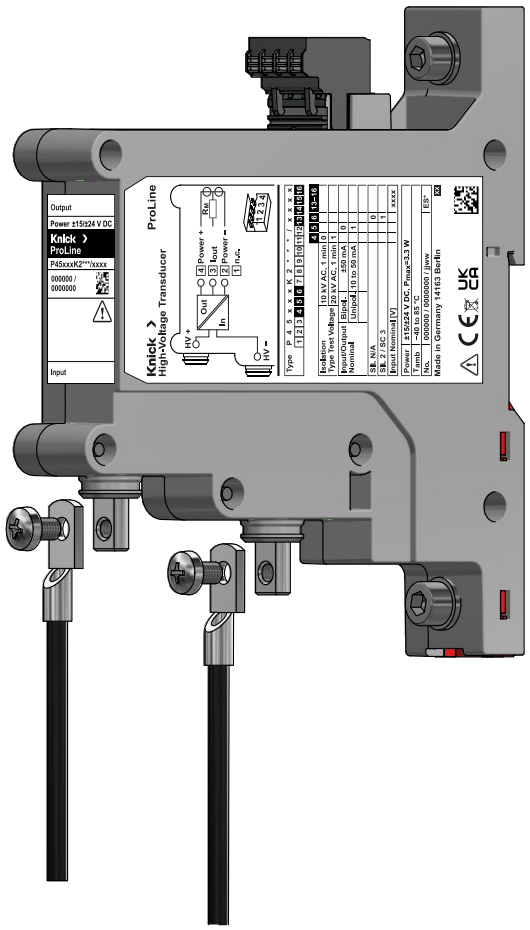
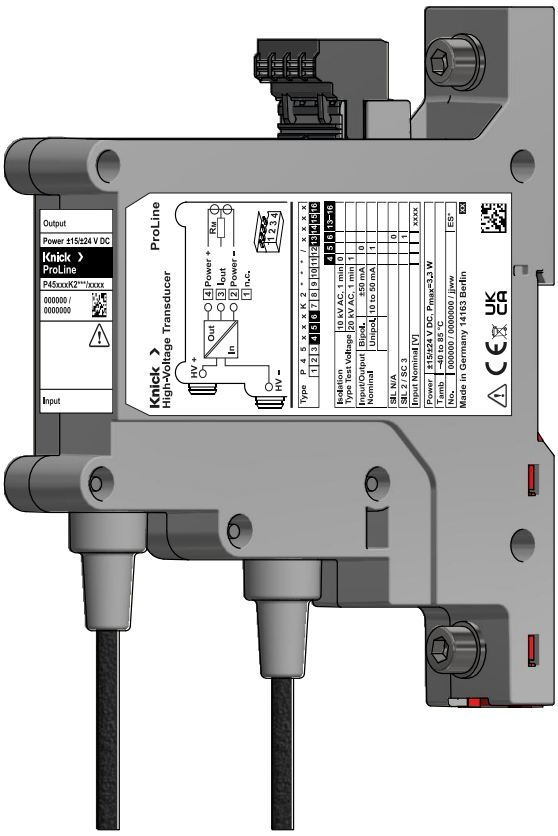
Knick

User Manual
incl. Safety Manual

# P45000 (P45*0*K2*, P45*1*K2*)
## High Voltage Transducer




Read before installation.
Keep for future use.

www.knick.de

# Supplemental Directives

**READ AND SAVE THIS DOCUMENT FOR FUTURE REFERENCE. BEFORE ATTEMPTING TO ASSEMBLE, INSTALL, OPERATE OR MAINTAIN THE PRODUCT, PLEASE ENSURE A COMPLETE UNDERSTANDING OF THE INSTRUCTIONS AND RISKS DESCRIBED HEREIN. ALWAYS OBSERVE ALL SAFETY INFORMATION. FAILURE TO COMPLY WITH INSTRUCTIONS IN THIS DOCUMENT COULD RESULT IN SERIOUS INJURY AND/OR PROPERTY DAMAGE. THIS DOCUMENT IS SUBJECT TO CHANGE WITHOUT NOTICE.**

These supplemental directives explain how safety information is laid out in this document and what content it covers.

### Safety Chapter

This document's safety chapter is designed to give the reader a basic understanding of safety. It illustrates general hazards and gives strategies on how to avoid them.

### Warnings

This document uses the following warnings to indicate hazardous situations:

| Symbol | Category | Meaning | Remark |
|---|---|---|---|
| ⚠ | **WARNING** | Designates a situation that can lead to death or serious (irreversible) injury. | The warnings contain information on how to avoid the hazard. |
| ⚠ | **CAUTION** | Designates a situation that can lead to slight or moderate (reversible) injury. | |
| *None* | **NOTICE** | Designates a situation that can lead to property or environmental damage. | |

# Table of Contents

**1 Safety ..... 5**
1.1 Intended Use ..... 5
1.2 Personnel Requirements ..... 5
1.3 Avoiding Electric Shocks and Fires ..... 6
1.4 Residual Risks ..... 6

**2 Product ..... 7**
2.1 Package Contents ..... 7
2.2 Product Identification ..... 7
2.2.1 Product Code ..... 7
2.2.2 Example of a Version ..... 7
2.3 Nameplate ..... 8
2.4 Symbols and Markings ..... 8
2.5 Design ..... 9
2.6 Functional Description ..... 12
2.7 Output/Power Supply Terminal Assignments ..... 13
2.8 Installation ..... 14
2.8.1 General Installation Instructions ..... 14
2.8.2 Mounting ..... 14
2.8.3 Preparing to Connect ..... 16
2.8.4 Electrical Connection ..... 16

**3 Operation ..... 19**
3.1 Commissioning ..... 19
3.2 Operation ..... 19
3.3 Troubleshooting ..... 19
3.4 Maintenance ..... 19
3.5 Return ..... 19
3.6 Disposal ..... 19

**4 Dimension Drawings ..... 20**

**5 Dimensioning of the Load ..... 22**
5.1 Maximum Load ..... 22
5.2 Minimum Load ..... 23
5.2.1 Single Operation ..... 23
5.2.2 Side-By-Side Operation ..... 24

**6 Specifications ..... 25**
6.1 Input ..... 25
6.2 Output ..... 26
6.3 Device Error Detection and Signaling ..... 26
6.4 Transmission Behavior ..... 26
6.5 Common-Mode Rejection Ratio ..... 27
6.6 Power Supply ..... 27
6.7 Isolation ..... 27
6.8 Clearance and Creepage Distances ..... 31
6.9 Ambient Conditions ..... 32
6.10 Device ..... 32
6.11 Further Data ..... 33

**7 Appendix ..... 34**
7.1 Accessories ..... 34
7.2 Standards and Directives ..... 34
7.3 Material Evaluation ..... 35
7.4 Common-Mode Response ..... 36

**8 SIL Manual (P45**1K2***) ..... 37**
8.1 General Description ..... 37
8.2 Determined Safety Characteristics ..... 37
8.3 Scope ..... 38
8.4 Applicable Standards ..... 38
8.5 Safety Sub-Function ..... 39
8.6 Signal Level for Measuring Signal and Failure Information ..... 39
8.7 Maintenance and Repair ..... 39
8.8 Proof Test ..... 39
8.9 Specifications (Functional Safety) ..... 39

**9 Abbreviations ..... 40**

**Index ..... 41**

# 1 Safety

This document contains important instructions for the use of the product. Always follow all instructions and operate the product with caution. If you have any questions, please contact Knick Elektronische Messgeräte GmbH & Co. KG (sometimes hereafter referred to as "Knick") using the information provided on the back page of this document.

The product may not be opened, modified, or independently repaired. Do not use the product if the housing is damaged. Replace with an equivalent product. Repairs may only be carried out by Knick.

## 1.1 Intended Use

The transducers in the P45000 product line measure voltages on rail vehicles as well as in rail infrastructure and industrial systems.

The P45000 may only be mounted on rolling stock in closed electrical operating areas at installation location 1 according to EN 50155 annex C. If the P45000 is mounted on the interior of rail vehicles, it must be mounted in closed and fireproof control cabinets.

The input may be connected directly to primary circuits (high potential). All definitions and specifications in the technical data must be observed.

The input signal is received by the P45000, processed, and galvanically isolated from the output and power supply. The output signal, which is proportional to the input, is galvanically connected to the power supply.

For further processing, the output signal is fed into a controller, a protection device, an indicator, or a data acquisition system.

**Fields of Application**

- Rolling stock
- Railway substations
- High voltage drives
- Industrial plants
- Infrastructure systems
- Power electronics
- Rectifiers and inverters
- Battery backup and emergency power systems

**USE CAUTION AT ALL TIMES WHEN INSTALLING, USING, OR OTHERWISE INTERACTING WITH THE PRODUCT. ANY USE OF THE PRODUCT EXCEPT AS SET FORTH HEREIN IS PROHIBITED, AND MAY RESULT IN SERIOUS INJURY OR DEATH, AS WELL AS DAMAGE TO PROPERTY. THE OPERATING COMPANY SHALL BE SOLELY RESPONSIBLE FOR ANY DAMAGES RESULTING FROM OR ARISING OUT OF AN UNINTENDED USE OF THE PRODUCT.**

## 1.2 Personnel Requirements

The operating company shall ensure that any personnel using or otherwise interacting with the product is adequately trained and has been properly instructed.

The operating company shall comply and cause its personnel to comply with all applicable laws, regulations, codes, ordinances and relevant industry qualification standards related to product. Failure to comply with the foregoing shall constitute a violation of operating company's obligations concerning the product, including but not limited to an unintended use as described in this document.

## 1.3 Avoiding Electric Shocks and Fires

Adhere to the specifications of EN 50343 when making electrical connections.

Connected tubing at the output and the voltage supply must be rated for the current limit of the protective device for the circuit.

Protective measures against direct contact: The operating company must take protective measures against direct contact at the freely accessible screwed contacts. As set out in EN 50153, Chapter 5, this can be ensured, for example, by installation in a lockable control cabinet. Other national or application-specific regulations must be observed.

Distances to adjacent devices and conductive parts in the vicinity of the device must be dimensioned and maintained in accordance with the applied standard. Isolation coordination with clearance and creepage distances (→ *Clearance and Creepage Distances, p. 30*, → *Clearance and Creepage Distances, p. 31*) and the relevant standards (e.g., EN 50124-1) must be carried out, evaluated, and ensured.

If the device is mounted horizontally according to EN 50124-1 and with pollution degree PD3A, it may only be mounted on plastic surfaces with CTI 600.

See also
→ *Installation, p. 14*

## 1.4 Residual Risks

The product has been developed and manufactured in accordance with generally accepted safety rules and regulations, as well as an internal risk assessment. Despite the foregoing, the product may among others bear the following risks:

### Environmental Influences

The effects of moisture, corrosion, and ambient temperature as well as high voltages and transient overvoltages may affect the safe operation of the product. Observe the following instructions:

- Only operate the P45000 in compliance with the stated operating conditions.
  → *Specifications, p. 25*

# 2 Product

## 2.1 Package Contents

- P45000 in the version ordered
- Installation Guide with safety instructions
- Test Report 2.2 according to EN 10204

## 2.2 Product Identification

The different versions of the P45000 are encoded in a model designation.

The product code is specified on the nameplate (extract). The actual product type can be determined from this code together with the order description stated on the product's front label (device front).

