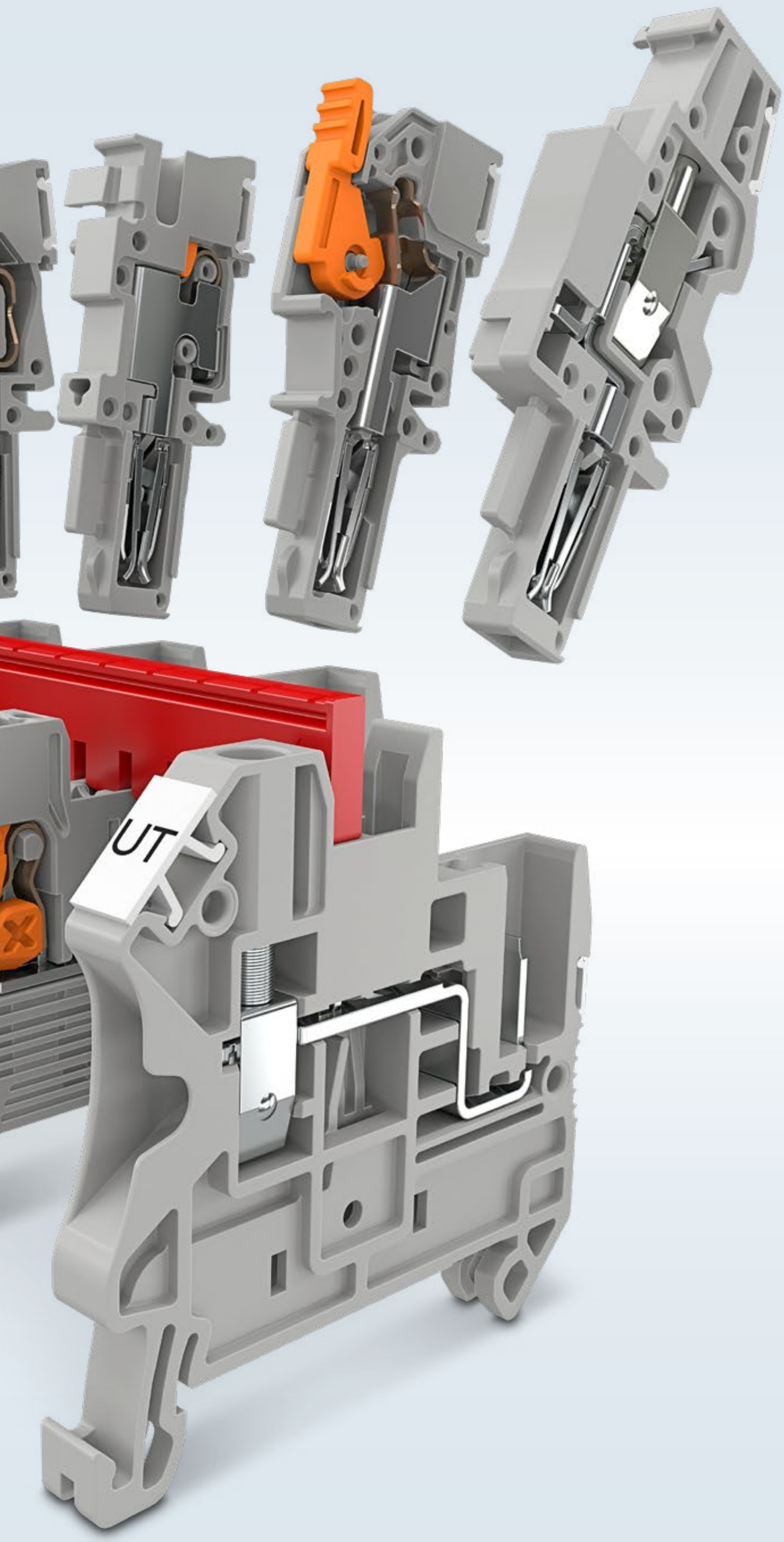
The quality of our products is our top priority. Quality is not only tested retrospectively on finished products, but is ensured responsibly at every stage of our production and logistics operations. To ensure the reliable use of our terminal blocks in all relevant industries, our products undergo a great number of tests. Alongside the standard test procedure in accordance with the IEC 60947-7-1/-2/-3 standard, our products also undergo specific tests which qualify them in accordance with numerous approvals.



ISO 45001 – Occupational health and safety management systems

A process-oriented, integrated management system based on the international standard ISO 45001 ensures that the laws and standards are taken into account during the manufacture of our products.



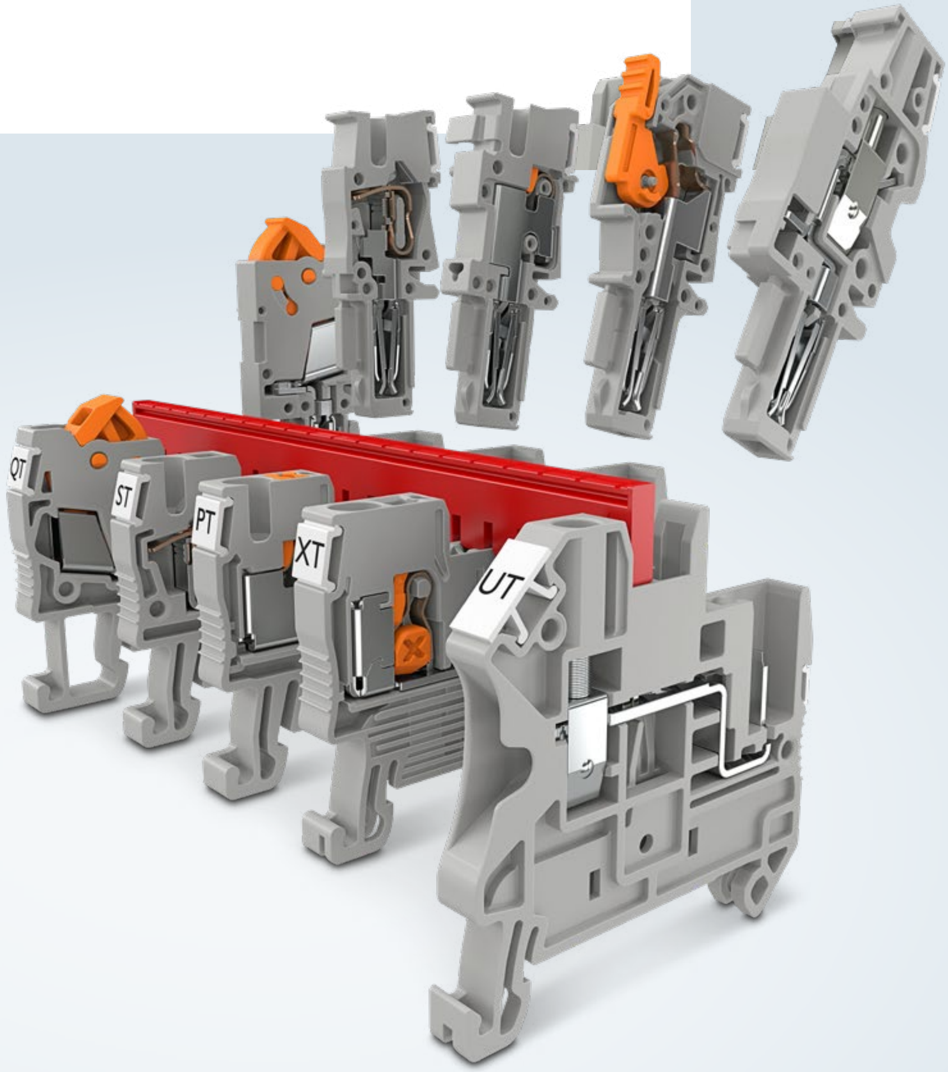


Contents

CLIPLINE complete
All connection technologies – one system

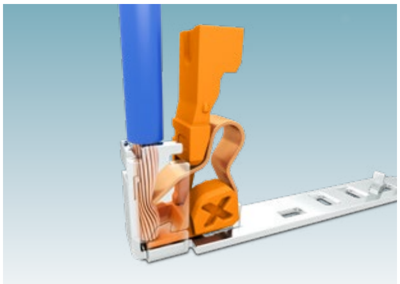
With CLIPLINE complete, the unique terminal block system from Phoenix Contact, you can freely select the connection technology.

This versatility enables you to respond flexibly to the demands and requirements of your customers anywhere in the world. All connection technologies can be freely combined with one another using the same accessories.



XT Push-X connection

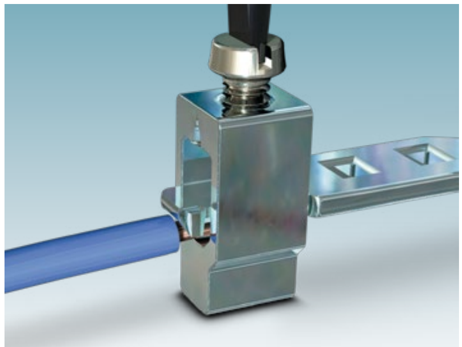
The Push-X connection technology enables easy connection of rigid and flexible conductors with or without ferrules. Even small and flexible conductors can be wired quickly and easily without ferrules due to the pretensioned contact chamber.



CLIPLINE complete connection technologies

PT Push-in connection

With Push-in connection technology, you can easily connect conductors from 0.25 mm², directly and without tools. The special contact spring allows easy insertion with up to 50% lower insertion forces. Furthermore, this connection technology features a high contact quality.



UT screw connection

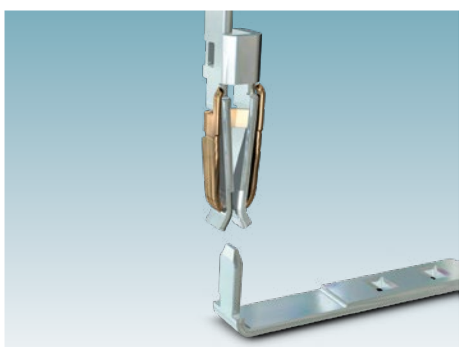
The UT connection technology is universal in every application. This marking of the screw connection technology features a multi-conductor connection and high contact forces. The screw connection technology is known and accepted worldwide and can be used everywhere.

ST spring-cage connection

ST is the proven connection technology for vibration-sensitive applications. The spring-cage always exerts the same constant force on the conductor, regardless of the influence of the operator. Wiring is carried out easily via the space-saving front connection.

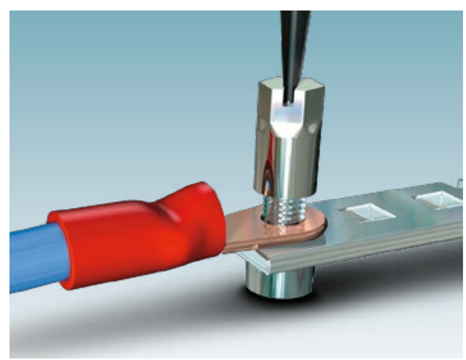
QT fast connection

Connect a conductor without stripping the insulation. Fast connection technology enables wiring times that are up to 60% shorter. The conductor connection is made easily, safely, and quickly with a simple turn of a standard screwdriver.



COMBI plug-in connections

Plug-in connections for high and universal demands. The nominal current of the connected conductor is carried through the plug-in contact. Connectors and basic terminal blocks in four connection technologies can be freely combined with each other due to the uniform plug-in zone.



RT bolt connection

The RT connection is a robust connection for conductors with ring cable lugs. RT combines the bolt connection with the advantages of the CLIPLINE complete system, such as simple potential distribution through plug-in bridges, large marking surfaces, and uniform test accessories.

Overview and assignment of the individual tests and certifications

Test	Standard test	Process industry	Machine building	Energy industry	Ship-building	Rail transport	Page
Basic principles							
CE accreditation laboratory		●	●	●	●	●	**9**
UL accreditation laboratory (UL 1059)		●	●	●	●	●	**9**
CENELEC Certification Agreement (CCA)		●	●	●	●	●	**10**
IECEE CB scheme	●						**10**
IEC test sequence (IEC 60947-7-1/2/3)	●						**10**
UL 1059 test sequence	●						**11**
Type test report	●						**11**
Mechanical tests							
Connection capacity (IEC 60947-7-1/2)	●	●	●	●	●	●	**13**
Touch protection (IEC 60529)			●	●		●	**14**
Flexion test (IEC 60947-7-1/2)	●	●	●	●	●	●	**14**
Tumbling barrel test (IEC 60068-2-32)		●	●	●	●	●	**15**
Tight fit of the terminal block (IEC 60947-7-1/2)	●	●	●	●	●	●	**15**
Conductor pull-out test (IEC 60947-7-1/2)	●	●	●	●	●	●	**16**
Mechanical strength (IEC 60947-7-1/2)	●	●	●	●	●	●	**16**
Impact test (IK rating)			●	●	●	●	**17**
Shock testing (IEC 60068-2-27)			●	●	●	●	**18**
Temperature shock testing (DIN EN 60352 T4)	(●)	●	●	●	●	●	**19**
Vibration test – noise signal (IEC 60068-2-64)			●			●	**20**
Vibration test – sine (IEC 60068-2-6)			●	●	●		**21**
Electrical tests							
Derating of connectors (IEC 60512-5-2)	●	●	●	●	●	●	**23**
Temperature-rise test (IEC 60947-7-1/2)	●	●	●	●	●	●	**23**
Dielectric test (IEC 60947-7-1/2 and UL 1059)	●	●	●	●	●	●	**24**
Short-time withstand current (IEC 60947-7-1/2)	●	●	●	●	●	●	**24**
Air clearances and creepage distances (IEC 60947-7-1)	●	●	●	●	●	●	**25**
Air clearances and creepage distances (UL 1059)	●	●	●	●	●	●	**26**
SCCR rating (NEC and UL 508A)			●	●			**27**
Voltage-drop test (IEC 60947-7-1/2)	●	●	●	●	●	●	**28**
Insertion cycles (IEC 61984)			●	●			**28**
Surge voltage test (IEC 60947-7-1/2)	●	●	●	●	●	●	**29**

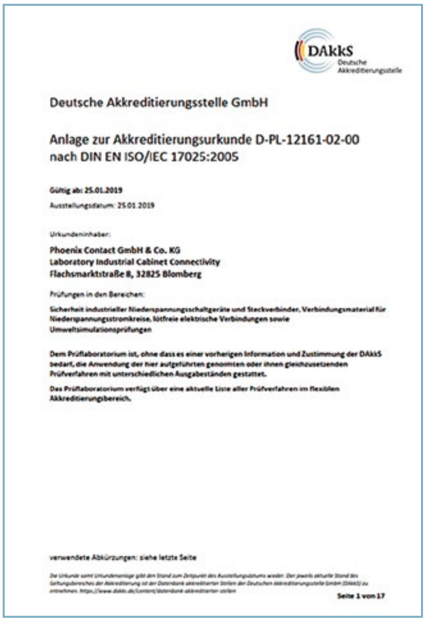
Material tests							
Aging test (IEC 60947-7-1/2)	(●)	●	●	●	●	●	**31**
Fire protection (EN 45545-2)				●			**31**
Flammability rating (UL 94)	●	●	●	●	●	●	**32**
Gross calorific value (DIN 51900/ASTM E 1354)		●	●	●	●	●	**32**
Glow-wire test (IEC 60695-2-11)		●	●	●	●	●	**33**
Halogen-free flame protection (DIN EN ISO 1043-4)		●	●	●	●	●	**33**
Insulation material properties – TI (IEC 60216-1)		●	●	●	●	●	**34**
Insulation material properties – RTI (UL 746B)		●	●	●	●	●	**34**
Climatic test: dry heat (IEC 60068-2-2)		●	●	●	●	●	**35**
Climatic test: damp heat (IEC 60068-2-30)		●	●	●	●	●	**35**
Corrosion test (DIN 50018)		●		●			**36**
Corrosion test – salt spray (IEC 60068-2-11/52)		●		●	●		**36**
Comparative tracking index CTI (IEC 60112)		●	●	●	●	●	**37**
Needle flame test (IEC 60947-7-1/2)	●	●	●	●	●	●	**37**
Surfaces and corrosion protection (WN 17)		●		●	●		**38**
Surface inflammability ASTM E 162 (NFPA 130)					●	●	**38**
Smoke gas development (EN ISO 5659-2)						●	**39**
Smoke gas development ASTM E 662 (NFPA 130)		●	●	●	●	●	**39**
Toxicity of smoke gas (NF X70-100-2 (600°C))						●	**40**
Toxicity of smoke gas SMP 800 C (NFPA 130)						●	**40**
Oxygen index (DIN EN ISO 4589-2)						●	**41**
Vertical small flames test (EN 60695-11-10)		●	●	●	●	●	**42**
Certifications, approvals, and static Q-values							
CCC			●				**45**
CE and attestation of conformity (2004/35/EU)		●	●	●	●	●	**45**
EAC		●	●	●	●	●	**46**
IECEx (IEC 60079)		●					**47**
JIS C 2811		●	●	●	●	●	**48**
NEC (ANSI/NFPA 70, Art. 409)			●	●			**48**
RoHS (EU Directive 2011/65/EU)		●	●	●	●	●	**49**
Shipbuilding registry (GL/LR/ABS/NV/KR/NK/RS)				●	●		**49**
UL 486A and UL 486 B		●	●	●	●	●	**50**
VDE	●			●			**50**
Static Q-values							**51**

Basic principles

To fundamentally ensure the quality of our products, it is very important to us that our high quality standards are met in all areas of manufacturing at Phoenix Contact. Our laboratories are very important factors in the quality assurance of our products throughout the entire manufacturing process. This is why our laboratories are the focus of our continuous optimizations and have a large number of accreditations and certifications.

CE accreditation laboratory

The Phoenix Contact development laboratories are accredited by independent accreditation bodies to perform environmental and electromechanical tests in accordance with various environmental and product standards. The test reports coming from these laboratories are internationally recognized, for example by customers, certification authorities, and government agencies.


DAkkS Deutsche Akkreditierungsstelle

Deutsche Akkreditierungsstelle GmbH

Anlage zur Akkreditierungsurkunde D-PL-12161-02-00 nach DIN EN ISO/IEC 17025:2005

Gültig ab: 25.01.2019

Ausstellungsdatum: 25.01.2019

Urkundeninhaber:

Phoenix Contact GmbH & Co. KG
Laboratory Industrial Cabinet Connectivity
Flachsmarktstraße 8, 32825 Blomberg

Prüfungen in den Bereichen:

Sicherheit industrieller Niederspannungsschaltgeräte und Steckverbinder, Verbindungsmaterial für Niederspannungsstromkreise, lötfreie elektrische Verbindungen sowie Umweltsimulationsprüfungen

Dem Prüflaboratorium ist, ohne dass es einer vorherigen Information und Zustimmung der DAkkS bedarf, die Anwendung der hier aufgeführten genormten oder ihnen gleichzusetzenden Prüfverfahren mit unterschiedlichen Ausgabeständen gestattet.

Das Prüflaboratorium verfügt über eine aktuelle Liste aller Prüfverfahren im flexiblen Akkreditierungsbereich.

verwendete Abkürzungen: siehe letzte Seite

Seite 1 von 17

Department	Standard / in-house method / versions	Title of the standard or in-house method (indicate deviations / modifications from the standard procedure if necessary)
Electrical engineering	DIN EN 60947-1 (VDE 0660-100) EN 60947-1 + A1 + A2 IEC 60947-1 + A1 + A2	Low-voltage switchgear and controlgear – Part 1: General rules Low-voltage switchgear and controlgear – Part 1: General rules
Electrical engineering	DIN EN 60947-7-2 (VDE 0611-1) EN 60947-7-1 IEC 60947-7-1	Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors
Electrical engineering	DIN EN 60947-7-2 (VDE 0611-3) EN 60947-7-2 IEC 60947-7-2	Low-voltage switchgear and controlgear – Part 7-2: Ancillary equipment – Protective conductor terminal blocks for copper conductors Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Protective conductor terminal blocks for copper conductors
Electrical engineering	DIN EN 60947-7-3 (VDE 0611-6) EN 60947-7-3 IEC 60947-7-3	Low-voltage switchgear and controlgear – Part 7-3: Ancillary equipment – Safety requirements for fuse terminal blocks Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Safety requirements for fuse terminal blocks

UL accreditation laboratory (1059)

The Phoenix Contact development laboratories are listed as manufacturer laboratories by the UL LLC. This makes them accredited for the performance of recognized UL tests as part of participation in the client-test data program. The in-house test results are thus used for certification processes and are recognized.


CERTIFICATE OF PARTICIPATION

Issued by

UL LLC

PHOENIX CONTACT GmbH & Co. KG

Development Quality Laboratory, Industrial Cabinet Connectivity, Flachsmarktstrasse 8, Blomberg 32825, Germany

has been assessed and found to be eligible to participate in the

Client Test Data Program (CTDP)

DA File: DA960
Issued: 2020-05-21
Expires: 2021-05-15

Kevin Mehaffey
Program Manager

CENELEC Certification Agreement (CCA) protocol

The documentation of the test results is the result of tests on test objects of the submitted product.