### 2.2.1 Product Code

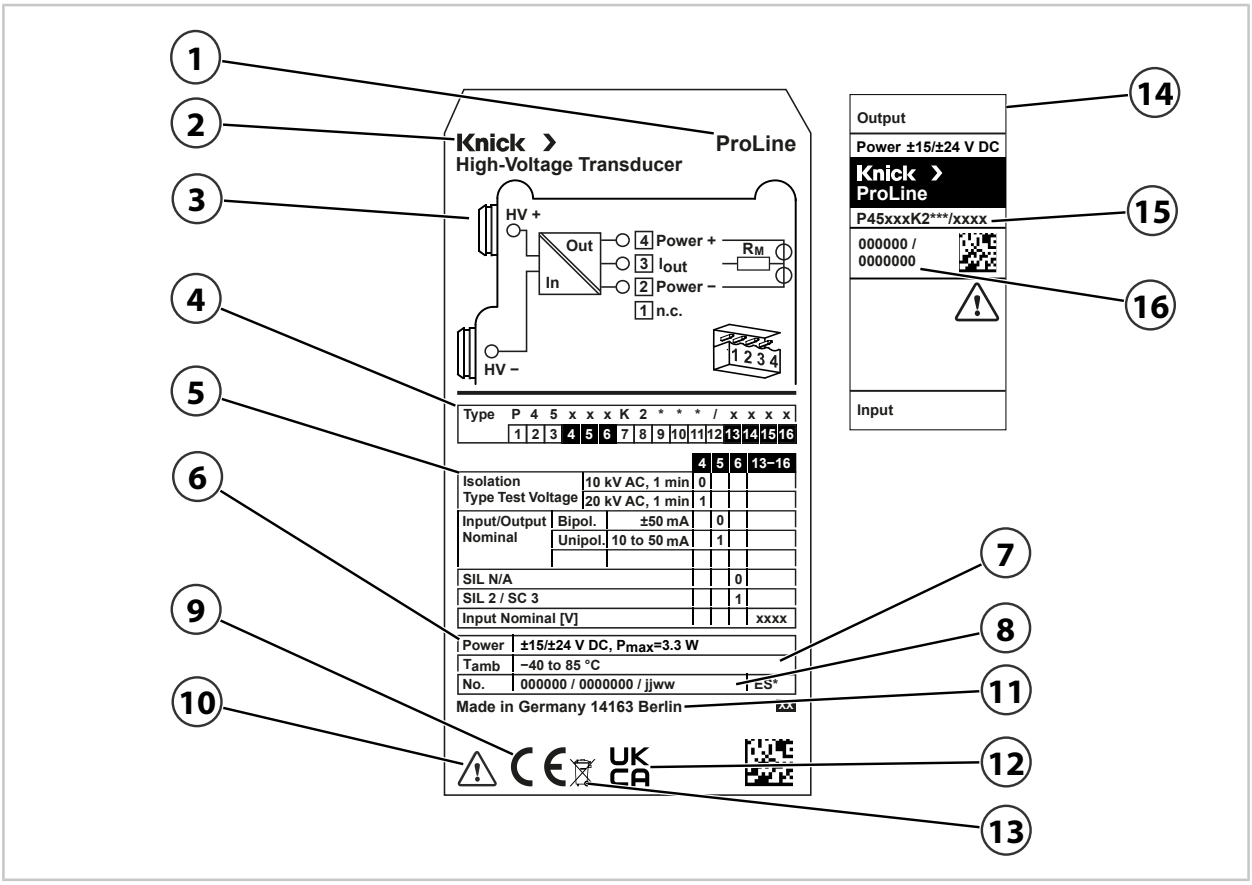
| **High Voltage Transducer** | **P45** | _ | _ | _ | K | 2 | _ | _ | _ | / | _ | _ | _ | _ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type test voltage 10 kV, rated voltage $U_{in,n}$ [V]: 500, 750, 1000, 1500 | | 0 | | | | | | | | / | | | | |
| Type test voltage 20 kV AC, rated voltage $U_{in,n}$ [V]: 500, 750, 1000, 1500, 2000, 2800, 3000 | | 1 | | | | | | | | / | | | | |
| $I_{out}$ = ±50 mA; 3-wire connection, bipolar | | | 0 | 0 | | | | | | / | | | | |
| $I_{out}$ = 10 ... 50 mA; 3-wire connection, unipolar | | | 1 | 1 | | | | | | / | | | | |
| $I_{out}$ = 4 ... 20 mA; 4-wire connection, unipolar | | | 3[1)] | | | | | | | / | | | | |
| $I_{out}$ = ±20 mA; 4-wire connection, bipolar | | | 5[1)] | 0 | | | | | | / | | | | |
| $U_{out}$ = ±10 V; 4-wire connection, bipolar | | | 6[1)] | 0 | | | | | | / | | | | |
| Without SIL suitability | | | | 0 | | | | | | / | | | | |
| With SIL suitability | | | | 1 | | | | | | / | | | | |
| Enclosure type | | | | | K | 2 | | | | / | | | | |
| Wall mount only | | | | | | | 0 | | | / | | | | |
| Wall mount/35 mm DIN rail | | | | | | | 1 | | | / | | | | |
| HV connection: Screwed contact/ring cable lug | | | | | | | | 0 | | / | | | | |
| HV connection: Captive tubing | | | | | | | | 1 | | / | | | | |
| Output/power supply: Push-in terminals | | | | | | | | | 1 | / | | | | |
| Output/power supply: Screw terminals | | | | | | | | | 2 | / | | | | |
| Input rated voltage: $U_{in,n}$ = xxxx V | | | | | | | | | | / | x | x | x | x |

### 2.2.2 Example of a Version

| **High Voltage Transducer** | **P45** | 0 | 0 | 0 | K | 2 | 1 | 0 | 1 | / | 1 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type test voltage 10 kV, rated voltage $U_{in,n}$ [V]: 500, 750, 1000, 1500 | | 0 | | | | | | | | / | | | | |
| $I_{out}$ = ±50 mA; 3-wire connection, bipolar | | | 0 | 0 | | | | | | / | | | | |
| Without SIL suitability | | | | 0 | | | | | | / | | | | |
| Enclosure type | | | | | K | 2 | | | | / | | | | |
| Wall mount/35 mm DIN rail | | | | | | | 1 | | | / | | | | |
| HV connection: Screwed contact/ring cable lug | | | | | | | | 0 | | / | | | | |
| Output/Power Supply: Push-in terminals | | | | | | | | | 1 | / | | | | |
| Input rated voltage: $U_{in,n}$ = xxxx V | | | | | | | | | | / | 1 | 0 | 0 | 0 |

1) Listed in other user manual.

## 2.3 Nameplate

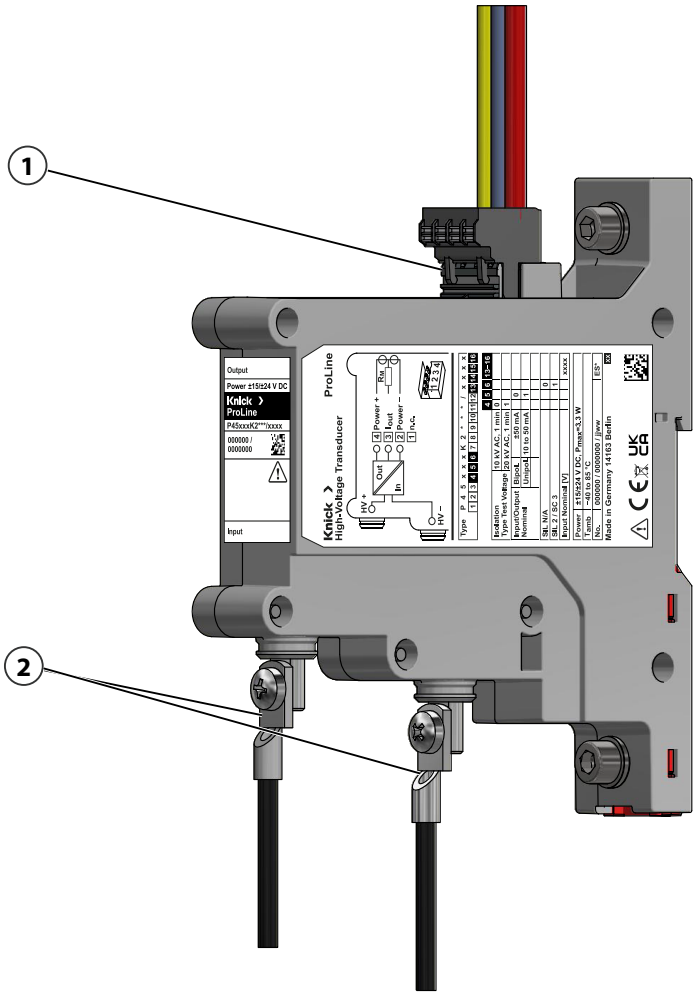



| | | | |
|---|---|---|---|
| **1** | Product line | **9** | CE mark |
| **2** | Manufacturer | **10** | Special conditions and danger points |
| **3** | Block diagram with terminal assignments | **11** | Manufacturer's address with designation of origin |
| **4** | Product description with individual product version | **12** | UKCA mark |
| **5** | Product code (excerpt) | **13** | WEEE mark |
| **6** | Power supply specification | **14** | Nameplate (front) |
| **7** | Permissible ambient temperature | **15** | Product description with individual product version |
| **8** | Item number / serial number / production date | **16** | Item number / serial number |

## 2.4 Symbols and Markings

| | |
|---|---|
| | Special conditions and the product's possible danger points. Read the user manual, observe the specifications, and follow the instructions in the Safety chapter. |
| CE | Attaching the CE marking to the product means that the product satisfies the applicable requirements specified in the European Union harmonization legislation. |
| UK CA | UK Conformity Assessed: Conformity mark for the United Kingdom (England, Scotland, and Wales) |
| | The symbol on Knick products means that the waste devices must be disposed of separately from unsorted municipal waste. |

## 2.5 Design

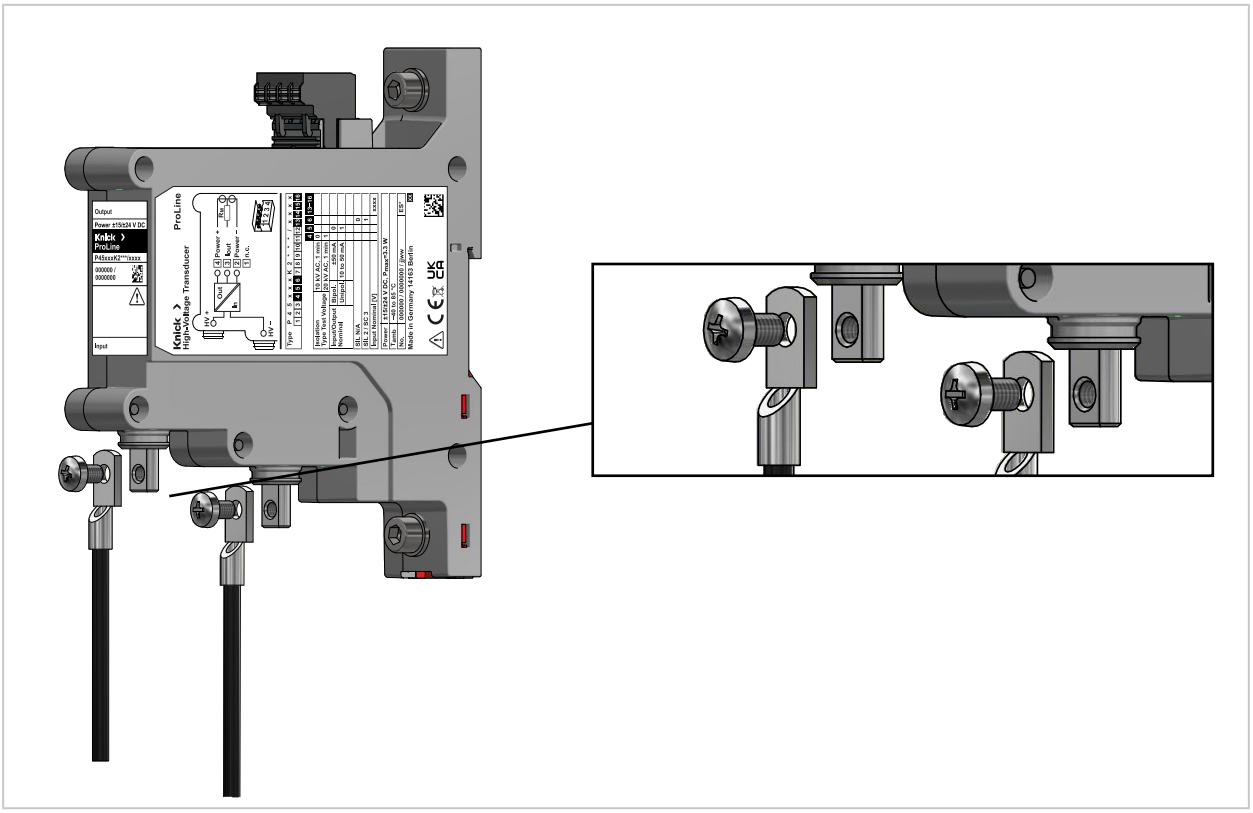



| | | | |
|---|---|---|---|
| **1** | Output | **2** | Input |

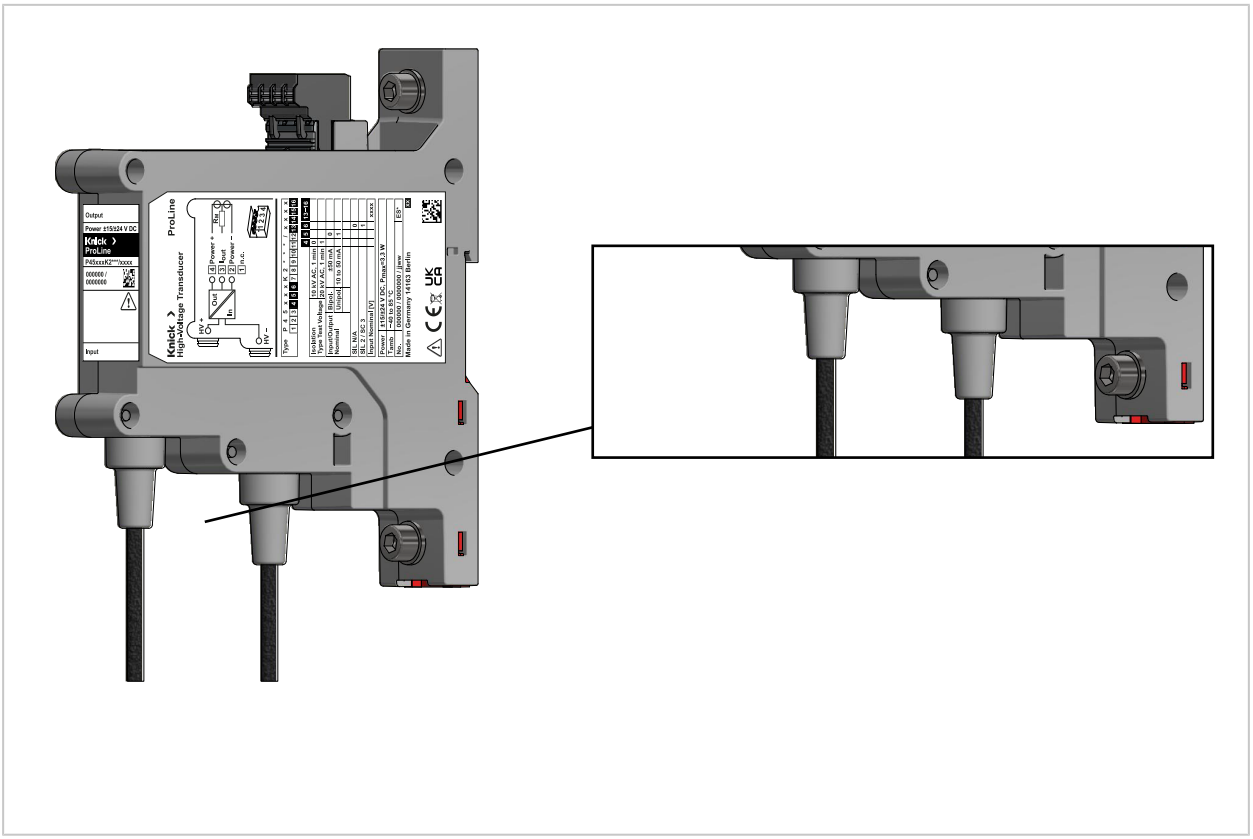
The P45000 can be ordered with two input variants:

- Screwed contact (M5) for tubing with ring cable lug
- Captive tubing potted in the device

### Input: Variant with Screwed Contacts

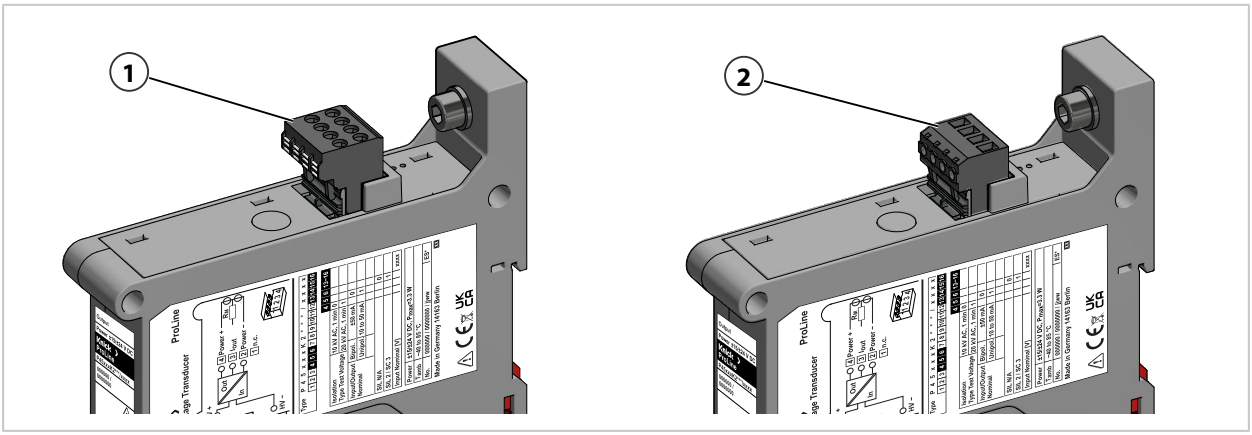


### Input: Variant with Captive Tubing



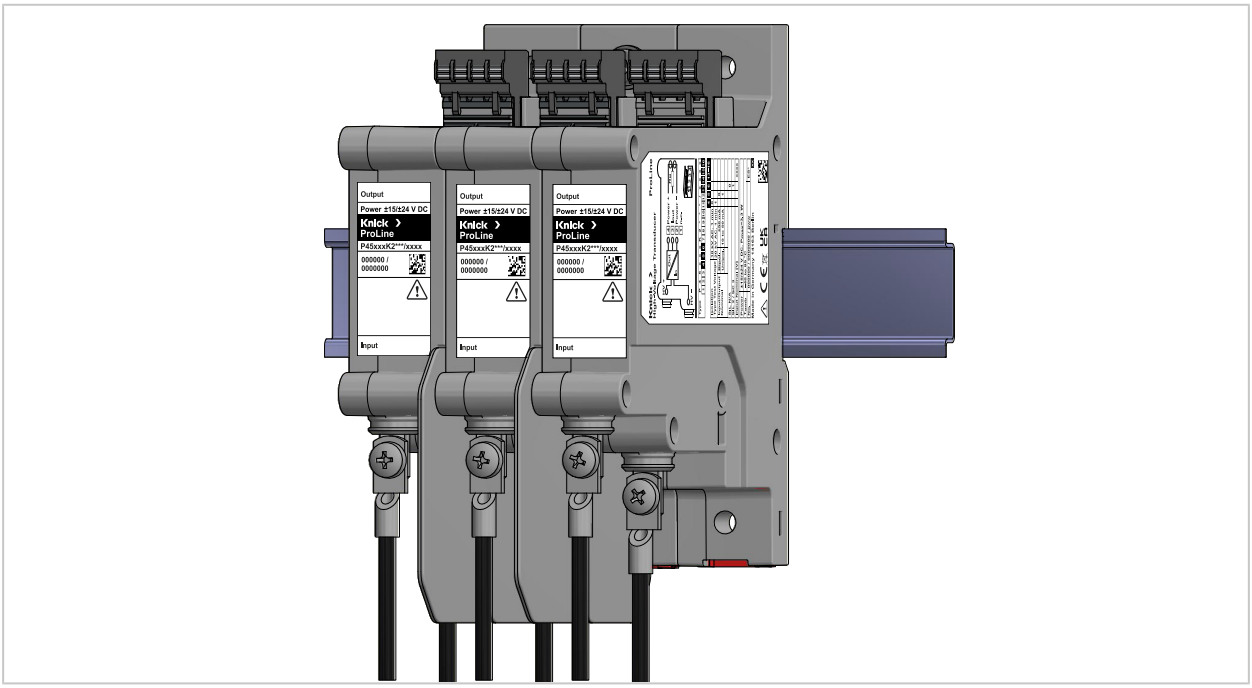
The captive tubing is available in lengths of up to 2 m.

### Output/Power Supply: Push-in Terminal and Screw Terminal



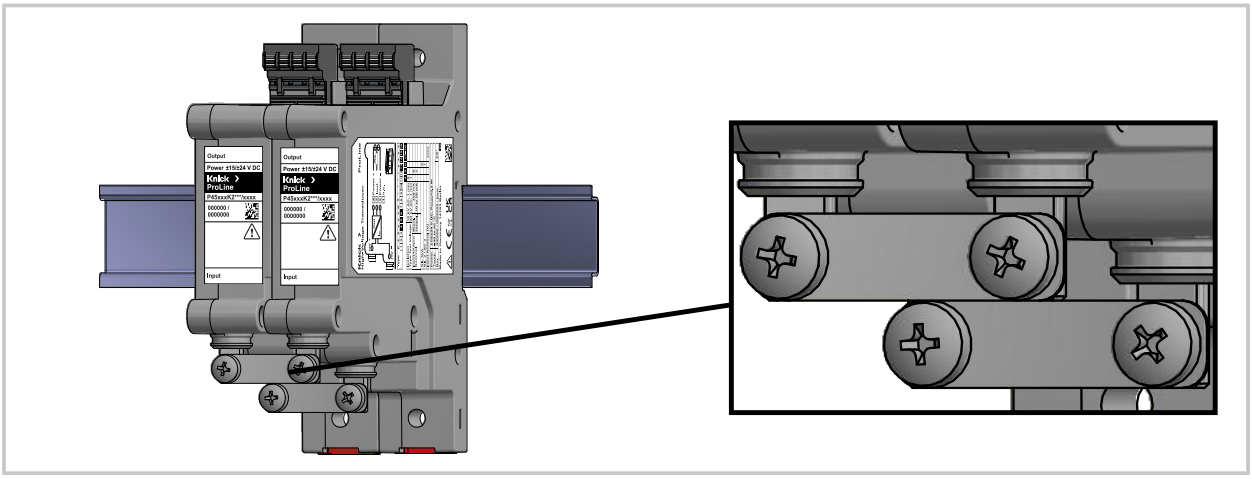

**1** Push-in terminal **2** Screw terminal

### Variant with Screwed Contacts and Partition (ZU1471)



To extend the clearances with side-by-side installation.

### Variant with Screwed Contacts and Jumper (ZU1474)



## 2.6 Functional Description

### Measuring Functions

The transducer is used for the conditioning, filtering, and galvanic isolation of high voltages. The transducer transfers analog signals from what is usually a high potential to a near-ground potential in order to be able to further process the detected signals safely and with low interference.