For mutual recognition by the various authorities and organizations on the European level, the documentation must be declared to be in agreement with the determinations of the respective standard by an accredited institute.

The basis for the terminal blocks is IEC 60947-7-1/-2/-3. CENELEC adopted a CENELEC Certification Agreement (CCA) on September 11, 1973 which was most recently revised on March 29, 1983 and which is thus valid today. In the agreement, the test results are documented in a standardized protocol (CCA protocol), which in turn can be submitted as a document to obtain numerous approvals and national conformity markings.

Phoenix Contact uses the CCA protocol as part of product approvals and certifications.

IECEE (CB scheme)

Manufacturers of electrical engineering products conduct numerous tests before market launch. These tests are run by certified laboratories and documented. Numerous approvals and releases are based on globally valid standards and tests. The CB scheme (CB = certified body) is an international program that was created by the IECEE. In this program, all participating laboratories and certification organizations are obligated to mutually recognize the results of the tests and examinations all over the world. Therefore, this program provides all participating manufacturers the opportunity to obtain multi-national certificates and approvals for their products in a simplified process. The documentation occurs in a test report (TRF) that conforms to the CB scheme based on the requested tests with a simple “pass, fail” or individual values. The Phoenix Contact development laboratories are certified accordingly.

Test sequence (IEC 60947-7-1/-2/-3)

The terminal block standard IEC 60947-7-1/-2/-3 describes the tests performed on terminal blocks for copper conductors. The tests are used to ensure the mechanical (§8.3), electrical (§8.4), and thermal (§8.5) features. All tests are performed as individual tests on brand new terminal blocks. Only the flexion and pull-out tests are performed in direct connection. The aging test is only performed on screwless terminal points. The standard is structured as follows:

1. Feed-through terminal blocks
2. Protective conductor terminal blocks
3. Fuse terminal blocks

Protective conductor terminal blocks are checked three times in succession for short-time withstand current.

Test sequence for terminal blocks in accordance with IEC

Section	Item	Category
8.3.2	Tight fit of terminal block	Mechanical tests
8.3.3.1	Mechanical strength (connection)	
8.3.3.2	Flexion test	
8.3.3.3	Conductor pull-out test	
8.3.3.4/5	Connection capacity	
8.4.2.2	Clearances	Electrical tests
8.4.2.3	Creepage distances	
8.4.3	Surge voltage test and power-frequency withstand voltage test	
8.4.4	Voltage-drop test	
8.4.5	Temperature-rise test	
8.4.6	Short-time withstand current	
8.4.7	Aging test	
8.5	Needle flame test	Material tests

Test sequence (UL 1059)

UL 1059 makes a distinction between terminal blocks based on application (use group) and nominal voltage.

Part I – Up to 600 V
Part II – 601 V to 1500 V
Part III – Spring-cage terminal blocks
Part IV – Cutting or piercing terminal blocks
Part V – Ground terminals

The test setup for terminal blocks is described in UL 486A-486B. Spring-cage terminal blocks and IDC or piercing contacts must withstand an additional temperature-rise test (30 days) directly followed by a withstand change voltage test.

They are also subject to an extended cyclic current heating test at 150% of the nominal current (aging).
Other requirements are: Ground terminals must contact the DIN rail without corrosion. They may only be removed using tools. A green-yellow identification is mandatory. In addition, there are specific values for the voltage drop and the short-time withstand current.

Other tests in accordance with UL 1059

Section	Item
11	Temperature-rise test
12	Power frequency withstand voltage test
13	Connection test, bent eyelet
14	Cable lug pull-out test
15	Mechanical strength (reconnection)
16	Plastic heat deformation test
17	Connection capacity

Test sequence in accordance with UL 486A-486B

Section	Item
7.1	General requirements
7.2	Cyclic current heating
7.3	Static current heating
7.4	Conductor pull-out and flexion test
7.5	Surge voltage test and power-frequency withstand voltage test
7.6	Conductor pull-out test
7.7	Drop test (height 914 mm)
7.8	Dielectric test in combination with the drop test
7.9	Flexion test for moving terminal block parts
7.10	Cold connection (Canada only)
7.11	Moisture absorption
7.12/7.13	Stress crack corrosion test

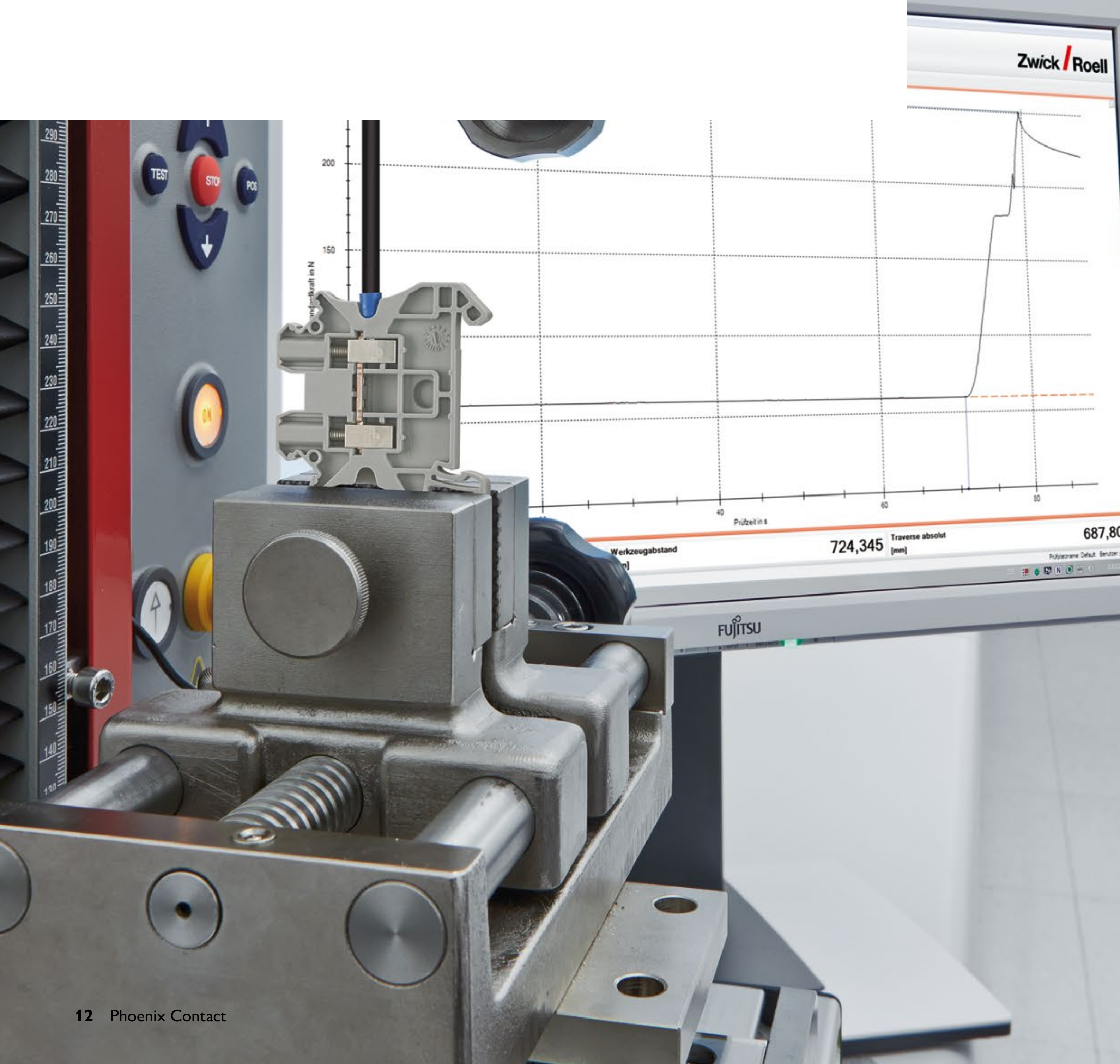
Type test report (IEC 60947-7-1/2)

The product development process in the Phoenix Contact Group is completed with laboratory tests and a product release. Approval is given after the tests relevant for the product have been successfully completed. The tests are described based on the product in performance and technical specifications and are recorded in a test plan. Our accredited laboratories are responsible for the testing.

In a European context, terminal blocks are checked based on Low Voltage Directive 2014/35/EU and IEC 60947-7-1/-2/-3, for example. In a UL context, they are checked based on UL 1059 and NEC 508. These test results are documented in a type test report in their entire scope. The report itself contains comprehensive information on the laboratory performing the tests, the equipment used for the test, and the test results. Therefore, type test reports are always treated with a certain degree of sensitivity, because the information they contain is considered confidential. Wider-ranging approvals may be requested based on the type test report. The type test report is also considered a legally-binding verification of the product properties. Phoenix Contact uses type test reports for legally safeguarding the product properties and for product approval.

Mechanical tests

The mechanical tests are primarily used to test the clamping parts of the terminal blocks and the insulating housing. These tests focus on safe connection capacity and the terminal block's ability to withstand conductor movement and conductor pull-out. In addition, the mechanical strength of the terminals and the influence of ambient conditions is tested. By performing these tests, we are able to guarantee you high quality standards with respect to the mechanical properties.



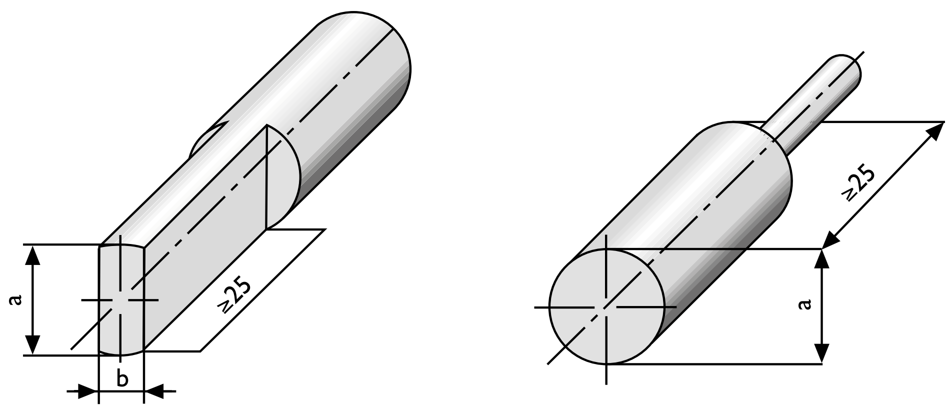
Connection capacity (IEC 60947-7-1/-2)

This mechanical test defines the connection of commercially available conductors in accordance with the manufacturer's specifications. Terminal blocks must be designed in such a way that conductors with the documented rated cross-section with the rated connecting capacity can be connected. The specifications are documented by the manufacturer in metric (mm^2) and imperial values (AWG).

Rated cross-section means: The value of the maximum possible cross-section of all connectable conductors (flexible, single or multi-stranded) that certain thermal, mechanical, and electrical requirements refer to.

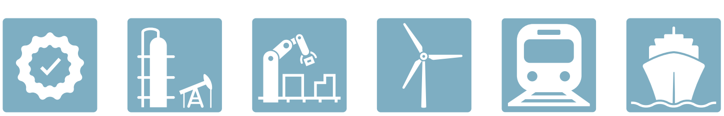
Rated connection capacity means: The range encompassing the largest to the smallest connectable cross-section (min. reduced by at least 2 increments) and the number of connectable conductors for which the terminal block has been designed.

During the test, the terminal blocks are connected with the rated cross-section and the rated connection capacity. Alternatively, the rated cross-section can also be verified using gauges. (See fig.) It must be possible to freely insert conductors or gauges into or connect them to the open terminal point. Terminal blocks from Phoenix Contact offer dimensions for the defined rated cross-section that are well above the standard. Thanks to appropriate design measures, the rated cross-sections can also be connected with a ferrule and insulating collar in all terminal blocks of the CLIPLINE complete system.



Conductor pull-out forces in accordance with IEC 60999/EN 60999/VDE 0609-1

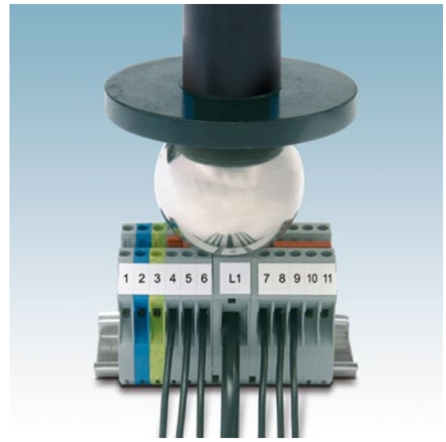
Conductor	Form	Diameter "a"	Width "b"	Form	Diameter "a"
1.5 mm²	A1	2.4 mm	1.5 mm	B1	1.9 mm
2.5 mm²	A2	2.8 mm	2.0 mm	B2	2.4 mm
4 mm²	A4	3.6 mm	3.1 mm	B4	3.5 mm
6 mm²	A5	4.3 mm	4.0 mm	B5	4.4 mm
10 mm²	A6	5.4 mm	5.1 mm	B6	5.3 mm
16 mm²	A7	7.1 mm	6.3 mm	B7	6.9 mm
35 mm²	A9	10.2 mm	9.2 mm	B9	10.0 mm
50 mm²	A10	12.3 mm	11.0 mm	B10	12.0 mm
70 mm²	A11	14.2 mm	13.1 mm	B11	14.0 mm
95 mm²	A12	16.2 mm	15.1 mm	B12	16.0 mm
150 mm²	A14	22.2 mm	19.0 mm	B14	20.0 mm
240 mm²	A16	26.5 mm	24.0 mm	B16	26.0 mm



Touch protection (IEC 60529)

Electrical installations and plants must also afford a high level of safety when carrying out maintenance or during measuring and testing tasks. BGV A3 prescribes the voltage-free state of the affected low-voltage system parts up to 1,000 V AC and 1,500 V DC for general work in the vicinity of live parts. To prevent electric shock, live parts must be secured against direct contact through the use of covers or barriers. The terminal blocks from Phoenix Contact therefore offer electrically skilled persons and instructed persons touch protection based on EN 50274. During testing based on EN 50274, the test probes are led from the operating direction to the test object. Electrical contact between the test probes and live parts must not occur. Finger contact safety is tested with a test force of 10 N and back-of-hand safety at 50 N. Phoenix Contact terminal blocks are mainly designed in accordance with DIN EN 50274. For more detailed information, please refer to the product documentation.

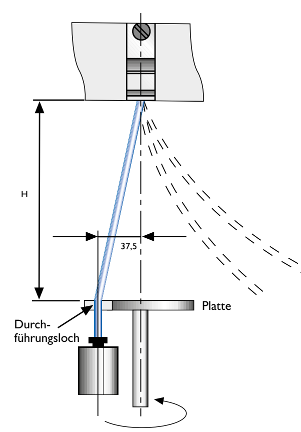
Touch-proof safety: Test finger Ø12.5 mm



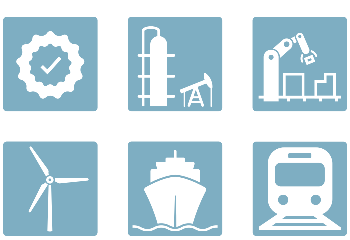
Back-of-hand safety: Test ball Ø50 mm

Flexion test (IEC 60947-7-1/-2)

Correctly wired terminal blocks must offer a high degree of mechanical safety. This includes reliable connection of the conductor. Therefore, tests are performed with solid and stranded wires with the smallest cross-section, with the rated cross-section, and with the maximum cross-section. A vertically fixed terminal block is connected to a conductor. At the end of the conductor, a test weight corresponding to the cross-section is attached. The conductor is fed through a central 37.5 mm aperture in a rotating disc and turned on its own axis 135 times. This procedure must not damage the clamping area on the conductor. Afterwards, the contact must pass a conductor pull-out test. Terminal blocks from Phoenix Contact are designed to ensure that the conductor makes gentle contact in the clamping area. This prevents damage to the conductor and contact point, which still have identical properties even after repeated clamping.



Test equipment for the flexion test in accordance with the standard



Cross-section	AWG	Spacing H	Load
0.2 mm²	24	260 mm	0.3 kg
4 mm²	12	279 mm	0.9 kg
240 mm²	500	464 mm	20.0 kg

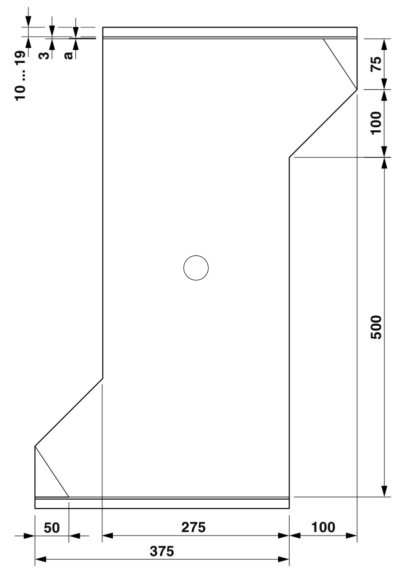
Flexion test test parameter

Tumbling barrel test (IEC 60068-2-32)

The tumbling barrel test is an impact test that simulates the fall of a test specimen from a height of 500 mm 50 times in a standardized rotating barrel. This test is carried out on a single terminal block. In the process, no defects that might impair further use of the terminal block may occur. This includes all damage that affects the tight fit on the DIN rail as well as chipping and fractures that affect the insulation or the air clearances and creepage distances.

In the case of Phoenix Contact terminal blocks, this test also guarantees the tight fit of the assembled individual parts in the housing, given the sometimes-long transport distances of the packaged terminal blocks before installation.

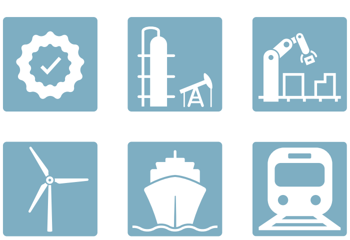
Tumbling barrel test



Dimensional drawing of a tumbling barrel

Tight fit of the terminal block (IEC 60947-7-1/-2)

Besides the reliable connection of the conductor, the terminal block itself must be able to withstand forces without coming loose from its support. To test whether the fit is tight, a terminal block is mounted on a standard DIN rail according to the manufacturer's specifications. Then steel rods with a length of 150 mm are clamped into the terminal points. Tensile and pressure forces based on the cross-section are exerted on the terminal points and the latching of the terminal block with a lever distance of 100 mm. The terminal block must not come loose or break off the DIN rail in the process. Furthermore, no unacceptable damage may occur on the housing. The structural design of the terminal blocks from Phoenix Contact ensures a reliable tight fit on different DIN rail systems.

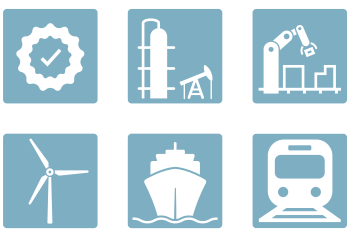


Cross-section	AWG	Force	Diameter of the steel bar
0.75 mm²	18	1 N	1.0 mm
1 mm²		1 N	1.0 mm
1.5 mm²	16	1 N	1.0 mm
2.5 mm²	14	1 N	1.0 mm
4 mm²	12	1 N	1.0 mm
6 mm²	10	5 N	2.8 mm
10 mm²	8	5 N	2.8 mm
35 mm²	2	10 N	5.7 mm
50 mm²	0	10 N	5.7 mm
240 mm²	500 kcmil	20 N	20.5 mm

Test parameter for tight fit of the terminal block

Conductor pull-out test (IEC 60947-7-1/-2)

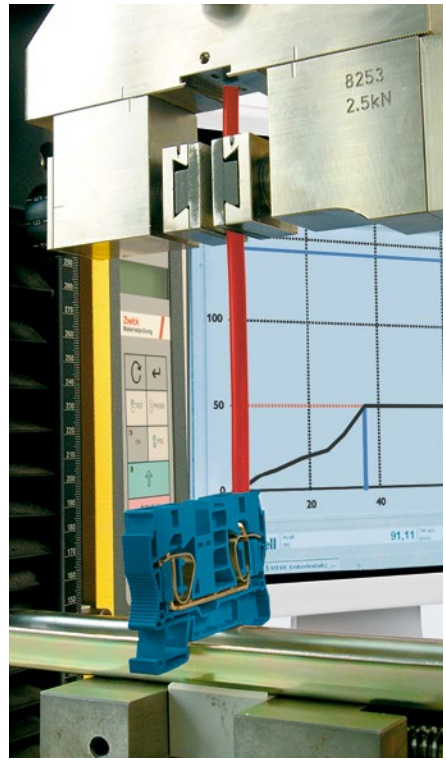
In practice, tensile forces can affect the terminal point during wiring or operation. Therefore, terminal blocks must be wired correctly to offer a high degree of mechanical safety. To test the tensile load capacity of a terminal point, the terminal point must withstand a given tensile force based on the cross-section for over 60 seconds. This test is performed after the flexion test. Performing these two tests directly one after the other intensifies the requirements. The tensile force exerts stress on the conductor at the terminal point. The conductor must be held without damage. The AWG tensile force is based on the cross-section to be tested (see table).



The test results for terminal blocks from Phoenix Contact are up to 150% above the required minimum values.

Cross-section	AWG	Tensile force
0.2 mm²	24	10 N
4 mm²	12	60 N
300 mm²	600	578 N

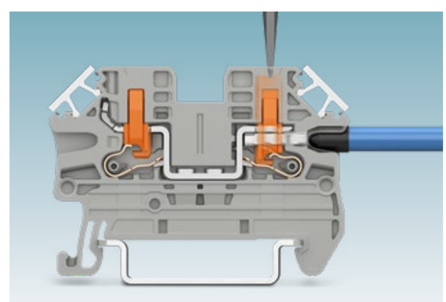
Conductor pull-out forces in accordance with IEC 60999/EN 60999/VDE 0609-1



Absorption of tensile force on a 10 mm² spring-cage terminal block

Mechanical strength (IEC 60947-7-1/-2)

The mechanical strength of the terminal point is checked in a practical test. For this purpose, the terminal points of the terminal blocks must be repeatedly connected without loss of quality in the terminal connection. Therefore, solid conductors with the rated cross-section are used to connect and disconnect a terminal block five times as specified in the manufacturer's specifications. Switching is done on the middle terminal block of a block of five. Before and after the test, the terminal blocks must pass a voltage-drop test. The terminal point must withstand repeated reconnection without sustaining noticeable damage. The voltage drop must not exceed 3.2 mV before the test. The voltage drop after the test must not exceed 1.5 times the value measured before the test. Terminal blocks from Phoenix Contact are suitable for repeated connection without any perceivable loss of quality. The number of possible connections can reach up to 5,000 cycles, depending on the connection technology.



PTV terminal block

Impact test (IK rating) (IEC 62262)

IEC 62262 describes a test procedure to determine a degree of protection (IK value) against mechanical strain. This degree of protection is mainly determined in connection with housings and boxes. In the test, a defined impact element (hammer) hits the horizontally mounted test object five times in succession at different points in a vertical drop with a precisely defined energy. The impact range of the impact element forms a semi-circle.

The impact elements for the different degrees of severity are divided into six categories. The CLIPLINE complete connector housings for the Push-in COMBI series have a degree of protection of IK5.

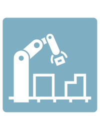
IK code	Stress energy
IK00	1)
IK01	0.15 J
IK02	0.2 J
IK03	0.35 J
IK04	0.5 J
IK05	0.7 J
IK06	1 J
IK07	2 J
IK08	5 J
IK09	10 J
IK10	20 J

1) Relationship between IK code and stress energy not protected under this standard.

Impact test

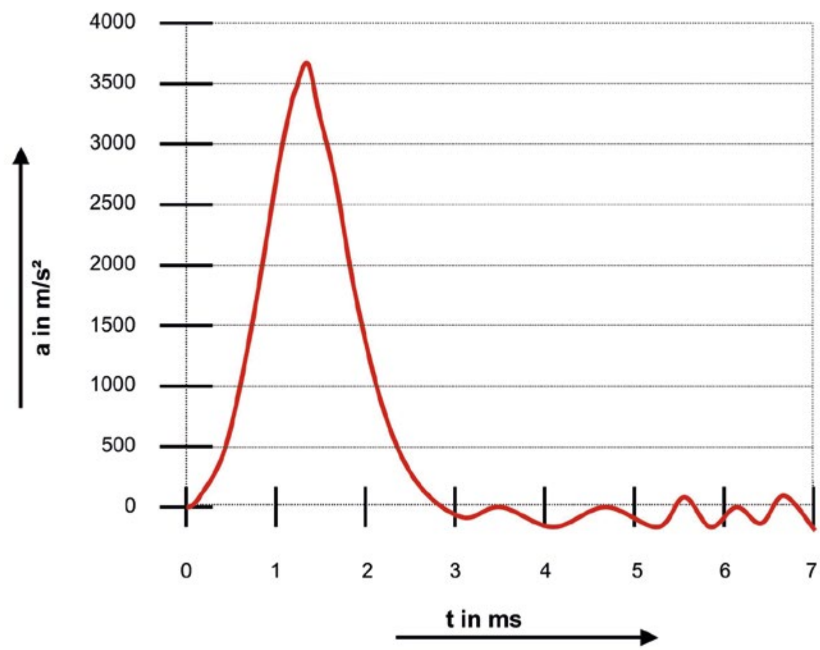
Category	Weight	Diameter	Material	Drop height
IK01 ... IK05	0.2 kg	Ø10 mm	Polyamide	200 mm
IK06	0.5 kg	Ø10 mm	Polyamide	200 mm
IK07	0.5 kg	Ø25 mm	Steel	400 mm
IK08	1.7 kg	Ø25 mm	Steel	295 mm
IK09	5.0 kg	Ø25 mm	Steel	200 mm
IK10	5.0 kg	Ø25 mm	Steel	400 mm

IK values and the associated data

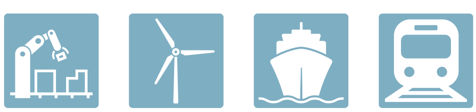



Shock testing (IEC 60068-2-27)

The shock testing is used to test and document the resistance of a terminal connection to shocks that occur at irregular intervals (with varying energy content). In doing so, degrees of severity from DIN EN 50155 and IEC 61373 (international standard for railway applications) are used to simulate the load in rail traffic. For the definition of the shock, acceleration and duration are specified. IEC 60068-2-27 prescribes three positive and negative shocks on each of the three spatial axes (X, Y, Z). The simulated accelerations reach 50 m/s^2 with a shock duration of 30 ms. No damage may occur at the terminal connection that would impair further use. The contact behavior at the test objects is monitored during the test. When the German railway standard is applied, no contact interruptions >1 µs are permitted. Phoenix Contact terminal blocks achieve this shock resistance, making them also suitable for applications with strong vibrations.

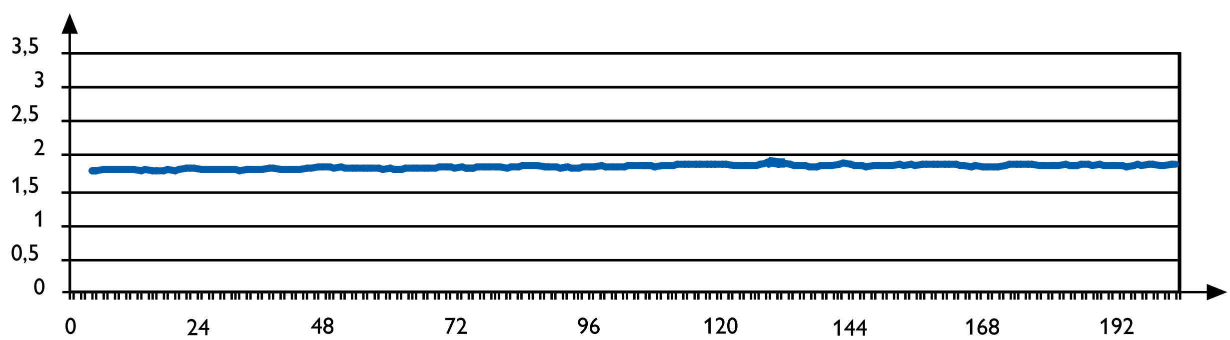


Shock diagram with 3500 m/s^2/3 ms

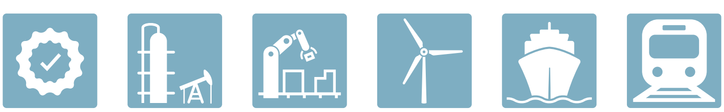


Temperature shock testing (DIN EN 60352 T4)

In process engineering, rapid changes in temperature often occur near process-related sources of heat and cold. This test verifies that the contact quality of the terminal points remains consistently high even in the case of rapid changes in temperature. For testing purposes, five terminal blocks are mounted on the support and wired to a conductor with the rated cross-section. The structure is subjected to rapid temperature changes using a two-chamber method. The temperatures lie close to the upper and lower limit temperatures of the terminal block. This is generally a temperature range of -60°C to +100°C. The dwell time in each climatic chamber is 45 minutes, whereby the change takes place within a few seconds. This change is performed for 100 cycles. The requirements are met if, after the test, the single parts are undamaged and their further use is guaranteed.



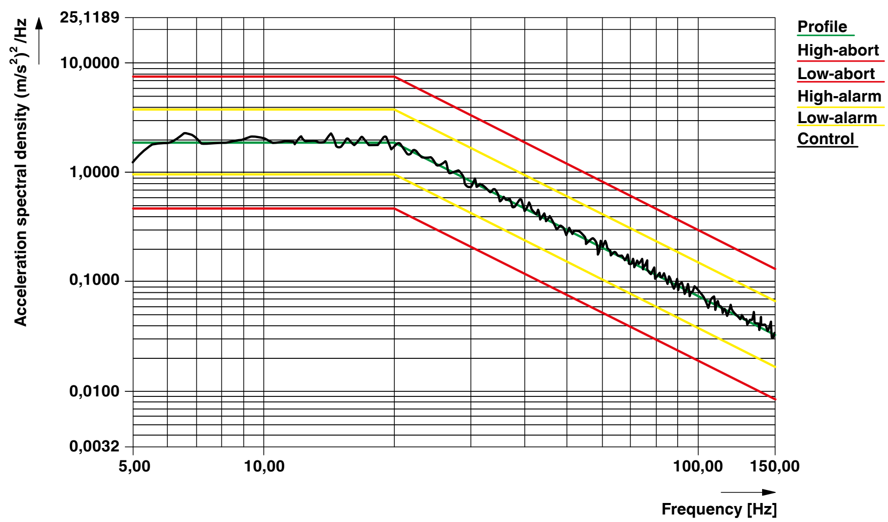
Voltage-drop test on more than 200 test objects following the test



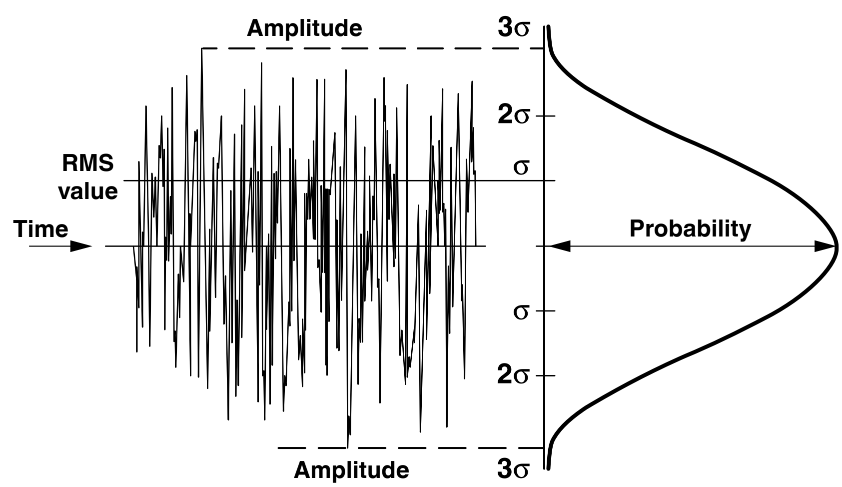
Vibration test – noise signal (IEC 60068-2-64)

In many applications, terminal blocks are exposed to vibrations and shocks. This interference is not always harmonic, regular, or consistent in frequency. Such vibrations can be caused by mounting in means of transport, such as rail vehicles, for example. These loads also occur in production machines or in mining technology. Rail applications are leading the way here in defining the degree of severity for vibration testing. DIN EN 50155 states that if not established otherwise, the requirements of EN 61373, Category 1, Class B apply. This results in the following parameters (see table).

For a practical simulation of the vibration stress, the test objects are subjected to broadband noise-induced vibrations in the laboratory. This means that realistic accelerations are generated at the terminal block and the connected conductor. For the signal mix to be real, a certain distribution of accelerations and amplitudes must be guaranteed. During the Category 1 B test, the objects are exposed to a frequency range of 5 Hz to 150 Hz. The RMS value of the acceleration is up to 5.72 m/s². The test objects are tested for 5 hours on each of the three axes (X, Y, Z). In addition to the vibrations, the electrical contact is monitored during the test for interruptions. During this, no damage may occur at the terminal blocks that would impair their further use. In addition, no contact interruptions >1 µs are permitted during the test. The contact resistance is measured before and after the test. The resistance must be ≤1.5 times the initial value. Terminal blocks of all connection technologies from Phoenix Contact achieve this requirement from the standard without impermissible contact interruption. They are therefore well-suited for demanding applications in which a reliable functioning of the terminal connection has to be ensured when subjected to vibrations.



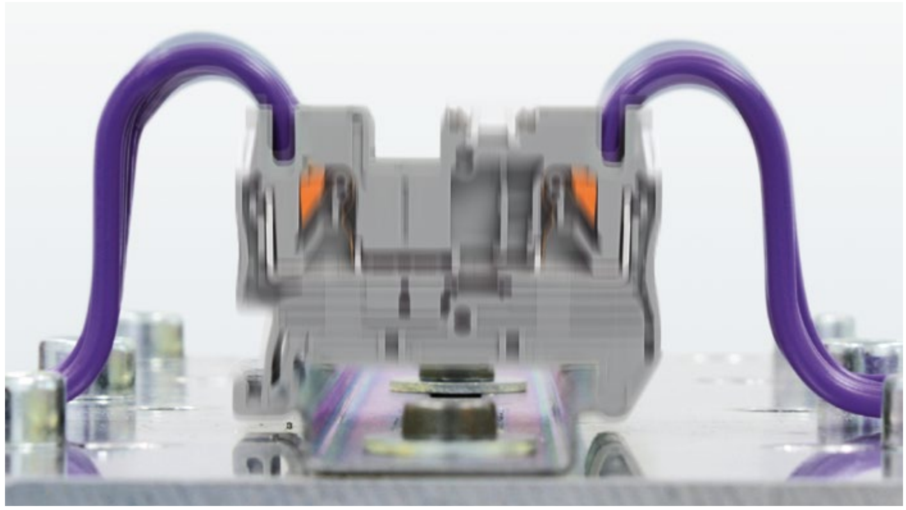
Testing diagram in accordance with Category 1B

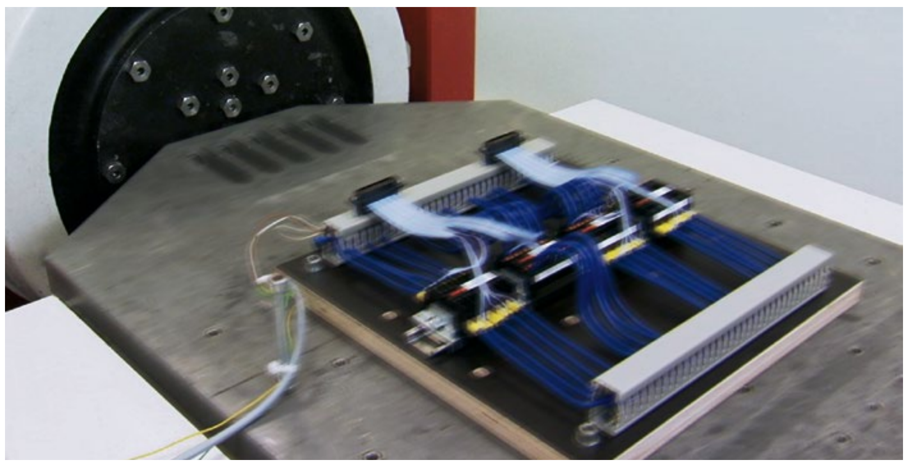


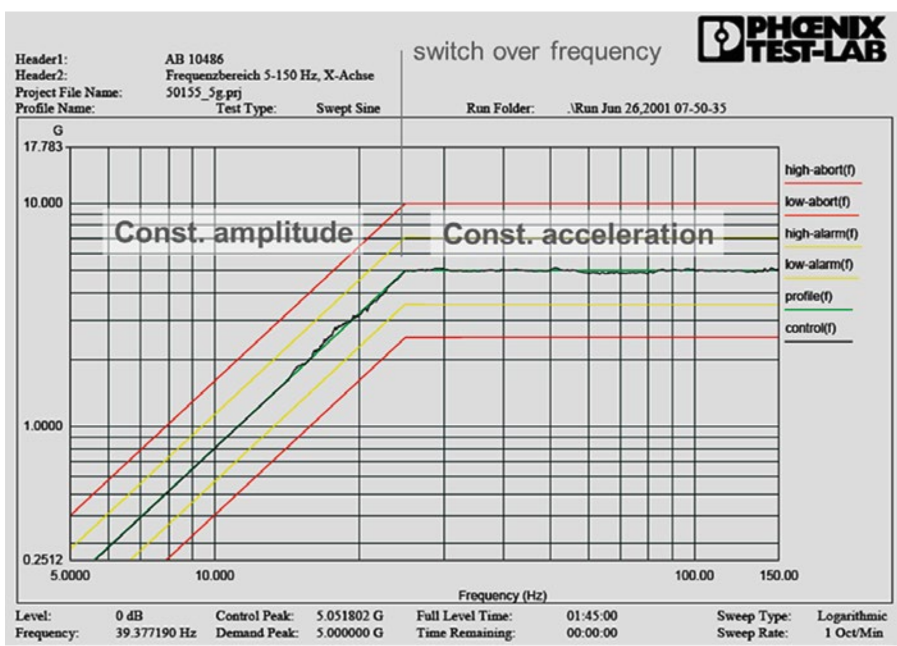
Category	Orientation	RMS value
1B – vehicle body	Vertical	5.72 m/s²
	Horizontal	2.55 m/s²
	Lengthwise	3.96 m/s²
1B – bogie	Vertical	30.6 m/s²
	Horizontal	26.6 m/s²
	Lengthwise	14.2 m/s²

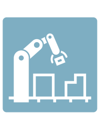
Vibration test – sine (IEC 60068-2-6)

This test demonstrates the vibration resistance of a terminal connection subjected to continuous vibrations as they can be caused by rotating masses, for example. Such vibrations occur for example in power plant turbines and generators, in wind turbine generators, and in motors or drives.
Harmonic, sinusoidal vibrations are applied to the test object on the vibration test system (vibrating table) to simulate even, vibrating forces. The test runs through a frequency range of 5 Hz to 150 Hz and then back to 5 Hz per cycle. In the process, the amplitude of the oscillation on the vibrating table is kept constant up to 25 Hz. However, above this value, the acceleration of the component remains constant. The RMS value of the acceleration is up to 50 m/s². The frequency changes with one octave per minute, i.e., it doubles or halves its frequency every 60 s. The test objects are tested for 2 hours on each of the three axes (X, Y, Z). During this, no damage may occur at the terminal blocks that would impair their further use. In addition, no contact interruptions (>1 µs) are permitted during the test. The contact resistance is measured before and after the test. The resistance must be ≤1.5 times the initial value. All connection technologies achieve this requirement from the standard without impermissible contact interruption. They are therefore well-suited for demanding applications in which a reliable functioning of the terminal connection has to be ensured when subjected to vibrations.