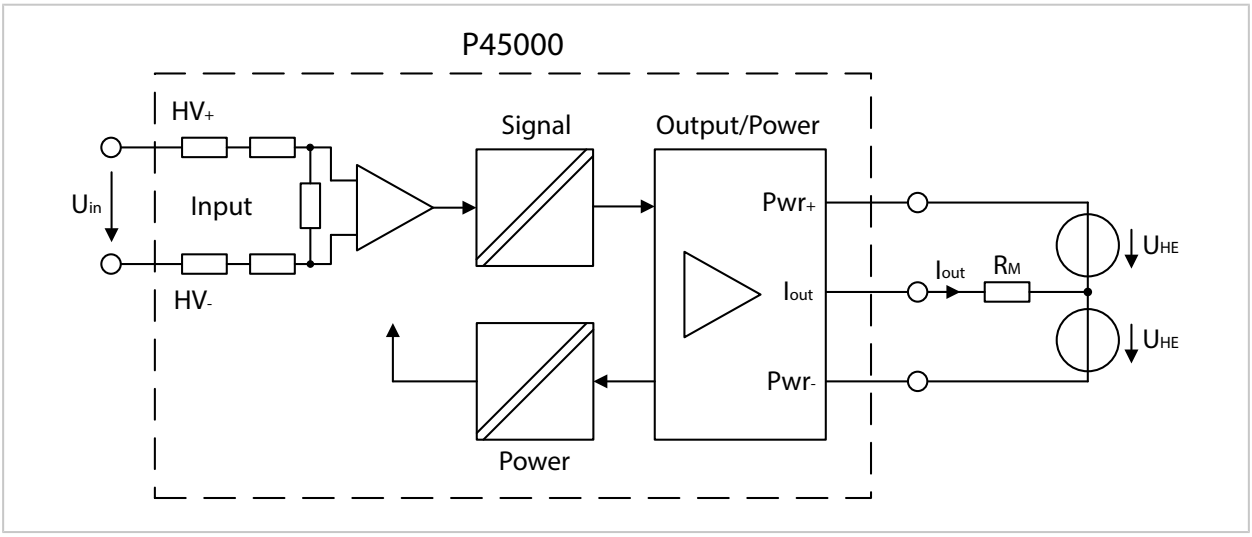
An analog signal is emitted at the output of the transducer, which is an image of the analog measuring signal at the input of the transducer. The amplitude of the input voltage may be up to several kilovolts, depending on the device design. Both unipolar and bipolar input signals can be processed. Either a unipolar or bipolar current signal is provided at the output of the transducer. The 2-port isolation, i.e., the galvanic isolation between input and output/power supply, ensures personal and plant safety as well as increasing the signal integrity of the measuring device.

### Live Zero Function (P45**1K2*** Only)

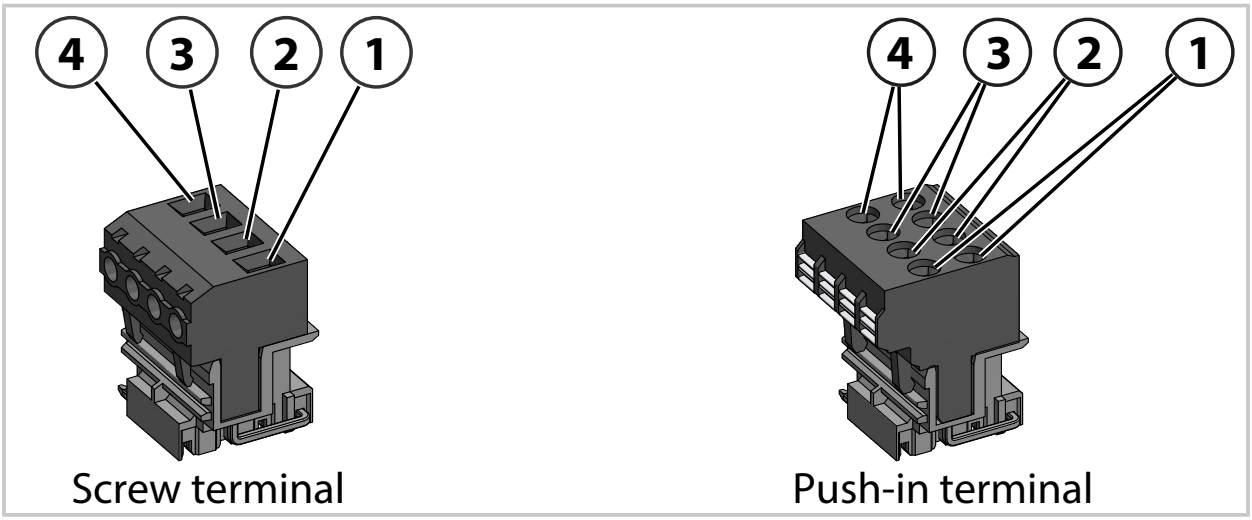
The products with SIL suitability detect certain internal faults (e.g., undervoltage, transmission failure) and set the output to a defined value as a fault response. This live zero function facilitates external monitoring of the output signal. The 10 ... 50 mA output signal (live zero) can be used to detect interruptions or short circuits of the output tubing. When doing so, output currents < 9 mA are to be interpreted as an error.

→ *Specifications, p. 25*

### Block Diagram



## 2.7 Output/Power Supply Terminal Assignments




| | | | |
|---|---|---|---|
| **1** | Not used | **3** | Current output |
| **2** | Negative supply voltage/power supply | **4** | Positive supply voltage/power supply |

The push-in terminal is executed as a two-tier terminal. Two internally connected terminals are available for each electrode. Consequently, the power supply can be looped in from one device to the next. It should be noted that the output signal is galvanically connected to the power supply in each case.

## 2.8 Installation

### 2.8.1 General Installation Instructions

⚠ **WARNING! Shock potential.** Do not install the product live.

⚠ **WARNING! Risk of electrical flashover.** When used in accordance with EN 50124-1 and pollution degree PD3A (P45***K2*1* only), the product may be mounted horizontally only on plastic surfaces with CTI 600.

⚠ **CAUTION! Safeguards!** In the interior of rail vehicles, the transducers must be mounted in closed and fireproof control cabinets.

The P45000 can be mounted in any installation position:

- vertically or horizontally on flat surfaces (with supplied self-locking screws with screw locking varnish)
- on a 35 mm DIN rail (without use of a DIN rail bus connector)
- side-by-side (maximum three devices next to or above each other, possible with all aforementioned installation types)

The ZU1471 accessory can be used to increase the clearances. It is installed near the input's high voltage contacts.

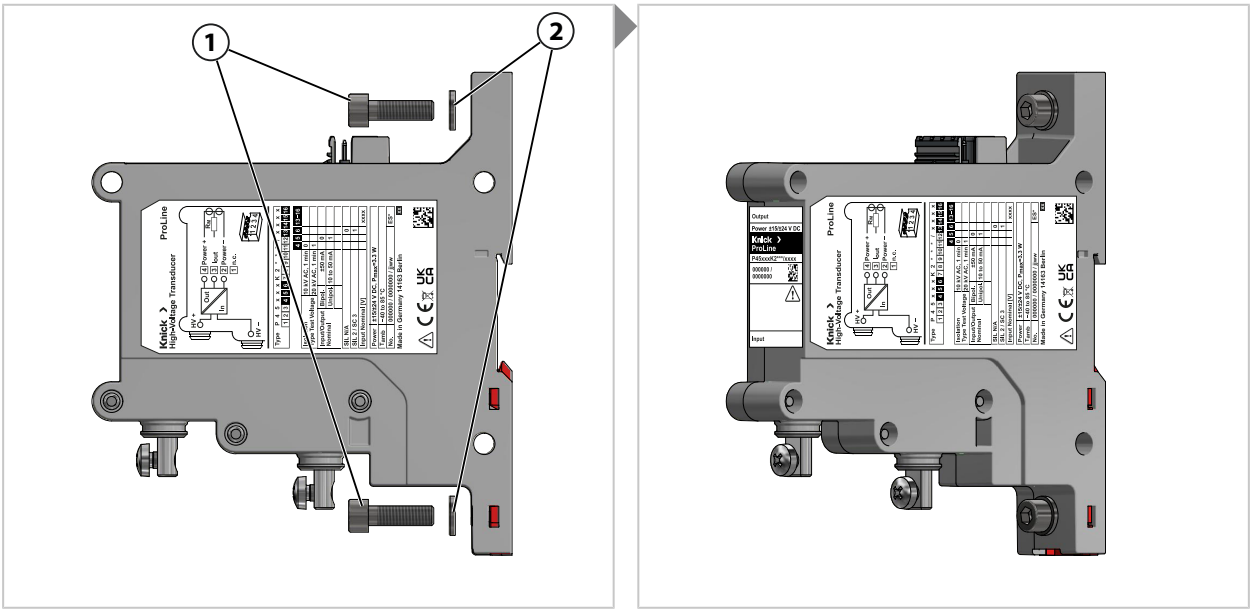
The ZU1474 accessory can be used to connect (in parallel) the input screw terminals of two devices for redundant operation. It is installed on the screwed contacts.

### 2.8.2 Mounting

⚠ **WARNING! Shock potential.** Do not install the product live.

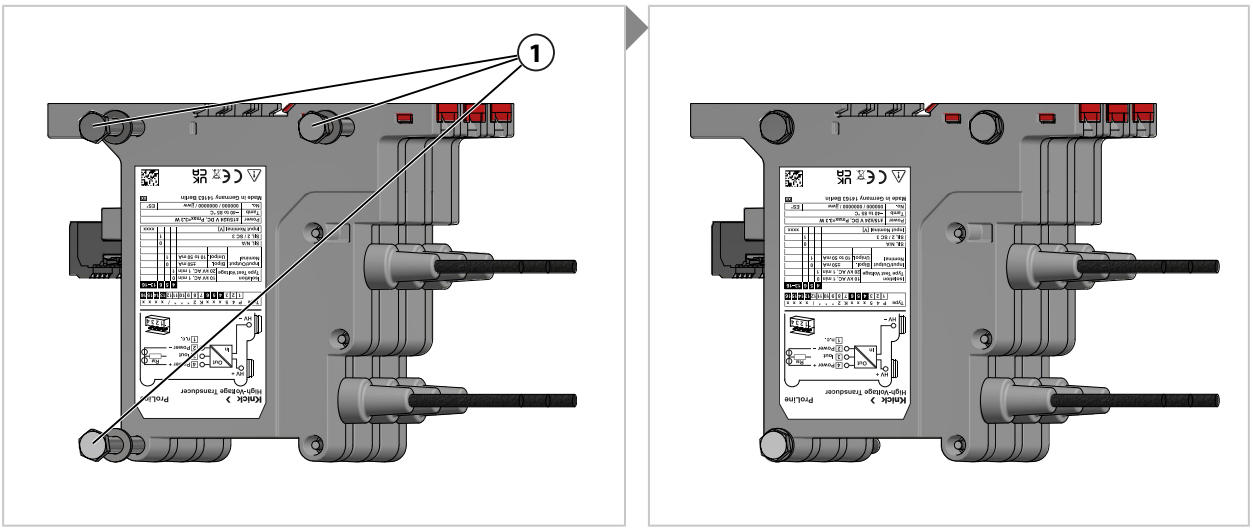
01. Check to ensure the package contents are complete. → *Package Contents, p. 7*
02. Check the P45000 for damage.

**Installation on Mounting Surface (Vertical)**




01. Install the ZU1471 partition as required.
02. Fasten the P45000 onto the mounting surface using two M6 screws **(1)** and two washers for M6 **(2)**. Tightening torque 5 Nm.

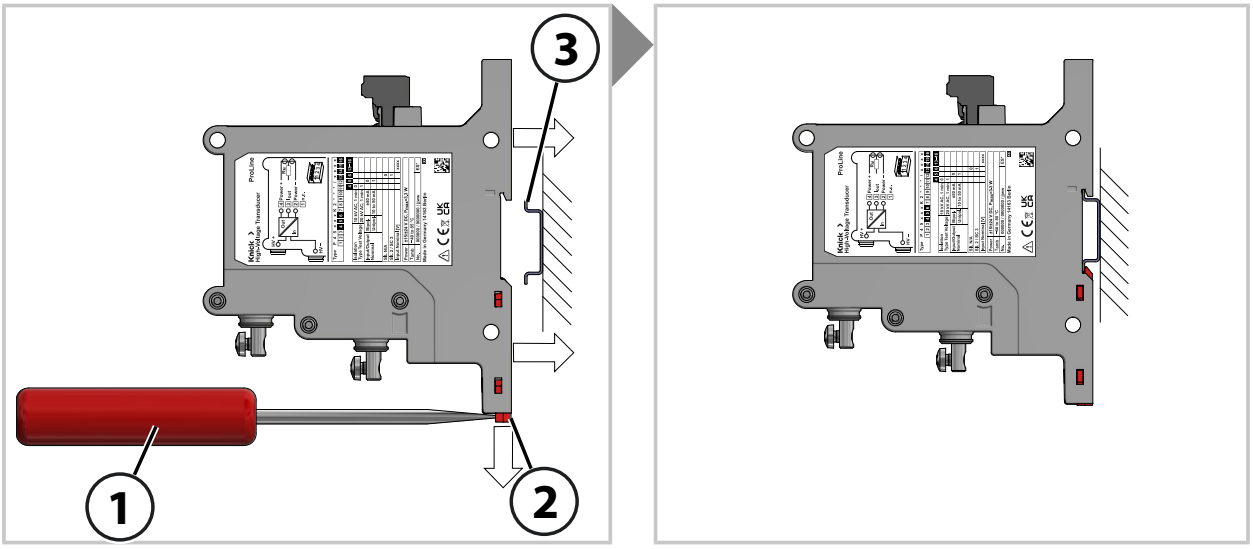
### Installation on Mounting Surface (Horizontal)




01. Install the ZU1471 partition as required.
02. Fasten the P45000 onto the mounting surface using three M6 screws **(1)** and three washers for M6. Tightening torque 3 Nm.

⚠ **WARNING! Shock potential!** When mounting the variant horizontally with P45***K2*0* screw contacts, observe the separation distances to the environment. → *Clearance and Creepage Distances, p. 30*

### Installation on DIN Rail P45***K21**




With 7.5 mm DIN rails:

01. Install the ZU1471 partition as required.
02. Using a screwdriver **(1)**, pull out the red base latch **(2)**.
03. Push the P45000 horizontally onto the DIN rail **(3)** and engage the base latch.

With 15 mm DIN rails:

01. Install the ZU1471 partition as required.
02. Place the P45000 on the top edge of the DIN rail and snap it on.

### 2.8.3 Preparing to Connect

#### Input

**Note:** Captive tubing with a cross-section of 1.5 mm² is pre-installed in the P45***K2*1* order version. This tubing has a length of up to 2 m and can be shortened to the length required in the application.

| **Input Tubing, Product Variant P45***K2*0*** | |
|---|---|
| Temperature resistance | min. 100 °C (212 °F) |
| Maximum tubing cross-section | 16 mm² |
| Minimum tubing cross-section | 1.5 mm² |
| Maximum cable lug length | 21 mm from center of screw hole |
| Cable lug orientation[1)] | Vertical, ±10° |
| Cable lug material | Steel, tin-plated |
| Phillips screwdriver material | Steel, stainless |

#### Output/Power Supply Tubing

**Note:** Use ferrules with a metal sleeve length of 10 mm or, for rigid cables, remove 10 mm of the insulation at the cable ends.

| **Tubing Push-In Terminal or Screw Terminal** | |
|---|---|
| Maximum tubing cross-section | 2.5 mm² |
| Minimum tubing cross-section | 0.2 mm² |

### 2.8.4 Electrical Connection

⚠ **WARNING! Shock potential.** Do not install the product live.

01. Disconnect the electrical system from live parts.
02. Secure the electrical system against restart.
03. Verify that the electrical system is dead.
04. Ground and short-circuit the electrical system.
05. Cover or isolate adjacent live parts with insulating materials.

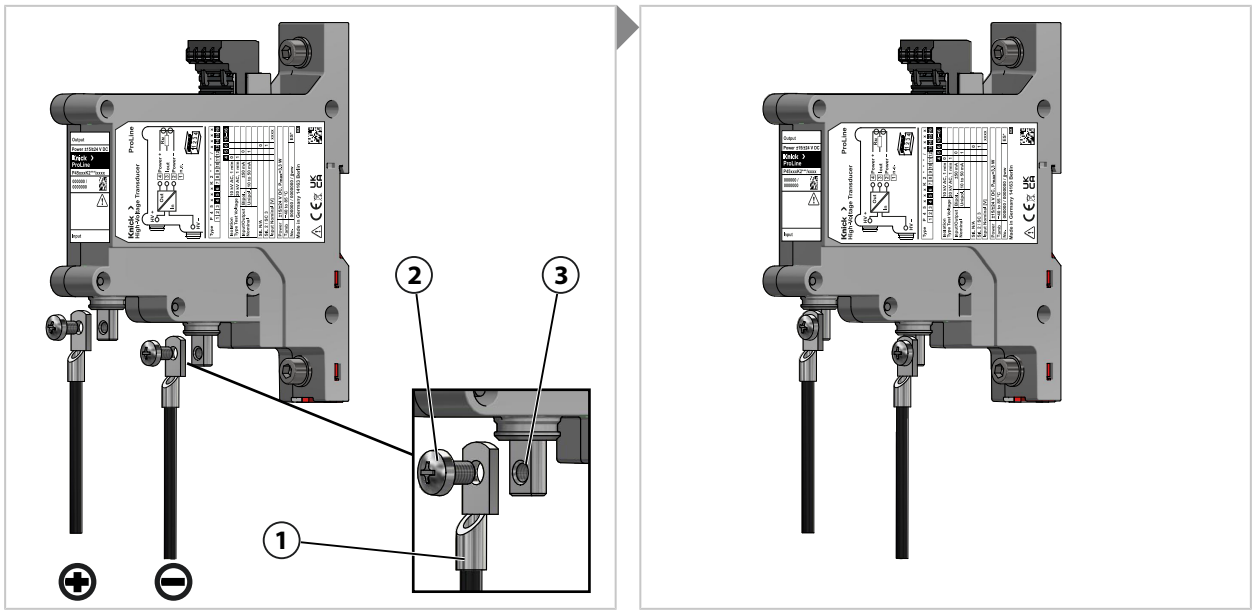
The polarity of the inputs is indicated on the side nameplate.

#### Reverse Polarity Protection

The connection of the supply voltage/power supply at the output is protected against polarity reversal. The product is not operational as long as the polarity is reversed.

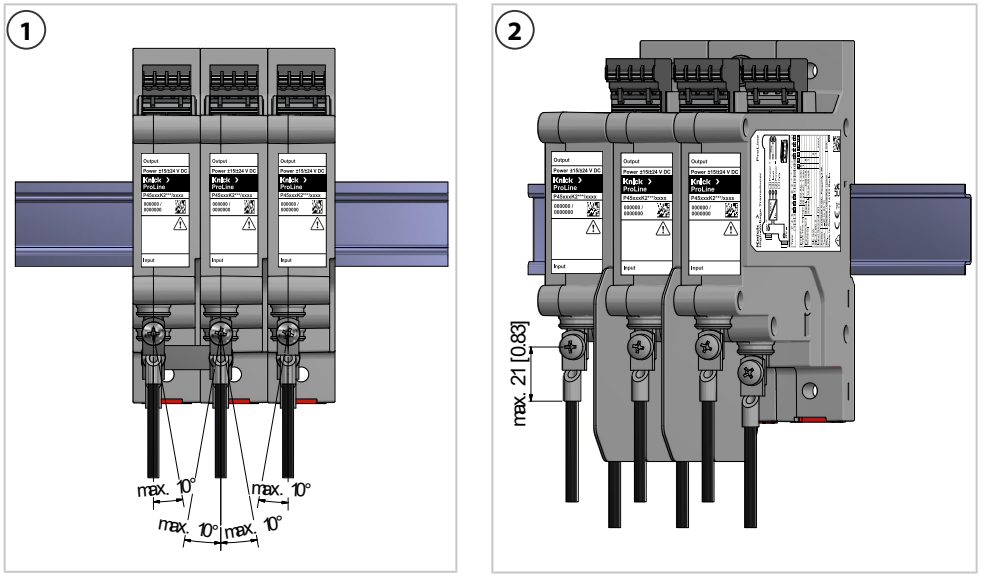
1) → *Electrical Connection, p. 16*

### Cable Lug Input Connection P45***K2*0*




01. Fasten the tubing **(1)** with screw M5 x 8 mm **(2)** to the screwed contact **(3)**. Tightening torque 1 ... 3 Nm.

### Side-by-Side Connection

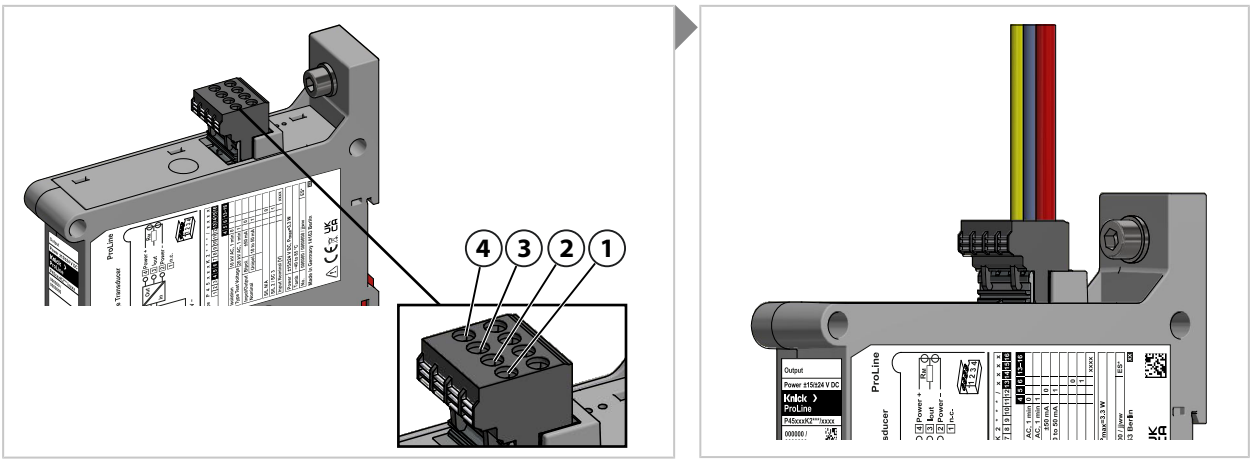



**1** Side-by-side

**2** Side-by-side with partition (ZU1471)

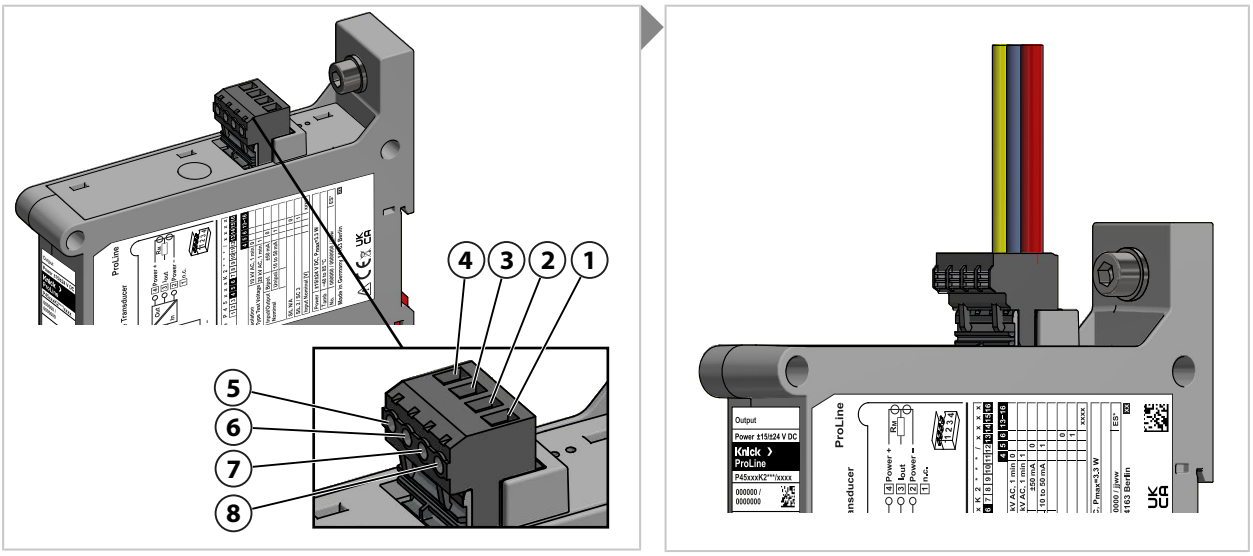
01. Align the cable lug vertically (±10°) **(1)** and **(2)**.