Vibration test – Push-in terminal block

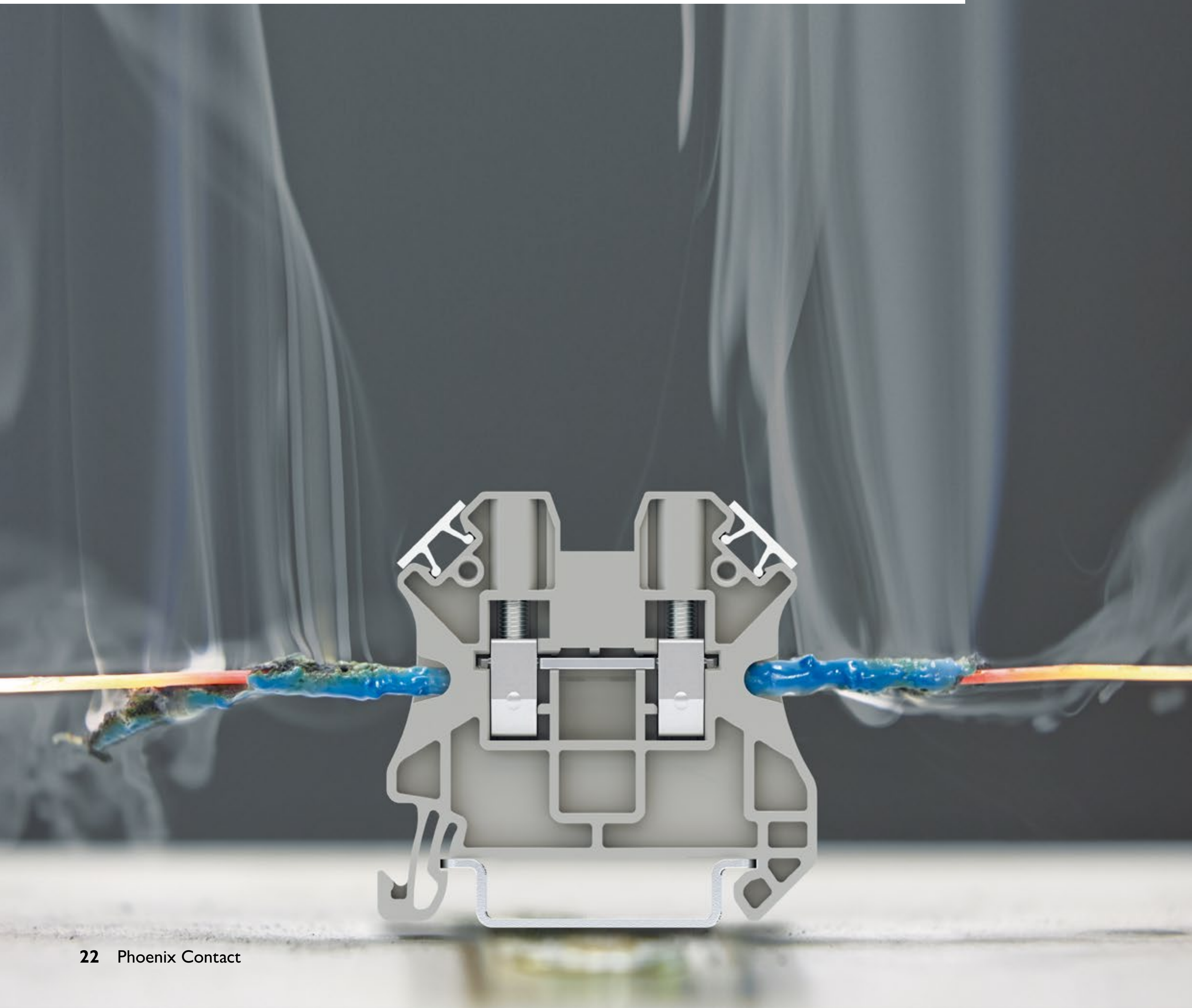

Vibration test – screw terminal block





Electrical tests

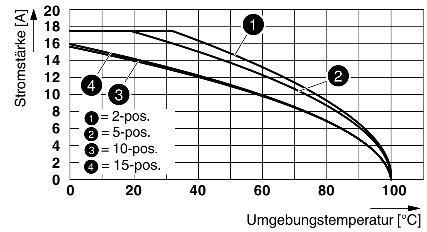
The electrical tests mainly concern the current flow in the terminal block. They involve imitating various scenarios in which the terminal blocks are tested for maximum reliable short-circuit currents or warming at nominal current. To ensure that the efficiency of the terminal blocks can be guaranteed, the voltage drop is also checked. The terminal blocks are also tested for electrical disruptive discharge, creepage distances, and insulation characteristics to ensure adequate electrical isolation.



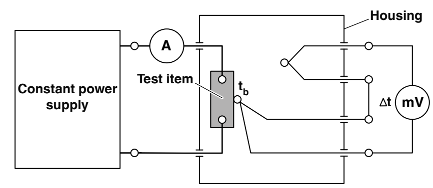
Derating of connectors (DIN EN 60512-5-2)

The derating curve represents the current carrying capacity of a component as a function of the ambient temperature and neighboring contacts. It is affected by the contact material and the insulating housing. To determine the current-carrying capacity of plug-in terminal blocks, arrangements with a variety of positions are selected, which are electrically connected in series using conductors with the same cross-section. For the practical determination of the derating curves, the current carrying capacity of the plug-in terminal blocks is determined in accordance with DIN EN 60512-5-1. Here, after applying various currents and setting the temperature balance, the maximum temperature increase that occurs on the test objects is measured.

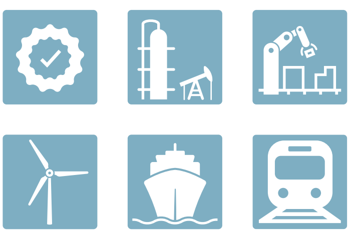
When the upper limiting temperature of the insulation material (here, always assumed to be 100°C) is taken into account, these values yield a derating curve dependent on the ambient temperature (the "base curve"). An adjusted capacity curve – the "derating curve" – is generated according to DIN EN 60512-5-2. In accordance with this standard, the permissible load current is 0.8 times the respective base current. The derating factor "...takes into account manufacturing tolerances in the connector contact system. It also takes into account uncertainties in the temperature measurement and the measuring arrangement." Derating curves with 2-, 5-, 10-, and 15-position arrangements are specified for pluggable terminal blocks from Phoenix Contact.



Derating curve



Test setup to determine the derating curve using the PP-H 2,5/5 COMBI connectors as an example



Temperature-rise test (IEC 60947-7-1/2 and UL 1059)

The rise in temperature of a terminal block due to the Joule effect must be kept to an absolute minimum. The contact resistance must therefore be as low as possible. In this test, the rise in temperature that occurs at room temperature during exposure to a test current is documented.

IEC 60947-7-1/-2

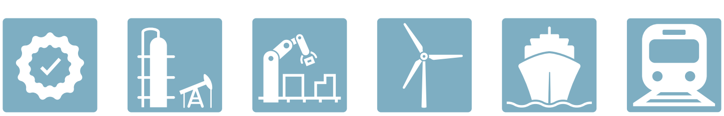
Here, five terminal blocks are horizontally mounted on a rail and connected in series using 1 or 2 m conductor loops with the rated cross-section. The terminal blocks are exposed to a test current that is as high as the current carrying capacity of the rated cross-section. The rise in temperature of the middle terminal block is documented (see figure Voltage-drop test, page 28). Assuming a room temperature of ~20°C, a maximum rise in temperature of 45 K (kelvin) is permitted in the terminal block.

Additionally, a voltage-drop test must be performed on the terminal block.

UL 1059

The process basically corresponds to the IEC test, only the conductor lengths differ. In the UL 1059, three terminal blocks are horizontally mounted adjacent to one another. The measurement is taken at an ambient temperature of 25°C, whereby a maximum rise in temperature of 30 K (measured as close as possible to the terminal point) is permitted. Due to the high-quality contact materials used in Phoenix Contact terminal blocks, all connection technologies offer lower heating values than required by the specified standards. High-value copper materials and reliable contact transitions guarantee low contact resistances in the terminal blocks.

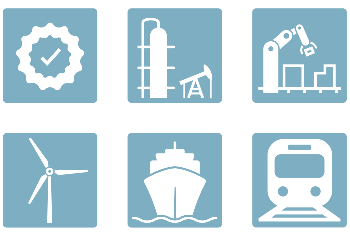
Temperature-rise test



Dielectric test with power-frequency withstand voltage (IEC 60947-7-1/2 and UL 1059)

This electrical test is used to demonstrate adequate creepage distances. To test that the distances between the potentials of two neighboring terminal blocks and between a terminal block and the DIN rail are sufficient, an appropriate test voltage is applied.

Definition:
Rated insulation voltage (U_i) is the RMS or DC voltage value that is permanently acceptable as a maximum when correctly used. The test voltage is maintained for 60 seconds. The assignment illustrated in the table is to be used as a basis.



IEC 60947-7-1/-2
No sparkover or disruptive discharge may occur during testing. Creepage currents must stay below 100 mA.

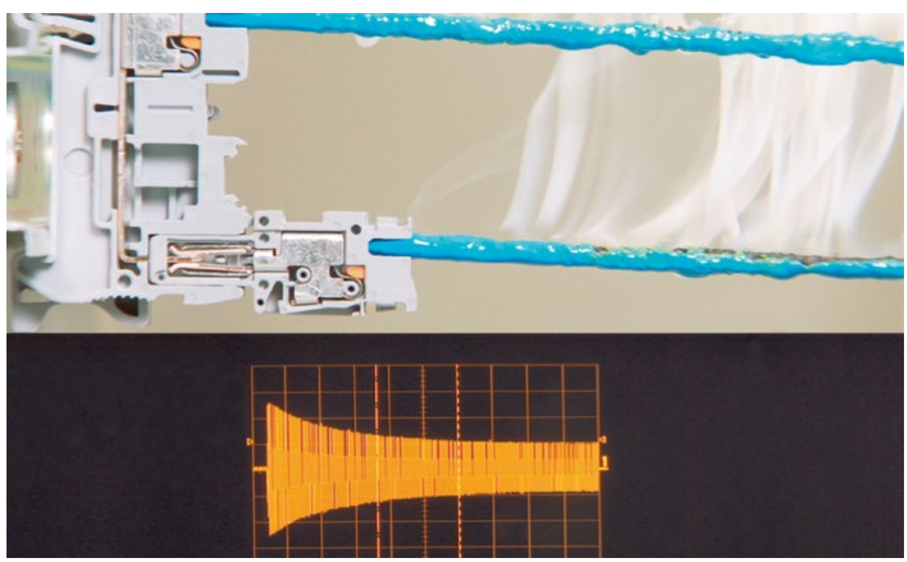
UL 1059
Test voltage = 1,000 V plus two times the rated insulation voltage Ui. Terminal blocks from Phoenix Contact with a rated insulation voltage of 800 V consistently pass the dielectric test with 2,000 V~.

Rated insulation voltage U_i	Test voltage (RMS)
U_i ≤60 V	1000 V
60 V< U_i ≤300 V	1500 V
300 V< U_i ≤690 V	1890 V
690 V< U_i ≤800 V	2000 V
800 V< U_i ≤1000 V	2200 V
1000 V< U_i ≤1500 V	

Test values of the dielectric test

Short-time withstand current (IEC 60947-7-1/-2)

Terminal blocks must, in practice, also be capable of resisting short-circuit currents until the relevant safety equipment cuts off the current without sustaining any damage. This can last a few tenths of a second and can occur at several times the nominal current. For testing purposes, a terminal block is mounted on the support and wired to a conductor with the rated cross-section. Protective conductor terminal blocks are subjected in three stages of 1 s each to a current density of 120 A/mm² of the rated cross-section. The requirements are met if, after the test, the individual parts are undamaged and they can still be used. Before and after the test, the terminal block must pass the voltage-drop test. The voltage drop before and after the test must not exceed 3.2 mV per terminal block nor may it exceed 1.5 times the value measured before the test. In the case of a 240-mm² high-current terminal block from Phoenix Contact, a test current of 28,800 A is passed through the terminal block for one second without loss of quality.



High contact reliability, even under extreme overload

Air clearances and creepage distances (IEC 60664-1)

Carrying out a dimensional check of air clearances and creepage distances confirms that electrical insulation characteristics are adequate with respect to the following:

- Design
- Expected contamination
- Expected ambient conditions

The distances are verified by measuring between two adjacent terminal blocks and between the live metal parts and the support, taking into account the shortest distances. This involves considering the isolation of the air as the clearance and the distance along the surface as the creepage distance. The minimum distances are defined in IEC 60947-1.

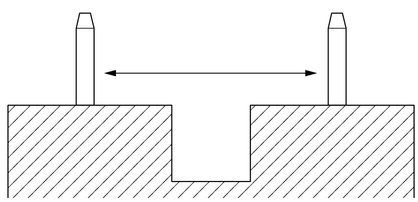
For the clearance, this means:
It is the shortest path through the air between two electrical potentials. The deciding factor for measuring the minimum clearance is the rated surge voltage, the overvoltage category of the terminal block, and the expected pollution degree. The rated surge voltage is derived from the neutral voltage with respect to the overvoltage category. If not documented otherwise, overvoltage category III is used for the terminal blocks. The category describes equipment in fixed installations and is intended for such cases where there are special requirements for the reliability and availability of the items.
The associated clearance is described in Table 2 (extract) of IEC 60664-1. Further specifications here are the generally non-homogeneous field for the application and pollution degree 3 (conductive pollution occurs or Table 2 – IEC 60664-1, a non-conductive pollution which becomes conductive since condensation is to be expected occurs).

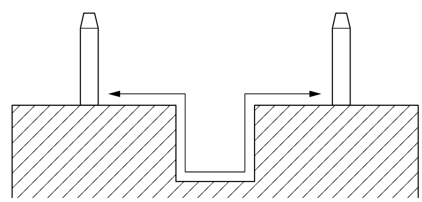
For the creepage distance, this means:
It is the shortest path along the surface of the isolation between two electrical potentials. The RMS value of the DC or AC voltage system (conductor to conductor, conductor to ground, conductor to neutral conductor) is decisive for determining the minimum creepage distance (see Table 3a and 3b of IEC 60664-1). Table 4 of IEC 60664-1 shows the relationship between the RMS value of the voltage, the pollution degree (3), and the insulation material group (I.) of the terminal block.

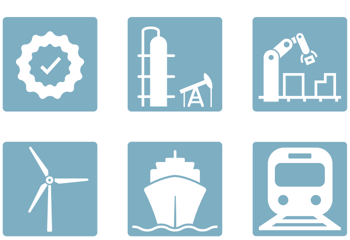
Neutral conductor conductor voltage (V)	Overvoltage category			
	I.	II.	III.	IV.
300	1500 V	2500 V	4000 V	6000 V
600	2500 V	4000 V	6000 V	8000 V
1000	4000 V	6000 V	8000 V	12000 V

Required impulse withstand voltage	Condition A: Non-homogeneous field		
	Pollution degree		
	1	2	3
4000 V	3.0 mm	3.0 mm	3.0 mm
5000 V	4.0 mm	4.0 mm	4.0 mm
6000 V	5.5 mm	5.5 mm	5.5 mm
8000 V	8.0 mm	8.0 mm	8.0 mm

Voltage RMS value	Pollution degree 3		
	Insulation material group		
	I.	II.	III.
500 V	6.3 mm	7.1 mm	8.0 mm
630 V	8.0 mm	9.0 mm	10.0 mm
800 V	10.0 mm	11.0 mm	12.5 mm
1000 V	12.5 mm	14.0 mm	16.0 mm


Clearance


Creepage distance



Air clearances and creepage distances (UL 1059)

UL 1059 takes a different approach to the assignment of air clearances and creepage distances. Even though the air and creepage distance definitions are physically the same, separate distance tables apply here as well as an assignment according to use groups and voltage ranges. In this case, use group C involves the default setting.

USE GROUP	Distances in inches (mm) between uninsulated potentials			
	Application	**Nominal voltage**	**Clearance**	
A	Operating elements, consoles, service equipment, etc.	51 V ... 150 V	1/2	(12.7 mm)
		151 V ... 300 V	3/4	(19.1 mm)
		301 V ... 600 V	1	(25.4 mm)
B	Commercially-available devices, including office and electronic data processing equipment, etc.	51 V ... 150 V	1/16	(1.6 mm)
		151 V ... 300 V	3/32	(2.4 mm)
		301 V ... 600 V	3/8	(9.5 mm)
C	Industrial applications, without restrictions	51 V ... 150 V	1/8	(3.2 mm)
		151 V ... 300 V	1/4	(6.4 mm)
		301 V ... 600 V	3/8	(9.5 mm)
D	Industrial applications, operating equipment with limited rating	151 V ... 300 V (10 A)	1/16	(1.6 mm)
		301 V ... 600 V (5 A)	3/16	(4.8 mm)
E	Terminal blocks with nominal voltage 601 V ... 1500 V	601 V ... 1000 V	0.55	(14.0 mm)
		1001 V ... 1500 V	0.70	(17.8 mm)
F	Using industrial devices with alternative approach to spacing	51 V ... 1500 V	As determined by evaluation	
G	LED lighting	51 V ... 300 V	1/16	(1.6 mm)
		301 V ... 600 V	1/16 ... 3/16	(1.6 mm ... 4.8 mm)

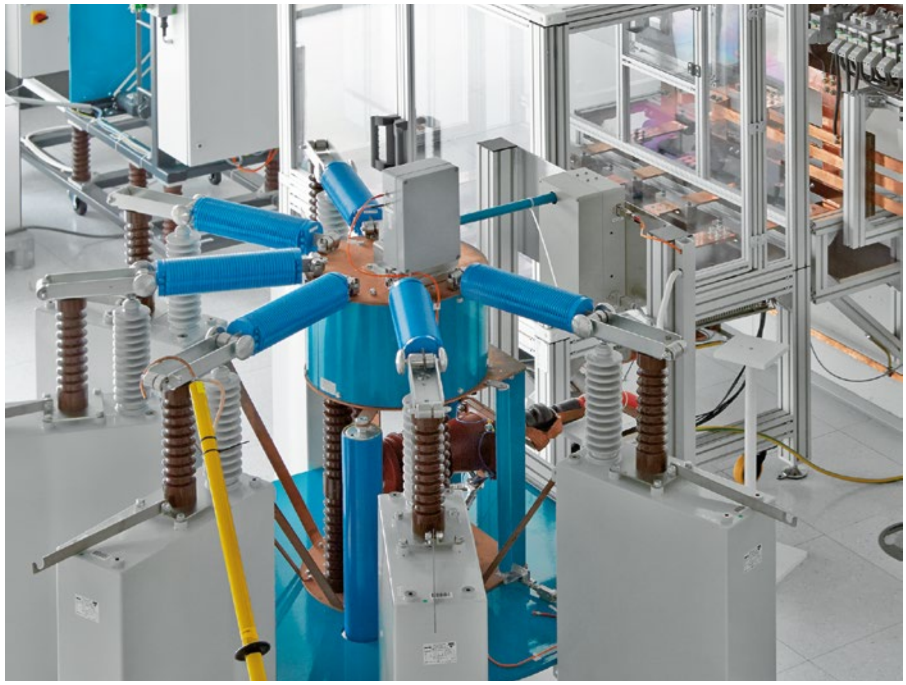
USE GROUP	Distances in inches (mm) between uninsulated potentials			
	Application	**Nominal voltage**	**Creepage distance**	
A	Operating elements, consoles, service equipment, etc.	51 V ... 150 V	3/4	(19.1 mm)
		151 V ... 300 V	1 ... 1/4	(31.8 mm)
		301 V ... 600 V	2	(50.8 mm)
B	Commercially-available devices, including office and electronic data processing equipment, etc.	51 V ... 150 V	1/16	(1.6 mm)
		151 V ... 300 V	3/32	(2.4 mm)
		301 V ... 600 V	1/2	(12.7 mm)
C	Industrial applications, without restrictions	51 V ... 150 V	1/4	(6.4 mm)
		151 V ... 300 V	3/8	(9.5 mm)
		301 V ... 600 V	1/2	(12.7 mm)
D	Industrial applications, operating equipment with limited rating	151 V ... 300 V (10 A)	1/8	(3.2 mm)
		301 V ... 600 V (5 A)	3/8	(9.5 mm)
E	Terminal blocks with nominal voltage 601 V ... 1500 V	601 V ... 1000 V	0.85	(21.6 mm)
		1001 V ... 1500 V	1.20	(30.5 mm)
F	Industrial devices that use the alternative approach to spacing	51 V ... 1500 V	As determined by evaluation	
G	LED lighting	51 V ... 300 V	1/8	(3.2 mm)
		301 V ... 600 V	1/8 ... 3/8	(3.2 mm ... 9.5 mm)

SCCR rating (NEC and UL 508 A)

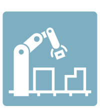
As of April 2006, the NEC (National Electrical Code) requires the short-circuit current rating of industrial controllers to be specified. These SCCR (short-circuit current rating) values can be calculated with the help of UL 508 A. In the USA, the calculation must be summarized on the rating plate of all industrial switchgears, for all main circuits, as well as for the feed-in of the control voltage supply. Standard values for non-specified components are listed in UL 508 A (Table SB 4.1). A standard value of 10 kA is specified for terminal blocks. This SCCR value describes the short-circuit rated current flow of a system or component under specification of a rated voltage. This is the maximum permissible symmetrical fault current that does not lead to significant damage that could impair use or lead to dangerous handling.

On the complete system side, this SCCR value is based on the weakest installed components in the associated distributor or feed circuit. Terminal blocks in the CLIPLINE complete system are documented as having SCCR values of 100 kA in the UL file XCFR2_ E60425. They help you to create powerful systems with high measured SCCR values.

For circuits in which the installation of higher documented components is not possible, the entire circuit can be rated higher by connecting a correspondingly high-current listed fuse terminal block upstream. The UK 10,3-CC HESI N fuse terminal block allows the SCCR for downstream circuits to be raised to 200 kA.