### Connection Piece Output/Push-In Terminal Power Supply




01. Insert the tubing into the terminals **(2)** ... **(4)**. → *Output/Power Supply Terminal Assignments, p. 13*
02. Reset the electrical system to its initial state. Reverse the steps taken to ensure voltage-free operation.

### Connection Piece Output/Screw Terminal Power Supply




01. Insert the tubing into the terminals **(2)** ... **(4)**. → *Output/Power Supply Terminal Assignments, p. 13*
02. Tighten screws **(5)** ... **(7)**. Tightening torque 0.6 Nm.
03. Reset the electrical system to its initial state. Reverse the steps taken to ensure voltage-free operation.

See also

→ *Input, p. 26*

# 3 Operation

## 3.1 Commissioning

***NOTICE!*** Permanent overdrive can lead to overheating and thus to increased failure rates. Adhere to the specifications and observe the chapter on dimensioning the load.

The P45000 is configured ex works for the version ordered and has no controls.

## 3.2 Operation

The high voltage transducer is configured ex works and does not have any operating elements.

## 3.3 Troubleshooting

Follow the Safety Instructions. → *Safety, p. 5*

Initial troubleshooting steps:

- check that all tubing is properly connected.
- check the power supply.

| Malfunction State | Possible Cause | Remedy |
|---|---|---|
| Unexpected measured value. | The input signal is not properly connected. | Check if the input signal is actually present. |
| | Current output overload. | Measure the voltage across the current output terminal and measure the output current. Calculate the resulting load. → *Output, p. 26* |
| | Input is overdriven: The input voltage is lower than the selected start-of-scale value or higher than the selected full scale value. Observe permitted overdrive. | Adjust the range or correct the overdrive. → *Input, p. 25* |
| | Tubing fault between output and control. | Check the 10 ... 50 mA output with an ammeter to determine if the output current is < 9 mA. Signals < 9 mA are to be interpreted as an error. Correct line short-circuits or interruptions at the output |

## 3.4 Maintenance

The devices are maintenance-free. The customer may request that the devices be recalibrated or adjusted at the factory. The electronics cannot be repaired, as the devices are potted.

## 3.5 Return

If required, send the product in a clean condition and securely packed to your local contact.
→ *knick.de*

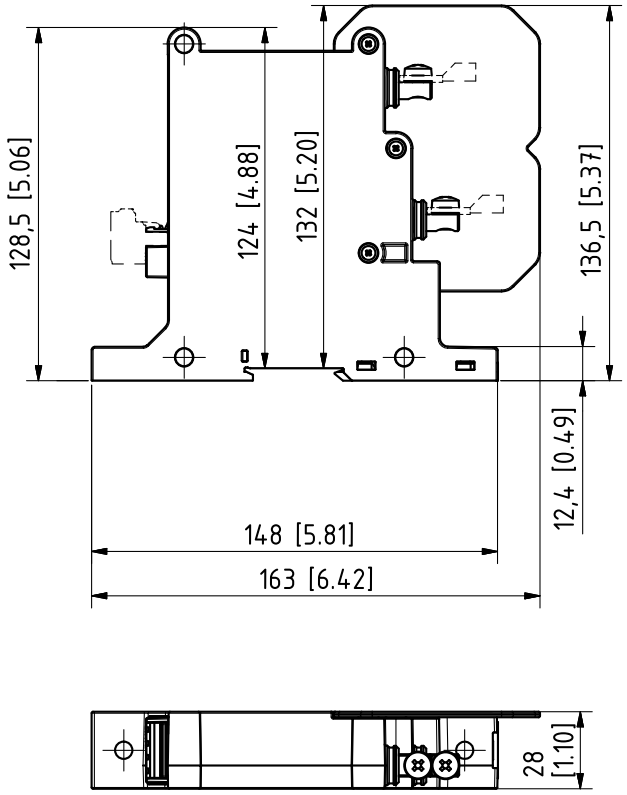
## 3.6 Disposal

Local codes and regulations must be observed when disposing of the product.

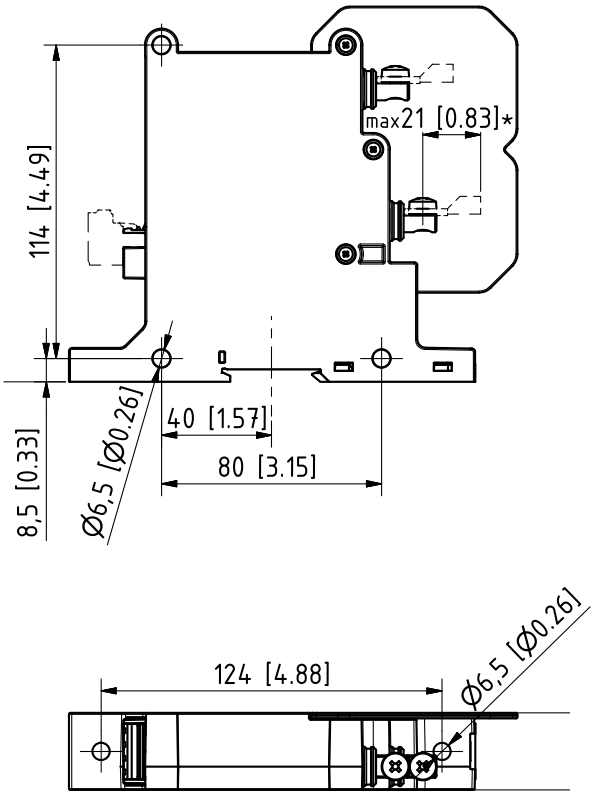
# 4 Dimension Drawings

**Note:** All dimensions are given in millimeters [inches].

**External Dimensions**



## Holes




* With partition

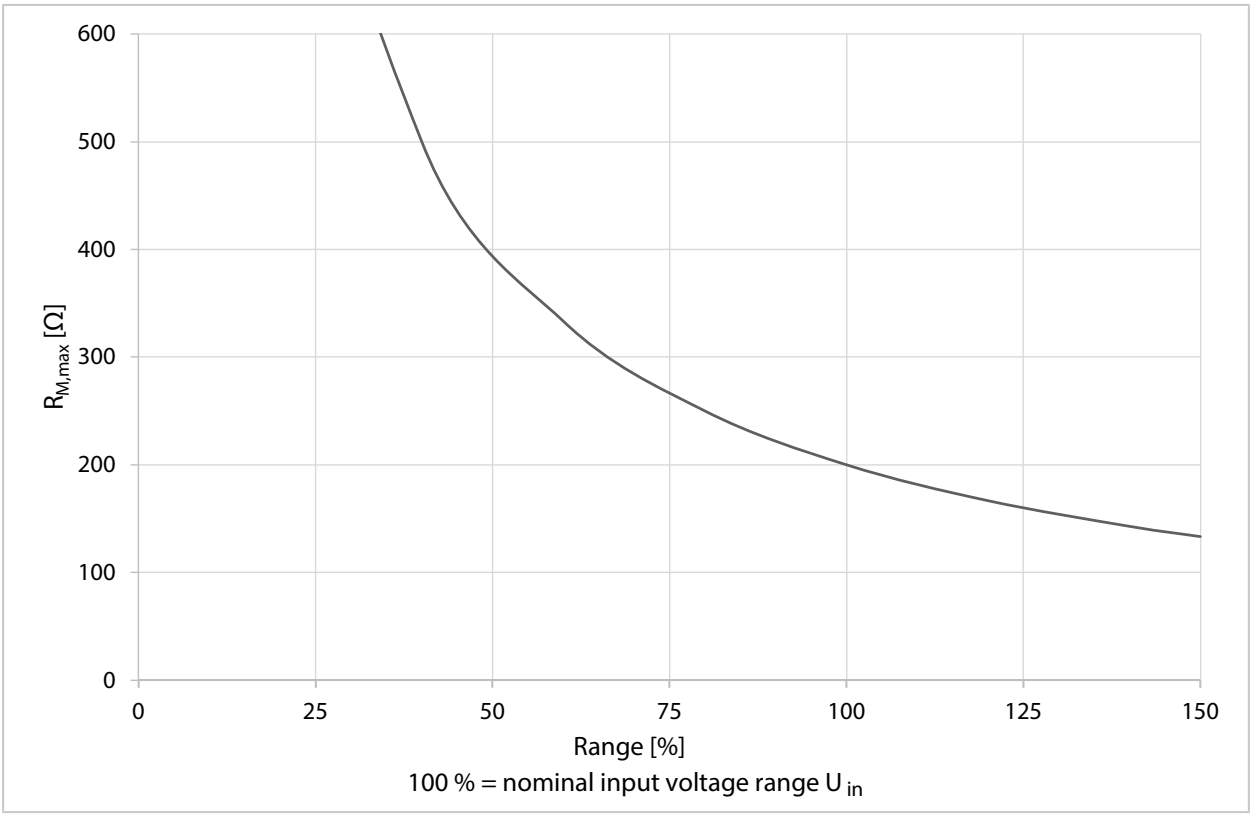
# 5 Dimensioning of the Load

When selecting the load $R_M$, the resulting load voltage, operating mode (single operation/side-by-side operation), the supply voltage, and the ambient temperature of the P45000 are to be taken into account. In general, the load may fall within a range from $R_M$ = 0 ... 200 Ω at $I_{out}$ = ±50 mA or $R_M$ = 0 ... 133 Ω at $I_{out}$ = ±75 mA. Upper restrictions are due to the maximum load voltage → *Maximum Load, p. 22*. Lower restrictions may be dependent on the operating mode (single operation/side-by-side operation), the supply voltage, and the ambient temperature → *Minimum Load, p. 23*.

## 5.1 Maximum Load

The P45000 generates a load voltage with the output current dependent on the input voltage at the load $R_M$. The load is to be selected in such a way that, with the expected output current, a load voltage of a maximum -10 V and a minimum 10 V results. If the load selected is too large, a linear representation of the input voltage to the output current is no longer guaranteed.

The following diagram depicts the maximum load $R_{M,max}$ depending on the input voltage up to the measuring range full scale for $T_{amb}$ = -40 ... 85 °C (-40 ... 185 °F) and $U_{HE}$ = ±13.5 ... ±26.4 V:



## 5.2 Minimum Load

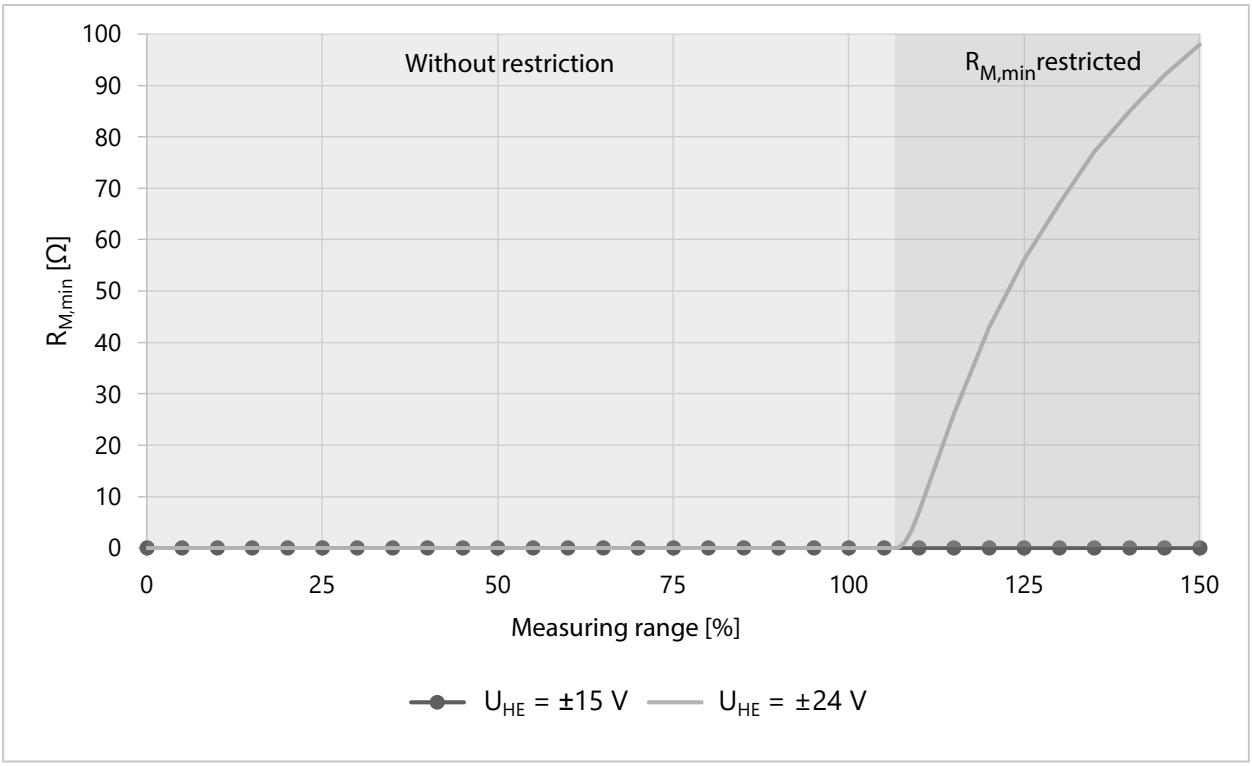
In principle, the minimum permissible load is $R_M = 0\ \Omega$. Under certain conditions (high ambient temperature, high supply voltage, high input signal), a load $R_M > 0\ \Omega$ is to be selected in order to avoid excessive heating of the P45000. With a higher load, the temperature of the product decreases during operation. This reduces the expected failure rate and increases the service life of the P45000. Therefore, a load $R_M >> 0\ \Omega$ should be selected if possible.

### 5.2.1 Single Operation

The restriction at $U_{HE} = \pm 24$ V is only to be taken into account with ambient temperatures of $T_{amb} = 75 \ldots 85$ °C (167 … 185 °F). At an ambient temperature of $T_{amb} < 75$ °C (< 167 °F) the minimum permissible load is $R_M = 0\ \Omega$, irrespective of the supply voltage and the input voltage.

A device is considered to be operated singly if the air gap to the side walls of other devices is ≥ 15 mm (0.59″).

The following diagram represents the minimum load $R_{M,min}$ depending on the input voltage up to the measuring range full scale and the supply voltage during single operation up to $T_{amb} = 85$ °C (185 °F):




**Note:** With a load of 100 Ω, the P45000 can be operated singly under maximum conditions for temperature, supply voltage, and input signal.

### 5.2.2 Side-By-Side Operation

Devices are considered to be operating side-by-side if the air gap between the side walls of the individual devices is < 15 mm (0.59”). With side-by-side operation, the above conditions for single operation apply plus the following restrictions:

The following table shows the maximum ambient temperature depending on the minimum load and the supply voltage (3 devices, side-by-side, in each case $I_{out}$ = 50 $mA_{rms}$):

| $U_{HE}$ [V] | ±13.5 | ±15 | ±16.5 | ±21.6 | ±24 | ±26.4 |
|---|---|---|---|---|---|---|
| **$R_M$ [Ω]** | | | | | | |
| **0** | 85 °C (185 °F) | 85 °C (185 °F) | 85 °C (185 °F) | 75 °C (167 °F) | 70 °C (158 °F) | 65 °C (149 °F) |
| **133** | 85 °C (185 °F) | 85 °C (185 °F) | 85 °C (185 °F) | 80 °C (176 °F) | 75 °C (167 °F) | 75 °C (167 °F) |
| **200 (only up to 50 mA DC)** | 85 °C (185 °F) | 85 °C (185 °F) | 85 °C (185 °F) | 85 °C (185 °F) | 80 °C (176 °F) | 75 °C (167 °F) |

**Note:** For applications with side-by-side devices and measured values within the nominal measuring range, 200 Ω is optimal. For applications with side-by-side devices and measured values up to 1.5 times the measuring range, 133 Ω is optimal.

# 6 Specifications

All data without stated tolerance specification are typical values.

## 6.1 Input

| Measuring ranges/output ranges | | | | |
|---|---|---|---|---|
| **Product variant** | **Rated voltage** | **Nominal measuring range** | **Nominal output range** | **Type test voltage** |
| Products without SIL suitability | | | | |
| P45000K2***/0500[1)] | 500 V | ±500 V | ±50 mA | 10 kV |
| P45000K2***/0750[1)] | 750 V | ±750 V | ±50 mA | 10 kV |
| P45000K2***/1000[1)] | 1000 V | ±1000 V | ±50 mA | 10 kV |
| P45000K2***/1500[1)] | 1500 V | ±1500 V | ±50 mA | 10 kV |
| P45100K2***/0500[1)] | 500 V | ±500 V | ±50 mA | 20 kV |
| P45100K2***/0750[1)] | 750 V | ±750 V | ±50 mA | 20 kV |
| P45100K2***/1000[1)] | 1000 V | ±1000 V | ±50 mA | 20 kV |
| P45100K2***/1500[1)] | 1500 V | ±1500 V | ±50 mA | 20 kV |
| P45100K2***/2000[1)] | 2000 V | ±2000 V | ±50 mA | 20 kV |
| P45100K2***/2800[1)] | 2800 V | ±2800 V | ±50 mA | 20 kV |
| P45100K2***/3000[1)] | 3000 V | ±3000 V | ±50 mA | 20 kV |
| Products with SIL suitability/EN 61508 | | | | |
| P45011K2***/0500[1)] | 500 V | 0 ... 500 V | 10 ... 50 mA | 10 kV |
| P45011K2***/0750[1)] | 750 V | 0 ... 750 V | 10 ... 50 mA | 10 kV |
| P45011K2***/1000[1)] | 1000 V | 0 ... 1000 V | 10 ... 50 mA | 10 kV |
| P45011K2***/1500[1)] | 1500 V | 0 ... 1500 V | 10 ... 50 mA | 10 kV |
| P45111K2***/0500[1)] | 500 V | 0 ... 500 V | 10 ... 50 mA | 20 kV |
| P45111K2***/0750[1)] | 750 V | 0 ... 750 V | 10 ... 50 mA | 20 kV |
| P45111K2***/1000[1)] | 1000 V | 0 ... 1000 V | 10 ... 50 mA | 20 kV |
| P45111K2***/1500[1)] | 1500 V | 0 ... 1500 V | 10 ... 50 mA | 20 kV |
| P45111K2***/2000[1)] | 2000 V | 0 ... 2000 V | 10 ... 50 mA | 20 kV |
| P45111K2***/2800[1)] | 2800 V | 0 ... 2800 V | 10 ... 50 mA | 20 kV |
| P45111K2***/3000[1)] | 3000 V | 0 ... 3000 V | 10 ... 50 mA | 20 kV |
| **Rated voltage according to EN 50163** | | $U_n$ = 600 V DC to 3000 V DC | | |
| **Maximum measuring range** | | 150 % of the nominal measuring range | | |
| **Maximum permissible crest factor** | | 1.5 related to nominal measuring range | | |

[1)] The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

| | | | |
|---|---|---|---|
| **Thermal overload capacity** | | | |
| Input rated voltage | Permanent overvoltage[1](DC) | Continuous overvoltage[1] (Peak-Wert) | Input resistance $R_{in}$ |
| ±500 V | ±750 V | ±750 V | 2.7 MΩ |
| ±750 V | ±1500 V | ±1500 V | 5.4 MΩ |
| ±1000 V | ±1500 V | ±1500 V | 5.4 MΩ |
| ±1500 V | ±3000 V | ±3000 V | 10 MΩ |
| ±2000 V | ±3000 V | ±3000 V | 10 MΩ |
| ±2800 V | ±3900 V[2] | ±4500 V | 16.8 MΩ |
| ±3000 V | ±3900 V[2] | ±4500 V | 16.8 MΩ |
| The section on isolation and the limits specified there must be taken into account. → *Isolation, p. 27* | | | |
| **Input capacitance** | | < 10 pF | |

## 6.2 Output

| | |
|---|---|
| **Output current in nominal measuring range** | |
| P45*0*K2***[3]: | $I_{out}$ = ±50 mA |
| P45*1*K2***[3]: | $I_{out}$ = 10 ... 50 mA |
| **Maximum output current** | |
| P45*0*K2***[3]: | $I_{out,max}$ = ±75 mA |
| P45*1*K2***[3]: | $I_{out,max}$ = 70 mA |
| **Load** | 0 ... 200 Ω for $I_{out}$ = -50 ... 50 mA<br>0 ... 133 Ω for $I_{out}$ = -75 ... 75 mA<br><br>Note the following information:<br>→ *Dimensioning of the Load, p. 22* |

## 6.3 Device Error Detection and Signaling

| | |
|---|---|
| **Output current (error)** | |
| P45*0*K2***[3]: | no error signaling |
| P45*1*K2***[3]: | $I_{out,failure}$: < 9 mA |

## 6.4 Transmission Behavior

| | |
|---|---|
| **Gain error** | < 0.2 % of measured value at 23 °C (73.4 °F) |
| **Offset error** | < 100 µA at 23 °C (73.4 °F) |
| **Temperature coefficient** | < 100 ppm/K full scale |
| **Total error in the complete temperature range** | < 1 % full scale |
| **Ripple** | ≤ 10 $mV_{rms}$ |
| **Cutoff frequency** (--3 dB) | ≥ 10 kHz |
| **Response time $T_{90resp}$** | < 70 µs |
| **Readiness for operation (after switching on the power supply)** | < 100 ms |

1) The data relating to isolation, load, ambient temperature, and power supply must be observed → *Isolation, p. 27* → *Output, p. 26* → *Ambient Conditions, p. 32* → *Power Supply, p. 27*

2) Only valid for version with captive tubing P45***K2*1*.