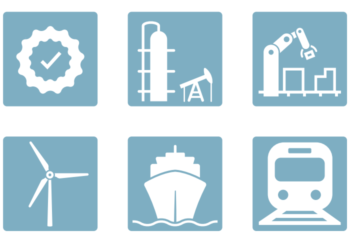


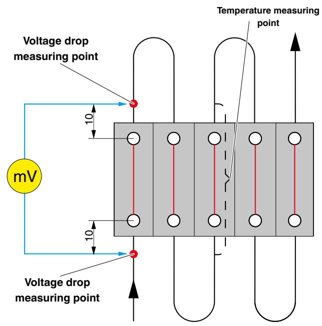
Overvoltage laboratory



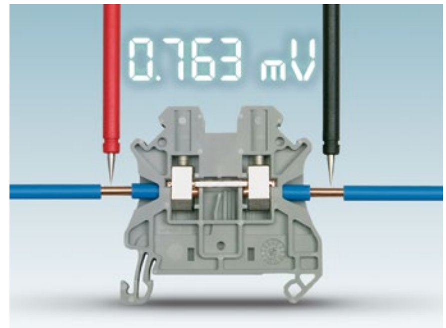
Voltage-drop test (IEC 61984)

In every terminal point of a terminal block, one or more conductors are connected – depending on the connection technology. Current transfer is strongly affected by the electrical resistance between the conductor and the current bar. High-quality contacts create a gas-tight connection. This guarantees a long-lasting and reliable connection. This electrical test therefore determines the voltage drop on a terminal block (two terminal points), from which conclusions about the contact resistance and the contact quality can be drawn. The terminal blocks are wired with the rated cross-section. For measuring purposes, a direct test current corresponding to 0.1 times the current carrying capacity of the rated cross-section is applied to the terminal blocks. The voltage drop is picked off at a distance of ≤10 mm from the middle of the terminal point (see diagram). At a room temperature of ~20°C, the voltage drop must not exceed 3.2 mV per terminal block before and after the test, nor may it exceed 1.5 times the value measured at the start of the test. Terminal blocks from Phoenix Contact are up to 60% below the limit values required by standards.





Voltage-drop test at terminal points



Voltage pick-off on a screw terminal block

Rated cross-section	Current carrying capacity	Rated cross-section AWG	Current carrying capacity
0.2 mm²	4 A	24	4 A
0.5 mm²	6 A	20	8 A
0.75 mm²	9 A	18	10 A
1 mm²	13.5 A	–	–
1.5 mm²	17.5 A	16	16 A
2.5 mm²	24 A	14	22 A
4 mm²	32 A	12	29 A
6 mm²	41 A	10	38 A
10 mm²	57 A	8	50 A
16 mm²	76 A	6	67 A
35 mm²	125 A	2	121 A
50 mm²	150 A	0	162 A
95 mm²	232 A	0000	217 A
150 mm²	309 A	00000	309 A
240 mm²	415 A	500 MCM	415 A

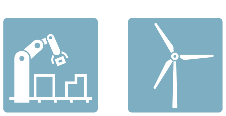
Test values for the voltage-drop test

Insertion cycles (IEC 61984)

IEC 61984 provides a complete test scenario for connectors in the power range of 50 V ... 1,000 V with up to 500 A current carrying capacity. To this end, design protection properties (e.g., IP class) as well as mechanical and electrical characteristics are classified and specified depending on the application. They are checked in groups A–E (see table). The indication of the insertion cycles as a durability test is a key statement from test group A. Preferred cycles for connectors without switching capacity (COC) and also with switching capacity (CBC) are 10, 50, 100, 500, 1,000, 5,000.

Three to four insertion cycles are completed per minute in the test with switching capacity. The speed is set to 0.8 ±0.1 m/s. After the test, you must ensure that no damage has occurred which could impair future use. This includes both a visual inspection of the corrosion protection layer as well as a voltage-drop test. Terminal blocks and male connectors from the CLIPLINE complete COMBI series are generally qualified for 100 insertion cycles.

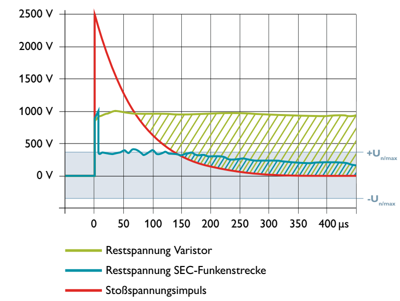
Test group A	Test group B	Test group C	Test group D	Test group E
Mechanical tests	Durability tests	Thermal tests	Climatic tests	Degree of protection tests



Surge voltage test (IEC 60947-7-1/2)

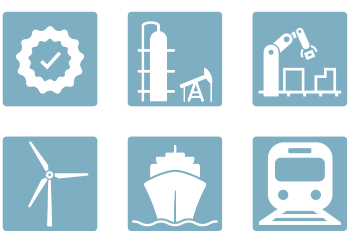
Proof of sufficiently large clearances between two neighboring potentials is provided through the surge voltage test. The test is carried out with the surge voltage five times for all polarities in relation to the rated insulation voltage. The time intervals in this process are at least 1 s. The distance between neighboring terminal blocks or between the terminal block and the rail is examined. There must be no unintentional sparkovers during the test.

Rated surge voltages for Phoenix Contact terminal blocks are between 6 and 8 kV in accordance with IEC 60664. The respective height is derived from the nominal voltage. Operationally safe use of the documented operating voltages of the terminal blocks is thereby effectively checked. Category III of the overvoltage category is the default setting.



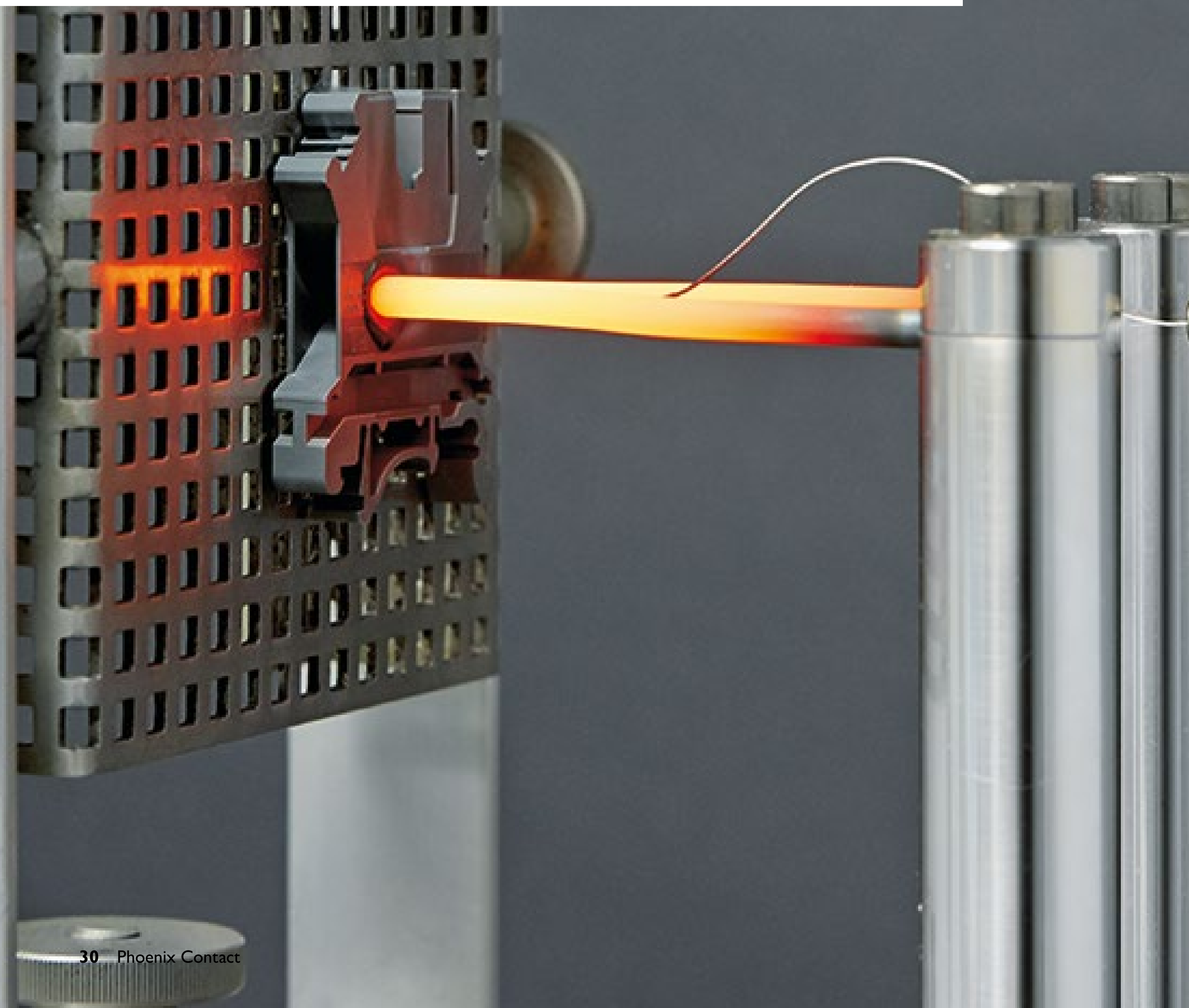
Time curve for a voltage surge pulse

Nominal voltage of the power supply system (mains) as per IEC 60038			Conductor-neutral conductor voltage derived from the total nominal AC voltage or nominal DC voltage	Rated surge voltage			
Three-phase		Single-phase		Overvoltage category			
				I	II	III	IV
		120 V ... 240 V	50 V	330 V	500 V	800 V	1500 V
			100 V	500 V	800 V	1500 V	2500 V
			150 V	800 V	1500 V	2500 V	4000 V
230 V/400 V	277 V/480 V		300 V	1500 V	2500 V	4000 V	6000 V
400 V/690 V			600 V	2500 V	4000 V	6000 V	8000 V
1000 V			1000 V	4000 V	6000 V	8000 V	12000 V



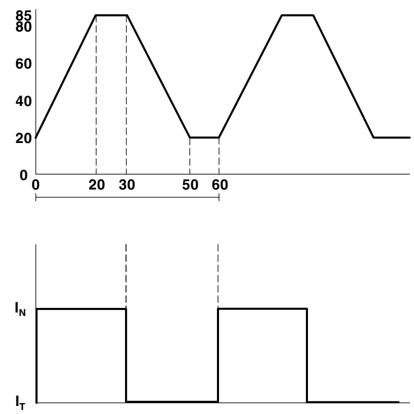
Material tests

Material tests are used to check the terminal blocks for material changes. The focus of the material tests is on longer load tests in the form of constantly higher temperatures, a comparative tracking index due to moisture and dirt, and the simulated aging of materials.

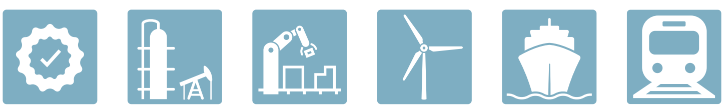


Aging test (IEC 60947-7-1/-2)

From the point of view of long life cycles of the terminal blocks, the aging behavior also plays an important role. In this test, the contact quality is verified by means of simulated aging. To simulate several years of use, five terminal blocks are mounted horizontally on a rail and connected in series using conductors with the rated cross-section. Conductors with a minimum length of 300 mm are connected and the voltage drop is measured on every terminal block. The minimum temperature in the climate chamber is set to 20°C. In contrast, the upper temperature is set so that the maximum permissible operating temperature (max. 120°C) of the test object is reached during the 10-minute pause phase. During the heating phase and the pause phase at the maximum temperature, the rated current flows. As a result, the maximum permissible operating temperature of the test object (maximum 130°C) is reached. This is followed by the cooling phase. The voltage drop is always measured after 24 cycles in the cooled down state (approximately 20°C). The test consists of a total of 192 cycles. The voltage drop must not exceed 3.2 mV initially. During or after testing, it must not exceed 4.8 mV or 1.5 times the value measured after the 24th cycle. Terminal blocks from Phoenix Contact are designed for extreme durability even under difficult temperature conditions. Plastic as well as metal parts provide sufficient safety reserves.



Current and temperature in relation to time



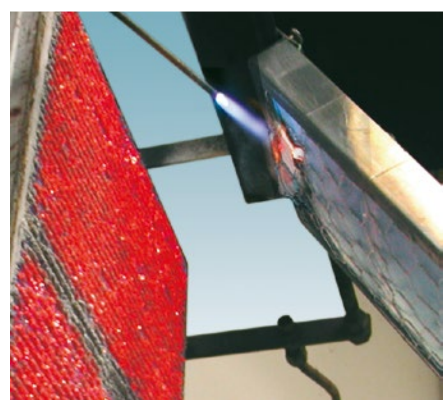
Fire protection (EN 45545-2)

EN 45545-2 has replaced the national fire protection standards for rail vehicles since March 2013. The current version of EN 45545-:2013+A1:2015 presents the demands placed on the fire behavior of materials and components. To qualify plastics for certain operating and design classes of rail vehicles, the standard describes testing methods for determining hazard levels (HL). In this case, HL 3 corresponds to the highest requirements.

The following tests are performed in order to qualify the plastics for electrical engineering applications:

- Oxygen index in accordance with DIN EN ISO 4589-2
- Development of smoke gas in accordance with EN ISO 5659-2 (25 kW/m²)
- Smoke gas toxicity NF X70-100-2 (600°C) Vertical small flames test in accordance with EN 60695-11-10

The unreinforced polyamides used in Phoenix Contact terminal blocks with flammability rating UL 94 V0 meet the highest demands. They meet the most stringent requirement of flammability rating HL3 in accordance with the tests described in the requirement sets R22, R23, R24, and R26.



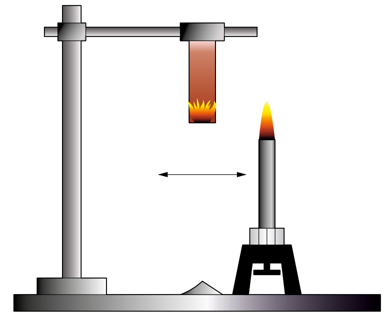
Test of the fire behavior of plastic based on standardized test pieces

Flammability rating (UL 94)

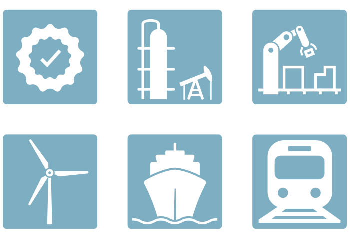
The UL 94 standard describes inflammability tests that have gained particular importance in the field of electrical engineering. Fire behavior is the main focus. Items are classified in accordance with either UL 94 HB (Horizontal Burn) or UL 94 V (Vertical Burn). The test setup is such that the UL 94 V0/1/2 classifications are stricter than the UL 94 HB classification.

UL 94 V0/1/2

After conditioning, the test bar is vertically clamped and flame-treated several times for 10 seconds at a time. Between the flame treatments, the time until the test bar is extinguished is measured. Afterwards, the afterburning times and the drip behavior are evaluated. The plastic used for Phoenix Contact terminal blocks fulfills the higher-grade criteria for classification as a V0 material.



Test setup in accordance with UL 94



Criteria	Material classification		
	V0	V1	V2
Afterburning time with flame of a single test specimen (t1 and t2)	≤10 s	≤30 s	≤30 s
Total afterburning time with flame of a set of test specimens after respective conditioning (tf)	≤50 s	≤250 s	≤250 s
Afterburning time with flame plus afterglow time of each individual test specimen after the second flame (t2 plus t3)	≤30 s	≤60 s	≤60 s
Afterburn and/or afterglow of a single test specimen to the holder may occur?	No	No	No
Ignition of the cotton pad by burning particles or drops may occur?	No	No	Yes

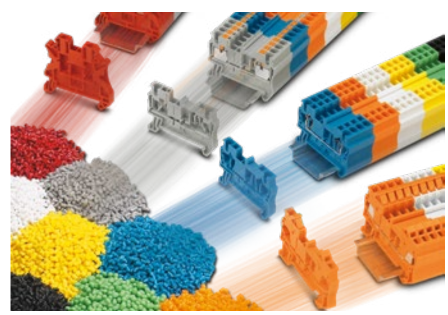
Classification

Gross calorific value (DIN 51900-2/ASTM E 1354)

The fire load is defined as the amount of energy released over a particular area during burning. The fire load value is usually expressed in MJ/m². The value is calculated based on the calorific value of a substance and the combustion factor (DIN 18230-1). The higher the calorific value and the presence of a substance, the greater the amount of energy released during burning. It follows that the possible fire load value is also higher. This affects all installed components in the application to be considered. The calorific values of polyamides such as PA 6.6 are relatively high. (For comparison, the calorific value of fuel oil is approx. 45 MJ/kg). For this reason, the calorific values of terminal blocks are also increasingly requested in the fire load determination. Calorific values of the plastics used by Phoenix Contact in accordance with DIN 51900-2 and ASTM E 1354.

To calculate the fire load of individual components, the calorific value of each polyamide must be multiplied by the weight of the part and the number of items installed.

Documentation of the heat emission takes place in the cone calorimeter according to ISO 5660-1 for the plastic materials.



Polyamide plastic granulate PA 6.6, frequently used for terminal blocks

DIN 51900-2:		ASTM E 1354:	
Polyamide 6.6 V2	Approx. 30 MJ/kg	Polyamide 66 V2	Approx. 22 MJ/kg
Polyamide 6.6 V0	Approx. 32 MJ/kg	Polyamide 66 V0	Approx. 24 MJ/kg
		For comparison: heating oil	Approx. 44 MJ/kg

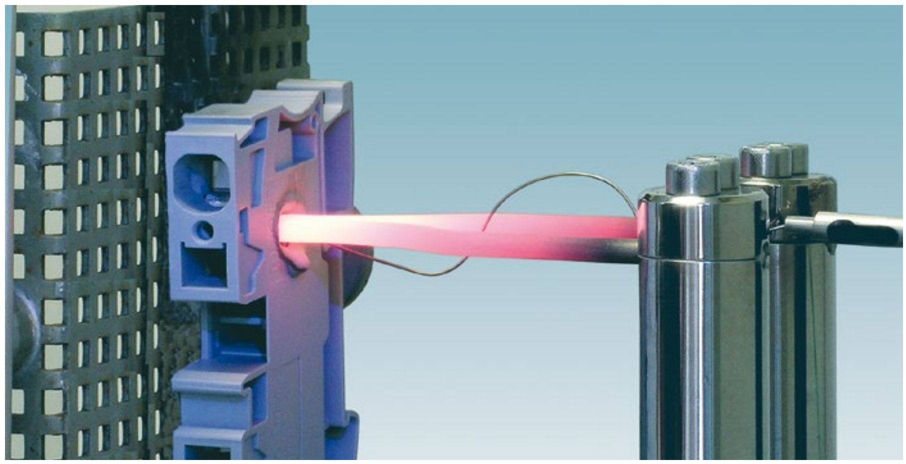
Overview of the average heating values of frequently used types of plastic

Glow-wire test (IEC 60695-2-11)

In the event of overload, conductive metal parts of the terminal block or connected conductors can heat up considerably. This additional heat also affects the plastic housing. To simulate this source of danger for electrical engineering components, a glow wire is heated to a particular temperature (550°C, 650°C, 750°C, 850°C, or 960°C). As shown in the figure, the wire is then pressed onto the thinnest point of the test object housing at a right angle with a force of 1 N. The test is deemed to be passed:

- When no flame or glowing process occurs during the test
- When the flames or glowing processes are extinguished within 30 seconds of the glow wire being removed
- When the tracing paper beneath the glow wire does not ignite due to any drops of burning substances falling down.

The polyamides used by Phoenix Contact as housing materials all fulfill the requirement of the glow-wire test at 960°C (highest temperature level).



Glow-wire test setup

Halogen-free flame protection (DIN EN ISO 1043-4)

Inflammability is a huge risk when using plastics in connection technology. Particularly in the event of an electrical fault, there is the possibility that the inflammation temperatures of polyamide (PA 6 and PA 6.6) or polycarbonate (PC) will be exceeded. To prevent fire, the plastic must be flame-retardant and self-extinguishing. This can be achieved through three types of flame protection agents:

- Organic halogen compounds (fluorine, chlorine, bromine, iodine, etc.)
- Inorganic substances (e.g., aluminum, magnesium oxyhydrate, zinc borate, etc.)
- Phosphorus or melamine-based flame protection

One property of halogen compounds is the ability to stop chain reactions in plastic. Without this property, a possible combustion process would not be stopped. Unfortunately, however, this substance is highly toxic and generates extremely poisonous vapors in the event of a fire. Therefore, they are also prohibited for many applications in the context of the RoHS directive.

When exposed to heat, inorganic substances tend to have the effect of splitting off water and thus cooling the surface. Thus, the ignition temperature in the fire area is not reached and the fire process is slowed down. However, for effective fire protection, high levels must be mixed into the plastic. However, this circumstance leads to a deterioration of the mechanical properties. This leaves the phosphorus or melamine-containing flame retardant additives. These additives can counteract the fire by charring the surface or by creating a kind of foaming. This slows down the supply of oxygen to the direct source of the fire. A striking effect is possible even with relatively small amounts in the polyamide. Terminal blocks from the CLIPLINE complete system made of polyamide are manufactured with fire protection classification UL 94 V0. Melamine cyanurates are used as flame protection agents. As such, all Phoenix Contact terminal blocks are entirely free of halogens based on the flame protection systems used.

Insulation material properties – TI (IEC 60216-1)

In the associated test, an increased thermal load on the terminal block is simulated over a longer period of time. For this purpose, the behavior of plastics at constantly higher temperatures is considered with respect to the tensile strength (mechanical properties). The standard requires at least three, but preferably four, different temperature measurement series to be performed on a test piece.
The tensile strength is measured over 500 hours to 5000 hours depending on the specification and the result is extrapolated to 10,000 hours (HCI) and 20,000 hours (TI). After these 20,000 hours, you can determine the temperature at which the tensile strength decreased by half.

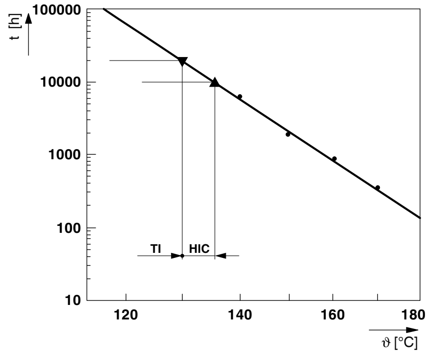


Diagram for extrapolating the TI and HCI value

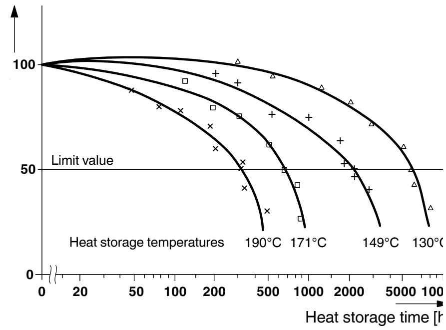


Diagram for determining the temperature

IEC 60216 specifies a temperature index that permits conclusions to be made about the mechanical service life of plastics under thermal loads.

	UL 94 V2	UL 94 V0
TI	105°C	125°C

TI value according to UL 94 V2 and V0

Insulation material properties – RTI (UL 746 B)

In the following tests, an increased thermal load on the terminal block is simulated over a longer period of time. To do so, multiple different test temperatures are evaluated in reference to 50% insulation strength loss (quadrant I: hot, warm, cold). These different storage times until the 50% drop occurred are then plotted against the corresponding storage temperatures (quadrant IV). This creates a time temperature curve (quadrant III). An insulation resistance-based temperature value (RTI) can then be derived from this curve. This value then corresponds to a 20,000-h time span with 50% property loss. UL 746 B provides a temperature index for the various polyamide combustibility classes. This index can be used to make a statement about the electrical service life.

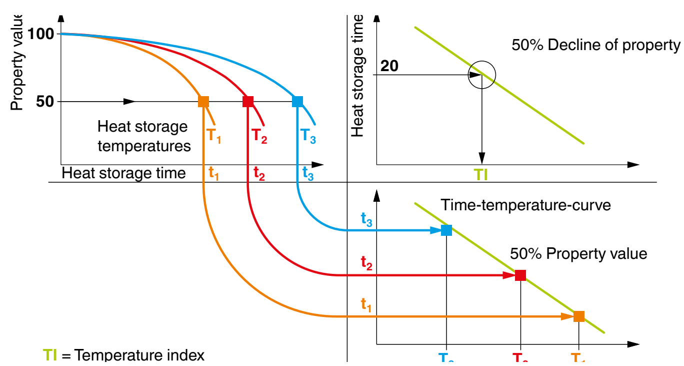


Diagram for deriving the insulation resistance-based temperature value

UL 746 B (RTI value)

The RTI indicates the highest operating temperature before an electrical disruptive discharge occurs under certain test conditions. The polyamides used by Phoenix Contact are classified as follows: (see table).

	UL 94 V2	UL 94 V0
RTI	125°C	130°C

RTI value according to UL 94 V2 and V0

Climatic test: dry heat (IEC 60068-2-2)

The following test with dry heat is used to evaluate the suitability of a component for operation, storage, or transport at a high temperature.

In the process, a distinction is made between heat-emitting and non-heat-emitting test objects. Terminal blocks belong to the latter category, and are therefore subjected to test scenario Test Bb (with gradual temperature change). The degrees of severity are defined by the strain temperature and the strain duration. In the case of terminal blocks, the proper tight fit and function must be subsequently ensured through an dielectric test and testing of the tight fit of the conductor.

+250°C	**+85°C**	**+45°C**
+200°C	+70°C	+40°C
+175°C	+65°C	+35°C
+155°C	+60°C	+30°C
+125°C	+55°C	
+100°C	+50°C	

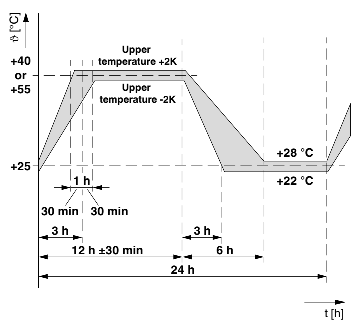
2 h	**72 h**	**168 h**	**336 h**
16 h	96 h	240 h	1000 h

Degree of severity for Phoenix Contact terminal blocks

Climate chamber

Climatic test: damp heat – cyclic (IEC 60068-2-30)

Humidity depends on temperature and atmospheric pressure. The warmer the air, the more humidity it can hold. 100% humidity reflects the maximum saturation of water vapor in the air at the respective temperature. The test described here includes one or more temperature cycles at high humidity (>90% ... 100% at 40°C or 55°C). Terminal housings are usually made of polyamide. These plastics absorb water proportionally and thus also change their elasticity. Polyamides PA6 and PA66 can absorb moisture content above eight percent by weight when stored in water at ~80°C for several days. Moisture absorption is also associated with a dimensional change due to “swelling”. Under actual climatic conditions, polyamide absorbs approx. 2 ... 4% moisture with a change in length of 0.6 to 0.8%. In the case of terminal blocks, the proper tight fit, the operability, and the function must be ensured after a dielectric test through an insulation test and testing of the tight fit of the conductor.



Temperature cycle for the climatic test

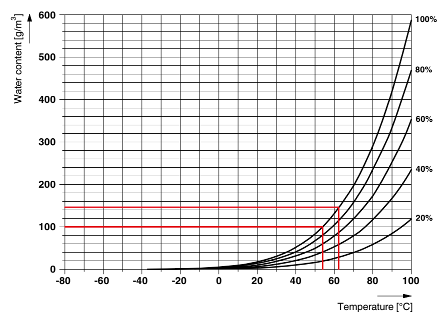


Diagram of water content in relation to the temperature

Glass fiber content	PA 6	PA 6.6
No glass fiber content	3%	2.5%
15%	2.6%	2.2%
25%	2.2%	2.1%
30%	2.1%	1.7%

Moisture absorption of polyamide at room climate (23°C, 50% humidity)

40°C				
2 cycles	6 cycles	12 cycles	21 cycles	56 cycles

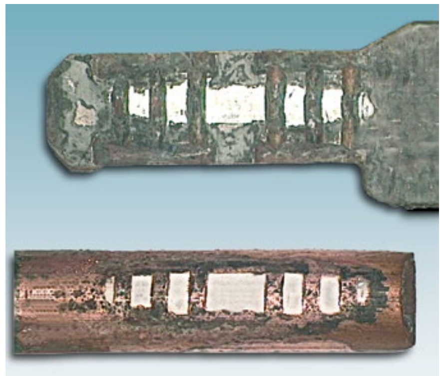
Test intensity a

55°C				
1 cycle	2 cycles	6 cycles		

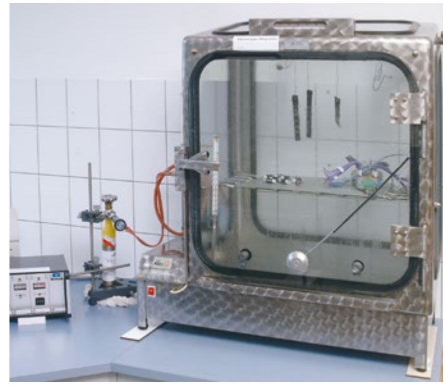
Test intensity b

Corrosion test (DIN 50018)

The key role of the metal parts of electrical connections becomes particularly apparent in aggressive environments. Corrosion-free contact areas are a prerequisite for low-resistance and therefore high-performance connections.
This test procedure describes a corrosion test in a condensation climate with an atmosphere that contains sulfur dioxide. Acidic compounds <pH 7 form here and attack metal surfaces. Two liters of distilled water and one liter of SO_2 gas are introduced into the test chamber. At a test temperature of 40°C, sulfurous acid forms during the test (H_2SO_3). After eight hours of testing, the test objects dry for 16 hours with the door open. After the end of the test, the test objects are visually inspected and the contact resistance is measured in order to show the influence of this corrosion test on the contact point in more detail.

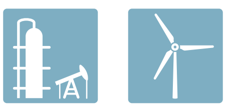


Contact area of a screw terminal block after testing



Corrosion test test setup

Phoenix Contact terminal blocks create high-quality, gas-tight connections that cannot be impaired even by aggressive substances.

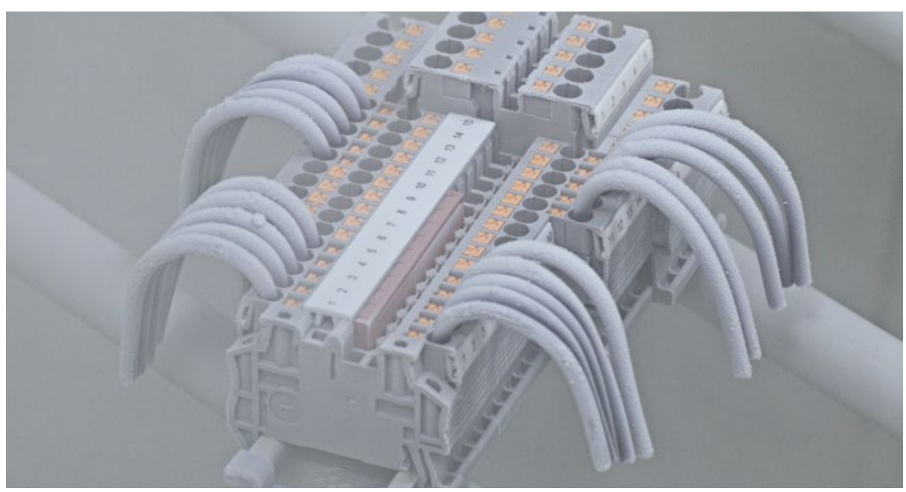


Corrosion test – salt spray (IEC 60068-2-11/-52)

Particularly in shipbuilding and offshore applications, technical components have to function continuously in corrosive atmospheres. The salt content of the air combined with the increased humidity places high demands on the metal parts used.

The impact of the climate at sea can be simulated on the basis of the above standard. The resistance of the metal parts and the corrosion protection is tested using salt spray in corrosive atmospheres. The test objects are placed in the test chamber and subjected to a finely dosed spray of 5% sodium chloride solution (NaCl; pH 6.5 ... 7.2) at a temperature of 35°C for a period of 96 h.

To better evaluate the influence on the contact points, there is a visual check of the test objects and an electrical test after the end of the test. Phoenix Contact terminal blocks with all connection technologies create gas-tight connections, which also protect the contact points from corrosion under extreme climatic conditions.

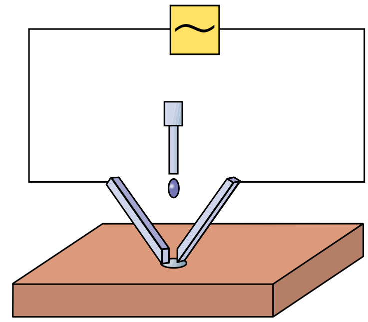


Salt spray test, PT terminal block

Comparative tracking index (CTI) (IEC 60112)

Humidity and contamination facilitate the formation of creepage distances on the plastic surface. The formation of creepage distances refers to the occurrence of conductive connections between neighboring potentials. Consideration is given to the dependence of the potentials on their voltage differences under electrolytic influences. The CTI value of a plastic indicates the extent to which this creepage distance formation is prevented.

Two platinum electrodes are placed 4 mm apart on a test piece measuring 20 mm x 20 mm x 3 mm. A test voltage in accordance with standard specifications is applied to both electrodes. An electrolyte solution is then dripped onto the electrodes by a test apparatus at a rate of one drop every 30 seconds. The test evaluates the maximum voltage value without a current flow >0.5 A. The plastics used by Phoenix Contact are classified in the highest test voltage category with a CTI value of 600.

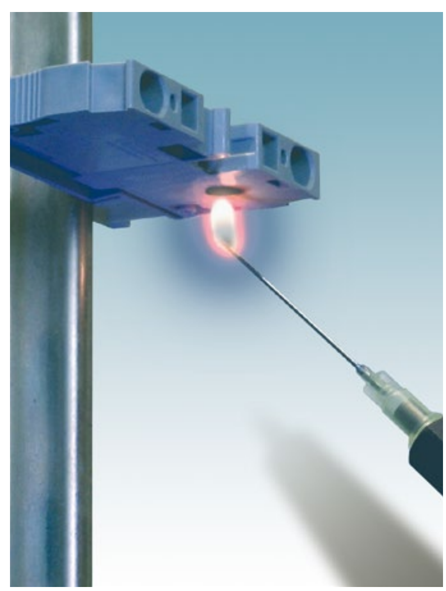


Schematic test setup

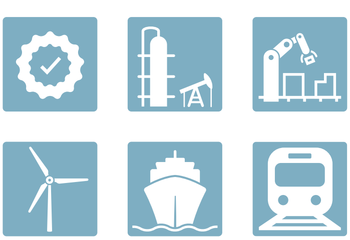
Needle flame test (IEC 60947-7-1/-2)

As far as the use of terminal blocks is concerned, fire behavior when in direct contact with a source of ignition is a major criterion. Such sources of ignition could be electric arcs, e.g., across a creepage distance. Terminal blocks must not aid or accelerate fires and the plastics must have self-extinguishing properties.
This fire test simulates the behavior of the components with an external source of ignition acting on them directly from outside.

In the test procedure, a naked flame fed with butane gas is held at an edge or surface of the test object at an angle of 45° for 10 seconds (see figure). The behavior of the test object without a source of ignition is then observed. The test is deemed to be passed when the flames or glowing processes are extinguished within 30 seconds of the flame being removed and when the tracing paper beneath the test object is not ignited by falling drops of burning substances.
All Phoenix Contact terminal blocks pass the needle flame test thanks to the high-grade plastics used and their structural design.



Needle flame test test setup

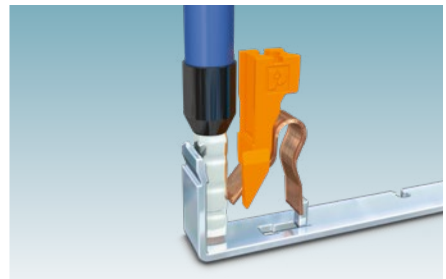


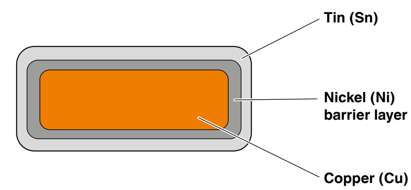
Surface corrosion protection (ISO 4042, EN 12450)

To guarantee long-term stable electrical or mechanical properties, metallic surfaces in industrial connection technology require good corrosion protection. Many of the components are also used in aggressive climates, such as in the process industry or in offshore applications. Friction values and the prevention of corrosion also play an important role in the area of screwed connections. Terminal blocks are products with a long service life with life cycles of many decades. Therefore, Phoenix Contact protects the metal parts installed in the terminal blocks against corrosion. In all connection technologies with contact springs, spring materials made of corrosion-free, high-alloy spring steels are used. Surfaces of components containing iron are thick-layer passivated in accordance with DIN ISO 4042. Particularly in the case of copper materials, the possible formation of tin whiskers is effectively counteracted by nickel plating in accordance with EN 12540. The electrical contact resistance of all terminal blocks between the conductor and the current bar is not negatively impacted by the corrosion protection system.

Material	Protection	Standard	Protection system	Coating thickness
Iron	Zinc	DIN EN 12329	Thick-layer passivation	5 µm ... 8 µm
			Blue chromate	5 µm ... 8 µm
Copper	Nickel	DIN EN 12540	Sulfate Nickel	3 µm ... 5 µm
Copper	Tin	DIN 50965	2 µm … 3 µm nickel barrier layer + tin layer	4 µm ... 8 µm


Tension sleeve with screw

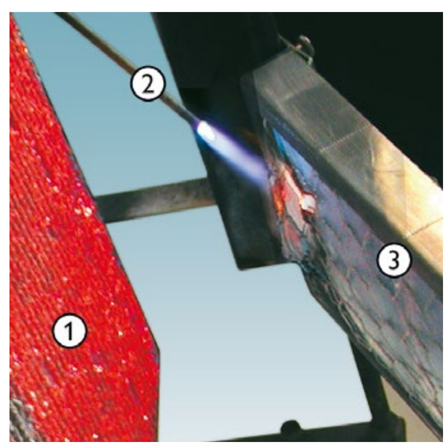

Current bar with the Push-in and screw connection technologies



Cross-section of the current bar

Surface inflammability (ASTM E 162 (NFPA 130))

To evaluate the surface inflammability and the flame spread of plastics, a “flame spread index” is devised in accordance with ASTM E 162. For this purpose, a sample is irradiated with a heat source and also ignited with a naked flame. During the duration of the test, the time in which the flame front reaches two measuring points that are opposite each other is determined. The product of this flame propagation time and a calculated heat development factor yields the flame spread index. The drip behavior of the plastic is also observed and evaluated during the test. In the United States, the maximum flame spread index is 35. Terminal blocks from Phoenix Contact achieve a value of 5 and produce non-burning droplets.
The value therefore lies well below the approved maximum values of the Federal Railroad Administration (FRA) of the US Department of Transportation.



1 Radiant heater 2 Flame 3 Plastic sample

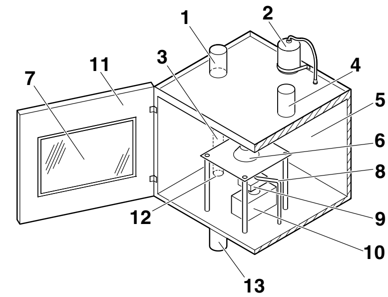
Smoke gas development (EN ISO 5659-2)

EN ISO 5659-2 describes a method for evaluating the smoke development of a substance in the event of a fire under additional radiant heat. The test is performed on a total of six test pieces, but individually in an airtight lockable test chamber. The test pieces must be square (75 x 75 mm) with a level surface and no thicker than 25 mm. They are wrapped with aluminum foil in such a way that only the top side is left free of a strain area of 65 x 65 mm. For the test, the test piece is fixed horizontally in a bracket and exposed on its surface to an irradiation of 25 kW/m² for 10 minutes. The test occurs on three samples with and three samples without a pilot flame. The optical smoke density is measured via a photometric process. First, the value changes of the focused light beam hitting a photo-sensor are measured in mV. (Full light quantity = 100%, darkness = 0%)

The determined values are calculated using the formula:

$$D_s\text{max} = 132 \frac{\log 10}{100\ T_{min}}$$

and indicated as smoke density.



1. Optical measuring system
2. Pressure regulator
3. Beam path
4. Upper air inlet opening (upper area) and lower air outlet opening, connected to the exhaust fan (at the bottom)
5. Chamber
6. Cone heating device
7. Window
8. Pilot flame burner
9. Test piece in the test piece bracket
10. Weighing equipment
11. Lockable door
12. Optical window
13. Light source

Smoke gas development (ASTM E 662 (NFPA 130))

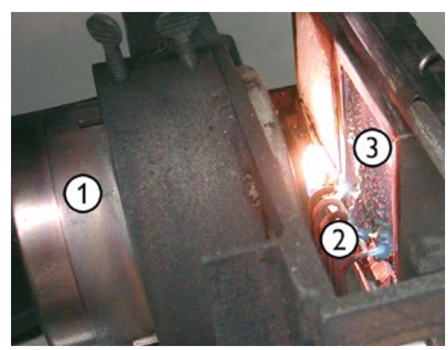
The standard ASTM E 662 specifies a procedure for evaluating the specific optical density of the smoke during an open fire or a smoldering fire. For this purpose, the percentage of light transmitted in relation to the burning chamber volume is observed. A sample is placed in a precisely defined smoke density chamber.
The test object is irradiated with a heat of 2.5 W/cm². Then, the following processes are simulated for 20 minutes:

1. Burning with a naked flame
2. Smoldering fire (avoidance of a naked flame)

The limit values for the optical smoke density of both processes are recorded after 1.5 and 4 minutes.

- Specific optical smoke density (Ds 1.5), limit value 100
- Specific optical smoke density (Ds 4), limit value 200
- Maximum smoke density (Dm) during the 20 minutes

The polyamides used for Phoenix Contact terminal blocks fulfill all the requirements of the Federal Railroad Administration (FRA) of the US Department of Transportation in accordance with ASTM E 662.



1 Radiant heater 2 Flame 3 Plastic sample

Toxicity of smoke gas (NF X70-100-2 (600°C))

NF X70-100:2006, as a part of requirement sets R22 and R23 of EN 45545-2:2013+A1:2015, describes a method for testing the smoke gas toxicity of a material in the event of a fire. In this test, 1 g of the material to be tested is thermally decomposed at 600°C in a quartz tube under defined conditions (air flow rate 120 L/min over 20 min) and in the absence of oxygen. Then, the fire gasses are collected and analyzed. For this purpose, the resulting fire gases are passed through scrubbing bottles filled with an absorption liquid so that the fire gases remain in this liquid. Then, wet chemical analyses are performed on the hydrogen halide acids hydrochloric acid (HCl), hydrogen bromide (HBr), hydrocyanic acid (HCN), and hydrofluoric acid (HF), as well as on nitrogen oxides (NO_X) and sulfur dioxide (SO2), and their concentrations are determined. The fire gases carbon monoxide (CO) and carbon dioxide (CO_2) are determined by IR spectroscopy. The smoke gas toxicity of a material is represented by the conventional toxicity index CITNLP, which is the ratio of measured gas components (ci) to specified reference concentrations (Ci):

$$CIT_{NLP} = \sum_{i=1}^{8} \frac{c_i}{C_i}$$

Gas components	Reference concentration [mg/m³]
CO_2	72000
CO	1380
HF	25
HCl	75
HBr	99
HCN	55
SO_2	262
NO_x	38

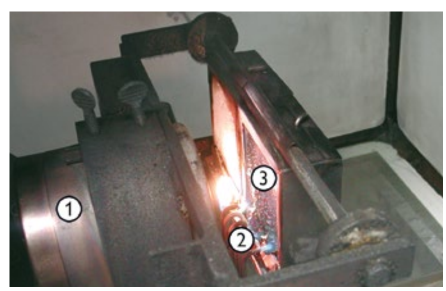
Smoke gas toxicity SMP 800 C

SMP 800 C describes the maximum permissible values of poisonous smoke gases when a plastic is burned.

In comparison to BSS 7239 (Boeing standard), this standard specifies more precise measuring methods for the qualitative and quantitative determination of toxic smoke gases. For this purpose, six liters of smoke gas is removed from the NBS chamber during the ASTM E 662 test between the 4th and 19th minute and fed to the analysis. SMP 800 C limit values of toxic smoke gases in ppm:

Carbon monoxide (CO)	3500
Carbon dioxide (CO_2)	390,000
Nitrogen oxides (NO_X)	3100
Sulfur dioxide (SO_2)	3100
Hydrochloric acid (HCl)	3500
Hydro-bromic acid (HBr)	3100
Hydrofluoric acid (HF)	3100
Hydrocyanic acid (HCN)	3100

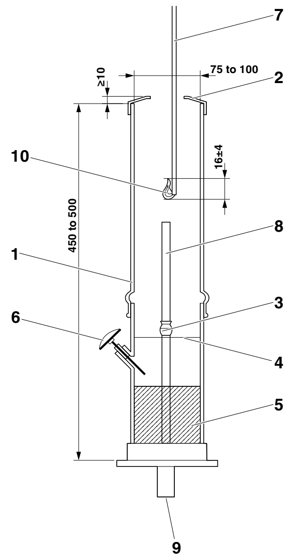
The polyamides used by Phoenix Contact are many times below the critical concentration levels.



1 Radiant heater 2 Flame 3 Plastic sample

Oxygen index (DIN EN ISO 4589-2)

NF DIN EN ISO 4589-2 describes a test to evaluate the fire behavior of plastics based on an oxygen index (OI). For plastics, such as those used in the electrical industry, a plate size with a length of 70 ... 150 mm, a width of 6.5 mm, (±0.5 mm) and a thickness of 3 mm (±0.25 mm) should be used for testing. This plate is mounted vertically in a glass cylinder, surrounded by a mixture of oxygen and nitrogen, and lit at the top edge with a propane gas flame. Then, the combustion behavior at different oxygen contents of the circulating gas is analyzed. Ignition consists of up to 30 s of exposure to flame followed by a 5 s pause. The exposure to flame is repeated in 5 s intervals until the test piece burns on the surface. The goal is a 180 s-long burn duration after removing the propane gas flame. No more than 50 mm, measured from the ignited edge, should have dripped or melted away while burning. Flame interruptions ≤1 s are permitted. If the flame goes out after 180 s have passed, the measurement is rated as "O" and the oxygen content is increased for the next sequence. If the flame is still there after the 180 s have passed, the measurement is rated as "X" and the oxygen content is reduced for the next sequence. On multiple test pieces, an accuracy of the oxygen threshold (at which the item is still burning) of ≤1% to "O" sequences is determined. This is later used to calculate the oxygen index OI.



1. Chimney
2. Chimney vent
3. Test piece bracket
4. Wire mesh shielding
5. Diffusor and a mixing chamber
6. Any temperature measuring device
7. Tube
8. Test piece
9. Oxygen/nitrogen mixture
10. Source of ignition

Vertical small flames test (EN 60695-11-10)

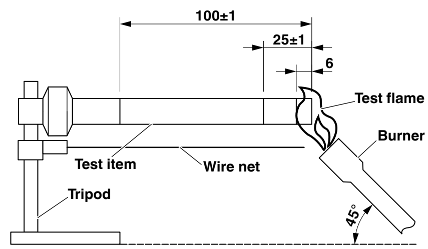
EN 60695-11-10 is used to evaluate the fire behavior. The material is ignited with a standardized 50 W needle flame. A rectangular bar-shaped test object must be created for this purpose beforehand. This test object must be 125 mm x 13 mm x optionally 0.1 ... 12 mm thick. In test procedure “A”, three test bars are needed. During the test, each bar is fixed horizontally and the linear firing rate is measured as the evaluation. To do so, two marks are attached at 25 mm and 100 mm. Depending on the burnup, the classification is HB // HB 40 // HB 75 // or, if the 100 mm mark is exceeded, with

$$v = \frac{L}{t} \cdot \frac{60\ s}{min}$$

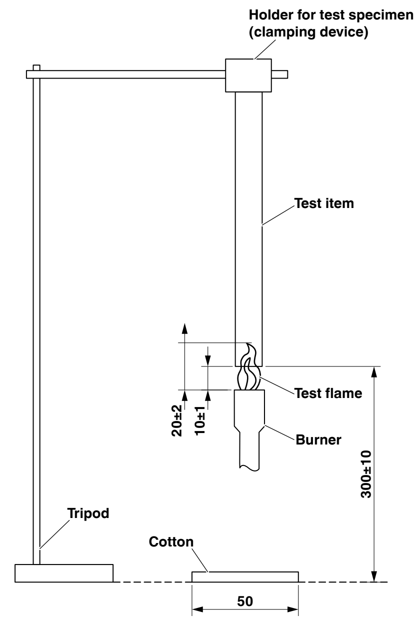
v = rate of fire
L = length of damage
t = time

Five test bars are needed in test procedure “B”, where each bar is suspended vertically at one end and the free end is ignited with a test flame for 10 s. There is a cotton pad under the test object. Then the afterburning time t1 is determined. This is immediately followed by a second flame exposure of 10 s with measurement of the afterburning time t2 and the afterglow time t3. In the process, no burning drops may fall off and ignite the pad.
The measured values for the evaluation are calculated as follows:

$$t_f = \sum_{i=1}^{5} (t_{1,i} + t_{2,i})$$

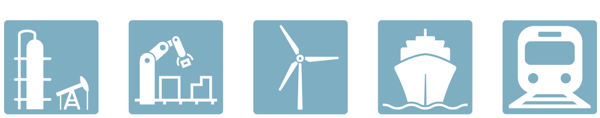


Test procedure “A”



Test procedure “B”

Criteria	Material classification		
	V0	**V1**	**V2**
Afterburning time with flame on a single test object (t1 and t2)	≤10 s	≤30 s	≤30 s
Total afterburning time with flame of a set of test objects after respective conditioning (tf)	≤50 s	≤250 s	≤250 s
Afterburning time with flame plus afterglow time of an individual test specimen after the second flame (t2 plus t3)	≤30 s	≤60 s	≤60 s
Afterburn and/or afterglow of a single test specimen to the holder may occur?	No	No	No
Ignition of the cotton pad by burning particles or drops may occur?	No	No	Yes



Certifications, approvals, and static Q-values

At all stages of the product lifecycle, our products are subject to the statutory and regulatory requirements, international standards, and customer requirements in the form of approvals, which we often exceed by far. We require these qualitative properties for entire series and not just individual products. We include necessary steps to meet these approvals in the corporate processes. The result is a modular product system with defined processes and tools for the success of the Phoenix Contact Group.

CE accreditation laboratory (IEC 60947-7-1/-2/-3)

EU declaration of conformity
With the EU declaration of conformity and the resulting CE marking on the product, the manufacturer confirms that the product it has placed on the market conforms to the essential health and safety requirements of the applied EU directives.

Conformity assessment procedure
Conformity assessment is particularly important with regard to the minimum safety requirements set. The evaluation must be performed before the manufacturer puts the product on the market. The EU conformity assessment is the basis for the manufacturer's declaration of conformity. In the event of mandatory identification, the goods are marked with a CE mark. The directives include appendices with modules for performing the conformity process that apply based on the classification of the item. Integrating a designated location as the laboratory is then obligatory if the goods are associated with any risk. This CE marking is an expression of the manufacturer's own responsibility to the relevant authorities that its product complies with the relevant legal provisions and technical specifications. It should be viewed as an indicator of market approval and not as an indicator of origin, quality, grade, or standard. In the area of the CLIPLINE complete product series, the CE mark is awarded and the following guidelines are applied:

2014/35/EU Low Voltage Directive (LVD)
2014/34/EU Equipment for potentially explosive atmospheres directive (ATEX)
2011/65/EU Restriction of the use of certain hazardous substances (RoHS)

CCC

CCC stands for China Compulsory Certification and is the certification system used in China. This system provides uniform standards for specific product categories. Products from these groups must be certified in accordance with the CCC standards. In principle, the CCC marking is comparable to the CE marking for the European Economic Area. The standard applies both to imported goods and to local Chinese products. Products that must undergo certification may only be imported, sold, and used in business activities in Chin after the product's CCC certification has been granted.

The product categories are:

- Electrical lines and cables
- Electrical switches and systems for protection or connections
- Low-voltage systems
- Motors
- Electrical vehicles
- Welding machines
- Household appliances
- Audio and video devices
- Computers and computer accessories
- Lights
- Telecommunications systems and accessories
- Motor vehicles and safety-relevant passenger car components
- Tires for motor vehicles
- Safety glass
- Agricultural machines
- Fire suppression devices
- Break-in protection and security equipment
- Wireless network devices
- Decorative and custom products
- Toys and products for children
- Products in the explosive range (added in 2019)

The CCC seal of approval is awarded by the CNCA, which is subordinate to the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ). The terminal blocks fall under the category added in 2019 ("Products in the explosive range"). They are certified for the explosive range and marked as such, even under the items with mandatory certification for China. Terminal blocks without certification for the explosive range remain outside the items that must get CCC approval.

EAC

The EAC marking allows the manufacturer to import the goods into the Eurasian Economic Union (EAEU). Countries such as Russia, Belarus, Kazakhstan, Kyrgyzstan, and Armenia currently below to this customs union.
The corresponding declaration of conformity declares that the safety requirements have been met according to the Technical Regulations (TRs) such as

- TR ZU 004/2011 On safety of low-voltage equipment
- TR ZU 012/2011 On safety of the equipment for operation in explosive atmospheres
- TR EAWU 037/2016 On restriction of the use of certain hazardous substances in electrical and electronic equipment

and the products are allowed to be imported into the Union.
The safety of the products is ensured by testing in an independent laboratory and confirmed by regular audits at the manufacturing sites.
Large parts of the CLIPLINE complete terminal block system have EAC approval and can be installed in systems that are intended for export to the countries listed above without issues.

IECEx (IEC 60079)

Explosion protection around the world is mainly based on the IEC 60079 series of international standards and European and American standards and directives. In North America, the basis for this is the National Electric Code (NEC) in the USA and the Canadian Electrical Code (CEC) in Canada. Directive 2014/34/EU (previously ATEX 100a) is of particular importance to manufacturers of devices and protective systems within CENELEC countries of the European Union and beyond. We meet international requirements with IECEx certificates. This means that use with the "increased safety" Ex eb type of protection is permitted in zone 1 and 2 and with Ex ec in zone 2. However, this is only under the condition that the terminal blocks are installed in housings that are qualified and certified for the respective type of protection.

Requirements for terminal blocks

The types of protection "d" – flameproof enclosure, "p" – pressurized enclosure, "m", "q", and "o" (molded, sand or oil immersion) do not place any special requirements on terminal blocks. The protection principle of the increased safety "e" type of protection (IEC/EN 60079-7) is essentially based on stricter design measures.

The most important of these for terminal blocks are:

- Air clearances and creepage distances
- Terminal blocks must be secured against loosening and they must be attached and designed so that the cables cannot come loose or become impermissibly damaged by the terminal point.
- No transfer of clamping pressure via insulated parts
- Terminal blocks that are intended for the connection of multi-stranded conductors must be fitted with an elastic intermediate element.

These requirements and the technical data are checked by an independent testing institute (notified body, e.g., PTB, DEKRA, KIWA, etc.) and certified by the appropriate certificate.

The type test is considered proof of the following tests:

- Type test in accordance with IEC 60947-7-1/-2
- Proof of air clearances and creepage distances and dielectric test
- Aging test:
- Stored for 14 days at 95°C and 95% humidity
- Stored for 14 additional days in dry heat
- Level of TI value of insulation material
- Stored for 24 hours at a low temperature of -65°C with subsequent conductor pull-out test.

Ex e-approved terminal blocks from Phoenix Contact are standard modular terminal blocks. These terminal blocks are individually tested in accordance with IEC/EN 60079 during the manufacturing process, including a dielectric test among other things. Type of protection Ex e, "increased safety" Ex eb and Ex ec.

The terminal blocks with Ex eb type of protection are therefore approved for installation in wiring spaces of zone 2 and, in particular, zone 1. The housings for installing the terminal blocks must also be approved for Ex e type of protection and must have at least IP54 degree of protection.

The terminal blocks approved for Ex eb type of protection are divided into the following groups:

- Push-in connection terminal blocks
- Screw connection terminal blocks
- Spring-cage connection terminal blocks
- Fast-connection terminal blocks
- Miniature terminal blocks
- Terminal blocks for specialized applications.

Along with the feed-through terminal blocks, function terminals – i.e., safety terminal blocks and test-disconnect terminal blocks – are available with Ex ec type of protection for use in zone 2 areas.

Ex standard symbols

The certificates certify that the test was carried out by the respective notified body

Ex i type of protection

No special approval is required for terminal blocks in applications with the Ex i "intrinsic safety" type of protection. In addition to Ex-e approved terminal blocks, other standard terminal blocks are also used here. The increased requirements for air clearances and creepage distances

- Between adjacent terminal blocks
- Between terminal blocks and grounded metal parts as well as distances through rigid insulation are specified in IEC/EN 60079-11.

JIS C 2811

The industry standard JIS C 2811 is a now-obsolete standard for specifying terminal blocks for industrial and similar applications. The standard tests terminal blocks that can be used for electrical circuits of no more than 600 V AC voltage (frequency 50 Hz or 60 Hz) or 600 V DC voltage.
This industry standard has been superseded by the group standard JIS C 8201-7-1,-2,-3,-4, which is based on IEC standards 60947-7-1,-2,-3,-4. However, the old JIS C 2811 standard has not lost importance for some customers in Japan. Therefore, the additional association standard NECA C 2811 was created, which contains the same regulations as JIS C 2811. It is often used in the public sector in particular. The NECA association (Nippon Electric Control Equipment Industries Association) is a private, voluntary organization that promotes growth in the area of electrical control equipment. Although not specifically indicated, large areas of the CLIPLINE complete modular terminal block system meet these requirements.

NEC

Article 409 for industrial circuit technology can be found in the NEC "National Electric Code" (NFPA 70). It contains rules and regulations with regard to electrical installations for public and private grounds, buildings, etc. Article 409 lists provisions related to short circuit current ratings (SCCRs) of control cabinets. It is established for control cabinets up to 600 V and regulates their design structure. Section 409.2 defines a control cabinet as follows: An arrangement of two or more components

1. In a main circuit such as motor control devices, overload relays, switch disconnectors with fuses and circuit breakers
2. In a control circuit such as pushbuttons/keys, signal lights, selection switches, time switches/relays, switches, control relays
3. Or in a combination of both circuits

These components with the associated wiring and terminal blocks are mounted in a housing or on a switchboard.
The control cabinet does not contain the controlling equipment.
Section 409.110 establishes that all control cabinets must be labeled with their short-circuit current rating (SSCR).
This value must either be based on the value of a listed and labeled structure or on another appropriate method to determine the value. For assistance in calculating the short-circuit current rating, reference is made here to UL 508 A, which shows a method for calculating the SCCR value.
Terminal blocks with a UL approval in accordance with UL 1059, for example, are approved for an SCCR value of 10 kA by default and can also be qualified for higher values by additional tests defined in Appendix SA of UL 1059.
Nearly all Phoenix Contact terminal blocks with elevated SCCR values (up to 100 kA) are listed in UL file E60425.

RoHS (EU Directive 2011/65/EU)

2011/65/EU Restriction of the use of certain hazardous substances (RoHS)
The 2011/65/EU (RoHS II) Directive is the basis for the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) within the territory of the European Union.
The directive applies to all electrical and electronic devices. The definition also includes such electrical and electronic devices that are generally designated as electrical and electronic components. Products from Phoenix Contact that do not fall into these categories but could be installed in such items are indirectly affected by the directive and must adhere to the material limitations of the directive to be able to be sold (compliance).
Terminal blocks from the Phoenix Contact product range satisfy these directives and are marked accordingly on the packaging.

Shipbuilding register (GL/LR/ABS/NV/KR/NK/RS)

The shipbuilding industry is a worldwide operation with suppliers around the globe. Both these sectors are subject to high safety standards. International classification bodies issue risk classifications as required by insurers and shipping companies. The classification is performed in five-year intervals. The aim of this classification is to achieve the most favorable level for the insurance. For this purpose, it is necessary to use certified and tested components for the electrical installation and equipment.

- DNV GL, merger completed in December 2012, headquartered in Hamburg
- Lloyds Register (LR), founded in 1760, headquartered in London
- Bureau Veritas (BV), founded in 1828, headquartered in Paris
- American Bureau of Shipping (ABS), founded in 1862, headquartered in Houston
- Korean Register (KR), founded in 1960, headquartered in Daejeon
- Maritime Register of Shipping (RS), founded in 1913, headquartered in St. Petersburg
- Polish Register of Shipping (PRS), founded in 1932, headquartered in Gdansk
- Nippon Kaiji Kyokai (NK), founded in 1899, headquartered in Tokyo

In international shipbuilding, Asia, with its countless docks in Korea, Japan, and China, is seen as the world market leader. Europe concentrates more on the special purpose ship market and innovative solutions in the field of safety technology.
However, these tests are also often required for offshore installations such as wind farms. The tests required for approval relate mainly to electrical/mechanical tests (IEC 60947-7-1/2 and UL 1059) as well as vibration and climate tests. The testing criteria overlap to a certain extent.

Here is an overview of the severity levels:

- IEC 60068-2-2 (dry heat) 16 hours at 55°C or two hours at 70°C.
  Phoenix Contact tests here with a degree of severity of 70°C over 16 hours.
- IEC 60068-2-30 (damp heat) 2 cycles at 2 x 12 h at 55°C, 95% humidity.
- IEC 60068-2-1 (cold) two hours at -25°C.
  Phoenix Contact tests here with -25°C over 16 hours.
- IEC 60068-2-11 and IEC 60068-2-52 (salt-spray test) one to four spray cycles with up to 7 days of storage for each
- IEC 60068-2-6 (vibration test)
- UL 94 (inflammability) V0.
  Phoenix Contact tests with 30 s of flame; the product test prescribes only 10 s.

Terminal blocks in the CLIPLINE complete range from Phoenix Contact are internationally approved according to a selection of the globally recognized classification bodies. The tests outlined above are passed.

UL 486 A and UL 486 B

This standard applies to single-pole electrical terminal points when using copper, copper alloys, aluminum, or copper-coated aluminum conductors for creating contacts between live parts.
The tests described apply in compliance with the Canadian Electrical Code (Part I, C22.1) in Canada, as well as the National Electrical Code NFPA-70 in the United States of America and the Standard for Electrical Installations (NOM-001-SEDE) in Mexico.
Parts of this standard are used for the test sequence at terminal points of terminal blocks in accordance with UL 1059.
However, it also includes a harmonized assessment for ferrules, which were not previously approved in the American UL standard listings. Furthermore, stripping lengths, test currents, tightening torques for screw connections, conductor pull-out values, and much more can be found here.

Test sequence			
1	**2[a)]**	**3[b)]**	**4[c)]**
Current cycles	Static heating	Contact reliability	Stress-corrosion cracking
	Contact reliability	Static heating	
	Static heating		
	Conductor pull-out test		

[a)] This test sequence is based on a static temperature-rise test

[b)] This test sequence is based on a mechanical test

[c)] This stress-corrosion cracking test, whether performed with ammonia or mercury nitrate, applies only to copper alloys that do not meet the specifications

VDE

VDE Prüf- und Zertifizierungsinstitut GmbH is a recognized, accredited testing institute that has stood for quality and product safety with a focus on the German market for decades.
The VDE mark for electrical products confirms conformity with VDE regulations, the European or international harmonized standards. In addition, the VDE mark indicates the thermal, electrical, and mechanical safety of the tested products.
The VDE markings are particularly widely recognized in installation technology. In order to be allowed to affix the VDE mark to a manufacturer's products, a large number of requirements must be met not only for the products, but also for production and quality monitoring.
Phoenix Contact meets these requirements through its own imposed high quality standards and through its transparent quality and production processes.
A large number of our terminal blocks have been tested by the VDE Prüf- und Zertifizierungsinstitut GmbH testing body and are thus allowed to bear the VDE mark.

Static Q-values

MTTF is the abbreviation for "Mean Time to Failure". This value is an important static quantity in the evaluation of the safety of machinery. It usually comes into play for non-repairable components that are replaced in the event of a fault. At Phoenix Contact, the following device categories fall under it:

- Relays
- Electronic items with relays
- Electronic items
- Connectors/terminal blocks

The MTTF values for terminal blocks are calculated as a conversion of the FIT (failure in time) values from DIN EN 61709 (Table 49). These values represent a failure rate during 10^9 hours at 40°C ambient temperature and 50% of the maximum current allowed for the junction.

Thus, for a screw connection terminal block, if n = number of terminal points:

$MTTF_{screw}$

$= \frac{1}{\lambda} \cdot 10^9 h \cdot n$

$= 10^9$ h / 0.5 x 2 $_{\text{screw terminal points}}$

$= 10^9$ h

= 114,155.25 years

MTBF is the abbreviation for "Mean Time Between Failures". If a component cannot be repaired, then this value is the counterpart to the MTTF function. For components that are reparable, it can be used to estimate anticipated service costs. Since terminal blocks usually fail very rarely but are not repairable, an MTBF specification for a terminal block makes no sense.

Method, technology	Cross-section in mm²	Failure rate FIT (λ)
Crimping	0.05 ... 300	0.002
IDC terminal blocks	0.05 ... 1	0.25
Screws	0.5 ... 16	0.5
Terminal blocks (spring-cage)	0.5 ... 16	0.5

Certification authorities and markings

Certification authorities and approval process						
Logo						
Certification authority	IECEE-CB scheme (in combination with certifying authority)	CENELEC Certification Agreement (CCA test report) (in combination with certifying authority)	Canadian Standards Association (CSA)	Canadian Standards Association (CSA) CSA approval for the USA	Canadian Standards Association (CSA), combination logo, CSA approval for Canada and the USA	Underwriters Laboratories Inc. (UL)
Country code	International	EU	CA	US	CA US	US
Logo						
Certification authority	Underwriters Laboratories Inc. (UL), UL approval for Canada	Underwriters Laboratories Inc. (UL), combination logo, UL approval for the USA and Canada	INSIEME PER LA QUALITA'E LA SICUREZZA	Eurasian Conformity	DEKRA Certification B.V.	Österreichischer Verband für Elektrotechnik
Country code	CA	US CA	IT	EAEU	NL	AT
Logo						
Certification authority	Eurofins Electro-suisse Product Testing AG, SEV certification scheme	Verband Deutscher Elektrotechniker e.V. (VDE) • Approval of drawings • Reports with production monitoring	Safety checked by Berufsgenossen-schaft (BG) GS	Intertek ETL Listed, approval for the USA	Intertek ETL Listed, approval for Canada	Intertek ETL Listed, approval for the USA and Canada
Country code	CH	DE	DE	US	CA	US CA
Logo						
Certification authority	TÜV Rheinland Industrie Service GmbH	China Compulsory Certification	Korean Certification Mark			
Country code	DE	CN	KR			

Explosion protection

Logo						
Certification authority	International Electrotechnical Commission	ATEX Directive	Canadian Standards Association (CSA)	Canadian Standards Association (CSA), CSA approval for the USA	Canadian Standards Association (CSA), combination logo, CSA approval for Canada and the USA	Underwriters Laboratories Inc. (UL)
Country code	International	EU	CA	US	CA US	US
Logo						
Certification authority	Underwriters Laboratories Inc. (UL), UL approval for Canada	Underwriters Laboratories Inc. (UL), combination logo, UL approval for the USA and Canada	FM Approvals	FM approvals, FM approval for Canada	FM approvals, FM approval for the USA and Canada	Eurasian Conformity for Ex products
Country code	CA	US CA	US	CA	US CA	EAEU
Logo						
Certification authority	Korean Certification Mark for Ex products	National Institute of Metrology, Standardization, and Industrial Quality	National Supervision and Inspection Center for Explosion Protection and Safety of Instrumentation	Corp. Centro de Investigación y Desarrollo Tecnólogico del Sector Eléctrico		
Country code	KO	BR	CN	CO		

Marine classification societies

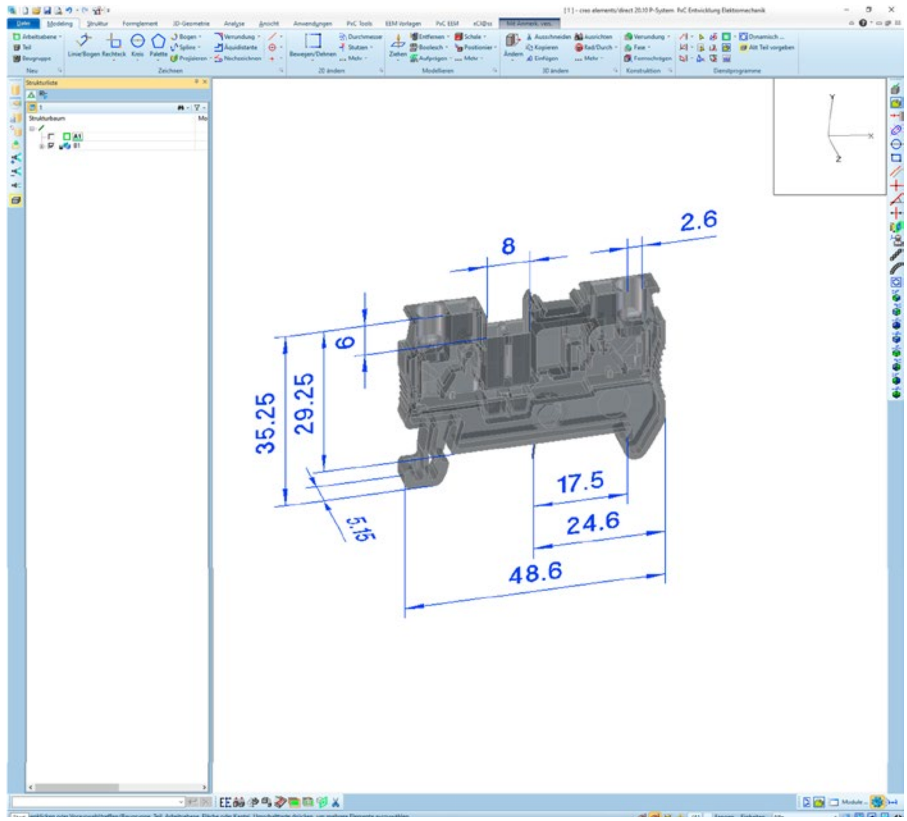
Logo						
Certification authority	DNV GL – MARITIME	Bureau Veritas	Lloyds Register of Shipping	Nippon Kaiji Kyokai	Polski Rejestr Statków	Russian Maritime Register of Shipping
Country code	DE	FR	GB	JP	PL	RU
	Korean Register of Shipping	American Bureau of Shipping	Registro Italiano Navale			
	KR	US	IT			

Digital quality

The quality of our products is our highest priority. But we also place great emphasis on quality in the digital area. That's why we're always working to drive digital issues forward. With the help of digitization, we want to make it as easy as possible for you to work with us. Enjoy the easy exchange of data and information or use our configurators to easily design your individual solution.

2D/3D data formats

To allow the CAD programs of the developers to integrate complete items or even assemblies into existing control cabinets without much effort, the component data is needed in commonly used 2D and 3D formats. Phoenix Contact supports users by providing easy access to our product data downloads. There, files are offered in 2D formats JPG, PDF, and DXF, and as 3D in STEP format. Thus, we enable you to easily import data into almost all available CAD tools.



Extract from a CAD program

BMEcat

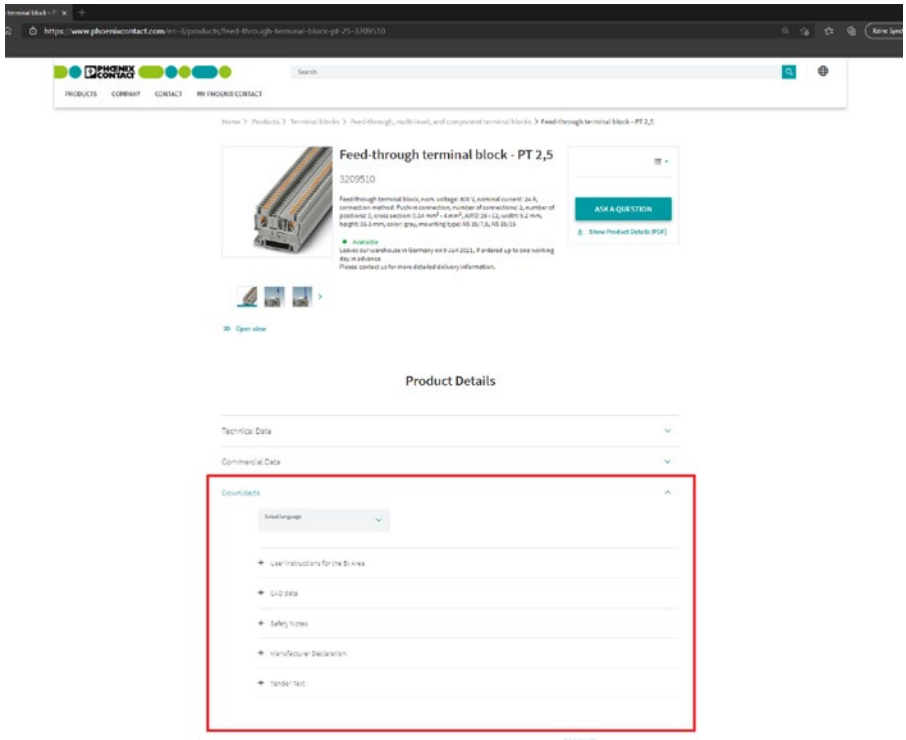
To exchange product information between different software applications, the data must be prepared in special formats. This is the only way that the data can be processed automatically. A key aspect of minimizing the effort required to process the data on both sides is the use of standardized formats. BMEcat is the standardized exchange format for the exchange of catalog data in the field of B2B. BMEcat is an XML-based, standardized exchange format. It is designed to support the procurement process from order placement to invoicing. In addition to information on products in the procurement process, such as prices and packaging information, other product information can also be exchanged via BMEcat. This can be used, for example, to provide the data for electronic catalogs or documentation. The advantage here is that product data can be exchanged with BMEcat in accordance with the generally recognized classification standard eCl@ss and ETIM. Phoenix Contact supports the formats BMEcat 1.2 and the BMEcat® 2005. These programs can be used to transfer multilingual catalogs in one file, for example. In addition to this, the BMEcat® 2005.1 format was developed specifically for exchanging data based on the eCl@ss Advanced Standard.

BMEcat software OXOMI

CAD formats and download

You can find a download area for every product on the Phoenix Contact website. You can download product-based information in various languages in this area. You can download the following information there:

- Safety notes (including assembly notes)
- Application notes (connection information, Ex area)
- CAD data (DXF, PDF, STEP)
- Tender text (.txt.x81, d81)
- Product information (reliability prognoses)
- Manufacturer's declaration (declaration of conformity for ATEX, EU, RoHS, etc.)
- Certifications (EU examination certificate, IECEx, etc.)

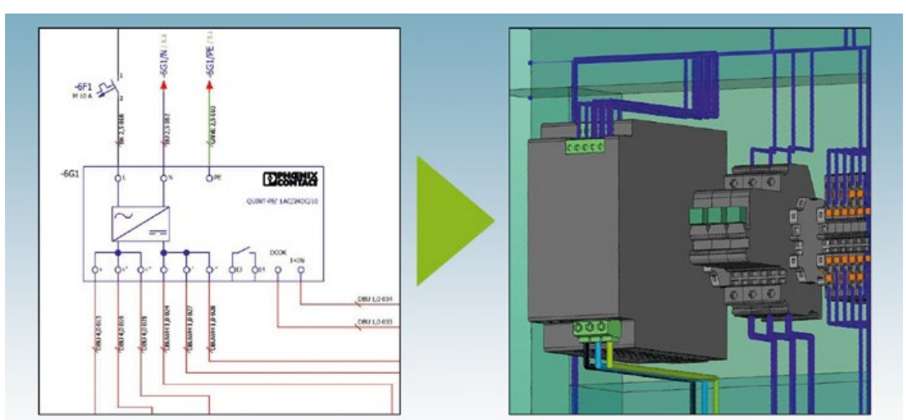


Extract from the online shop

eCl@ss – standard for master data and semantics for Industry 4.0

The use of a "common language" is mandatory for electronic and automated data exchange. With eCl@ss, a globally recognized and standard-compliant standard is available for this purpose. eCl@ss allows standardized, cross-sector classification and unique descriptions for products and services along the entire value-creation chain. With more than 45,000 product classes and around 19,000 characteristics, eCl@ss has established itself internationally. By using the eCl@ss standard, internal company processes can be optimized and cooperation with business partners can be made more efficient. eCl@ss is developed by eCl@ss e.V., which was founded in the year 2000.

As a non-profit organization, the association is supported by members from companies, associations, and institutions from various sectors of industry and commerce. Their common goal is to extend the eCl@ss standard in line with current and future market requirements and to promote its international application. Phoenix Contact supports the eCl@ss standard in material group management, where the cross-industry eCl@ss classification is applied in the purchasing process, and its four-level hierarchy, which is the basis for classifying products from different manufacturers. The characteristics assigned to the classes can be used to describe the respective product so that multi-supplier catalogs can be created, for example.



eCl@ss

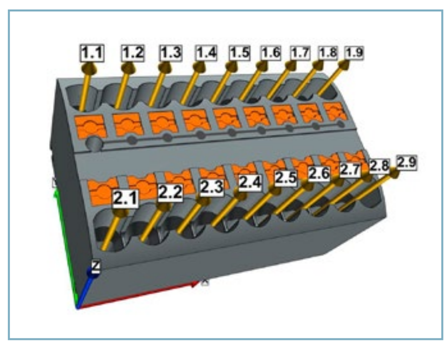
Configurators

Configurators allow configurable items to be ordered quickly and individually tailored to the customer. The physical variance of the possible combinations of these items rules out a classical numbering of the variance possibilities. Therefore, Phoenix Contact has online-based configurators.
Using these configurators, customers can put together their item from the assigned basic items and, if necessary, further customize it with markings and accessories. These items go into a shopping cart. Familiar customers (with login) can then access the price for the individual configuration directly in the specific country portal.
After completing the configuration, the configuration file is transferred to Phoenix Contact's internal systems by clicking on the shopping cart button. The respective price is then generated and transferred back to the shopping cart for display. Each transferred configuration is assigned a generated configuration key (config key). The customer can reuse this directly online when they reorder. Likewise, the configuration key enables direct orders in the system through the usual ordering channels. For customers who do not wish to register on the Phoenix Contact homepage, the ordering process will continue via inquiry email. An inquiry form will be generated automatically for this purpose. The Config ID it contains can be retrieved at any time by searching the e-shop. A price is therefore requested from the sales company via the Digital Process Framework (DPF). This also allows Phoenix Contact to send a quote to new customers within minutes.

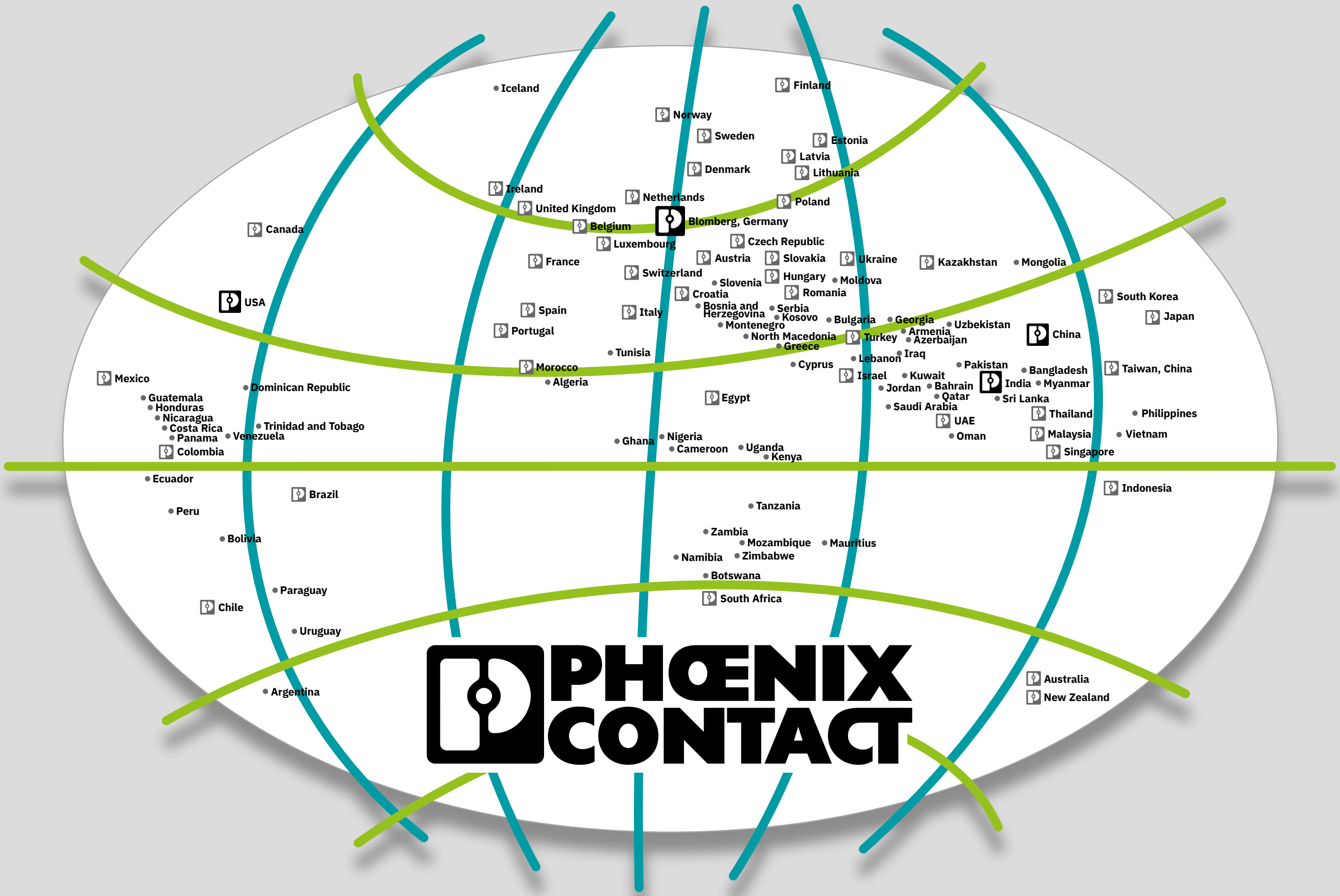

PTFIX configurator

Routing data – product data in engineering

Due to the large amount of data generated in engineering today, not every user wants to manually collect and update their application's data. Therefore, the users request the relevant data from the device manufacturer. The designer requires a 3D model, for example, and the electrical planner expects that the data on the components to be installed will be available in a format that their E-CAD tool can read. Here, Phoenix Contact uses the eCl@ss standard. With the data model, the required device data can be described and used in engineering tools. In the example of a terminal block, the position of the individual wire connections can be described using the eCl@ss-Advanced model. If the connections are used in the circuit diagram, then the ECAD software can determine the length of the individual wires from the 3D layout of the control cabinet. The individual cable bundles are then prefabricated and labeled for the control cabinet production process based on this data. In addition, the cable duct fill levels can be calculated. Even the automated wiring of the devices is possible, since the information for the positions of the connections are available in the required format. At Phoenix Contact, this data is therefore recorded directly on the 3D model of the product during the development process, and is then available for download, along with much other information, in the eCl@ss-Advanced standard or is available via various other portals.



Routing data based on a PTFIX distribution block



Open communication with customers and partners worldwide

Phoenix Contact is a global market leader based in Germany. We are known for producing future-oriented products and solutions for the electrification, networking, and automation of all sectors of the economy and infrastructure. With a global network reaching across more than 100 countries with over 21,000 employees, we maintain close relationships with our customers, something we believe is essential for our common success.

Our wide range of innovative products makes it easy for our customers to implement the latest technology in a variety of applications and industries. This especially applies to the target markets of energy, infrastructure, industry, and mobility.

You can find your local partner at

phoenixcontact.com

MNR 5176670/2023-11-15/06

3011574565