3) The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

## 6.5 Common-Mode Rejection Ratio

| | |
|---|---|
| **CMRR**[1] | > 150 dB (DC)<br>> 90 dB (AC 16.7 Hz/50 Hz/60 Hz) |
| **T-CMRR**[2] | > 70 dB<br>Input square step: Tr = 1 µs |

## 6.6 Power Supply

| | |
|---|---|
| **Power supply** | |
| Rated voltage range | ±15 V DC, ± 10% … ±24 V DC, ± 10% |
| DC ripple upstream power supply | ≤ 100 $mV_{p-p}$ |
| **Short-time interruption/undervoltage** | |
| Interruption class of the power supply unit according to EN 50155 | S1 |
| Switchover class of the power supply unit according to EN 50155 | According to upstream power supply |
| **Power consumption** | 0.8 W when supplied with ±15 V and $I_{out}$ = 0 mA<br>2.5 W when supplied with ±24 V and $I_{out}$ = ±50 mA<br>3.3 W when supplied with ±26.4 V and $I_{out}$ = ±75 mA |
| **Limit load integral (inrush current over time)** | 200 $µA^2s$ |
| **Reverse polarity protection** | Reverse polarity protected |

## 6.7 Isolation

| | | |
|---|---|---|
| **Galvanic isolation** | | Input against output/power supply<br>2-port isolation |
| **Type test** | | |
| | Test voltage P450**K2***[3] | 10 kV AC for 1 min |
| | Test voltage P451**K2***[3] | 20 kV AC for 1 min |
| | Surge voltage P450**K2***[3] | 30 kV |
| | Surge voltage P451**K2***[3] | 50 kV |
| | BIL P450**K2***[3] according to UL 347A (E533966): | 30 kV |
| | BIL P451**K2***[3] according to UL 347A (E533966): | 45 kV |
| **Routine test** | | |
| | Test voltage P450**K2***: [3] | 10 kV AC for 10 s |
| | Test voltage P451**K2***: [3] | 16 kV AC for 10 s |
| **Partial discharge extinction voltage** | | ≥ 10 kV AC (50 Hz) |
| **Overvoltage category** | | OV3 |
| **Pollution degree** | | |
| P45***K2***[3]: | | PD2 |
| P45***K2*1*[3]: | | PD3A[4] (only EN 50124-1) |

1) Common-mode rejection ratio = common mode input voltage / output voltage

2) For further information see → *Common-Mode Response, p. 36*

3) The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

4) Also note the requirements under → *Avoiding Electric Shocks and Fires, p. 6*.

## Isolation of the P45***K2*0* Screwed Contact Variant

| | | |
|---|---|---|
| **Rated isolation voltage $U_{Nm}$** | | |
| **Reinforced insulation input against output/power supply** | | |
| P450**K2*0*[1]: | EN 50124-1 (rolling stock) | 2300 V AC/DC |
| | EN 50124-1 (stationary installations) | 2300 V AC/DC |
| | EN 50178 | 2300 V AC/DC |
| | UL 347A | 2300 V AC/DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| P451**K2*0*[1]: | EN 50124-1 (rolling stock) | 3700 V AC/DC |
| | EN 50124-1 (stationary installations) | 3600 V AC/DC |
| | EN 50178 | 3600 V AC/DC |
| | UL 347A | 3600 V AC/DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| **Function isolation input against input** | | |
| P450**K2*0*[1]: | | |
| | EN 50124-1 (rolling stock) | 2300 V AC/DC |
| | EN 50124-1 (stationary installations) | 2300 V AC/DC |
| | EN 50178 | 2300 V AC/DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| P451**K2*0*[1]: | | |
| | EN 50124-1 (rolling stock) | 3700 V AC/DC |
| | EN 50124-1 (stationary installations) | 3600 V AC/DC |
| | EN 50178 | 3600 V AC/DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| **Isolation inputs against environment** | | |
| Measure distances to neighboring devices and conductive parts within the environment of the device according to the applied standard. Carry out, evaluate, and safeguard isolation coordination with clearance and creepage distances (→ *Clearance and Creepage Distances, p. 30*) and the relevant standards (e.g., EN 50124-1). | | |
| Evaluate and, if necessary, safeguard contact protection for accessible parts according to EN 50153. | | |
| Carry out cable laying according to EN 50343. | | |

See also

→ *Clearance and Creepage Distances, p. 31*

[1] The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

## Isolation of the Variant with Captive Cable P45***K2*1*

| | | |
|---|---|---|
| **Rated isolation voltage $U_{Nm}$** | | |
| **Reinforced insulation input against output/power supply** | | |
| P450**K2*1*[1]: | EN 50124-1 (rolling stock) | 2300 V AC/DC |
| | EN 50124-1 (stationary installations) | 2300 V AC/DC |
| | EN 50178 | 2300 V AC/DC |
| | UL 347A | 2300 V AC/DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| P451**K2*1*[1]: | EN 50124-1 (rolling stock) | 3600 V AC / 4800 V DC |
| | EN 50124-1 (stationary installations) | 3600 V AC / 4800 V DC |
| | EN 50178 | 3600 V AC / 4800 V DC |
| | UL 347A | 3600 V AC/DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| **Function isolation input against input** | | |
| | EN 50124-1 (rolling stock) | 3600 V AC / 4800 V DC |
| | EN 50124-1 (stationary installations) | 3600 V AC / 4800 V DC |
| | EN 50178 | 3600 V AC / 4800 V DC |
| | EN IEC 60664-1 | 1000 V AC / 1500 V DC |
| | EN 61010-1 | 1000 V AC/DC |
| **Isolation inputs against environment** | | |
| Measure distances to neighboring devices and conductive parts within the environment of the device according to the applied standard. Carry out, evaluate, and safeguard isolation coordination with clearance and creepage distances (→ *Clearance and Creepage Distances, p. 30*) and the relevant standards (e.g., EN 50124-1). | | |
| Carry out cable laying according to EN 50343. | | |
| Isolation given by cable insulation with 3600 V AC/4800 V DC. Check whether additional isolation may be required. | | |

[1] The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

## Clearance and Creepage Distances

| | | | |
|---|---|---|---|
| **Clearances** | | | |
| P45***K2*0*[1]: | Between the inputs | F1 | Min. 36 mm (1.42″) |
| | Between the inputs and output/power supply: | B1, D1 | Min. 102 mm (4.02″) |
| | Between the inputs and fastening screw for installation[2] | B3, D3, B5, D5 | Min. 35 mm (1.38″) |
| | Between the inputs and DIN rail | B8, D8 | Min. 62 mm (2.44″) |
| | Between side-by-side devices without partition | F2 | Min. 14 mm (0.55″) |
| | Between side-by-side devices with partition | F2‘ | Min. 33 mm (1.29″) |
| | Between the inputs and mounting plate with partition, horizontal on mounting plate | B2, D2 | Min. 18 mm (0.71″) |
| P45***K2*1*[1]: | No accessible, live/conductive parts on the device. Cable is potted in the device. | | Dependent on remaining cable length. |
| **Creepage distances** | | | |
| P45***K2*0*[1]: | Between the inputs | F1 | Min. 56 mm (2.20″) |
| | Between the inputs and output/power supply: | B1, D1 | Min. 104 mm (4.09″) |
| | Between the inputs and fastening screw for installation[2] | B3, D3, B5, D5 | Min. 57 mm (2.24″) |
| | Between the inputs and DIN rail | B8, D8 | Min. 64 mm (2.52″) |
| | Between side-by-side devices without partition | F2 | Min. 64 mm (2.52″) |
| | Between side-by-side devices with partition | F2‘ | Min. 64 mm (2.52″) |
| P45***K2*1*[1]: | No accessible, live/conductive parts on the device. Cable is potted in the device. | | Dependent on remaining cable length. |

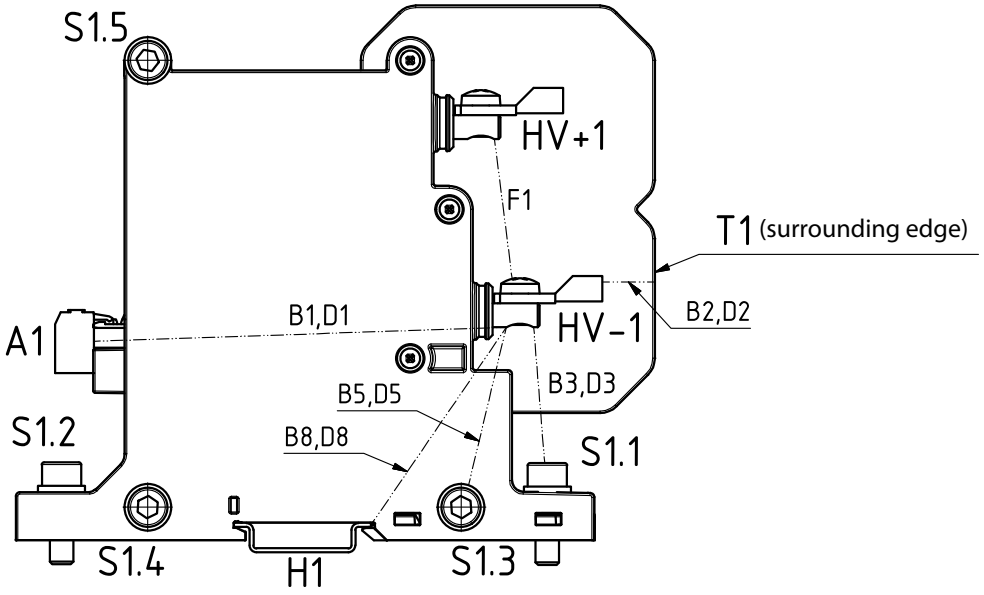
See also

→ *Clearance and Creepage Distances, p. 31*

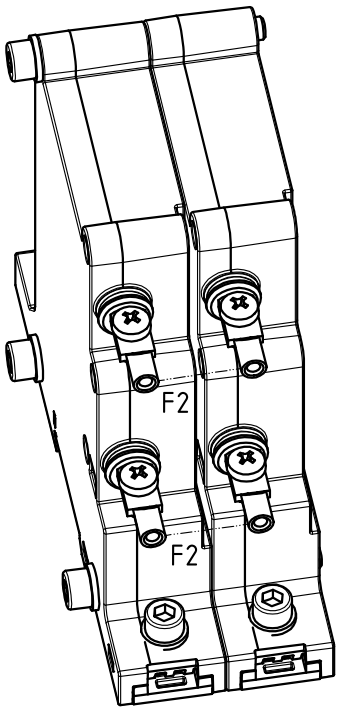
1) The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

2) ISO 4762 hexagon socket screw M6 h = 6 mm, ISO 7089 washer M6 h = 1.6 mm

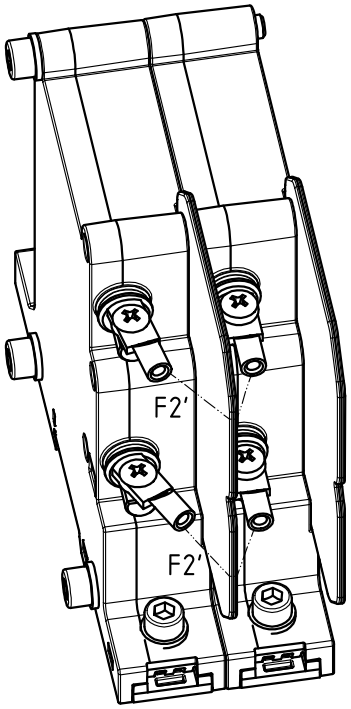
## 6.8 Clearance and Creepage Distances




without partition




with partition



## 6.9 Ambient Conditions

| | | |
|---|---|---|
| **Installation site according to EN 50155** | Enclosed control cabinet,<br>Annex C: 1 | |
| **Height class according to EN 50125** | AX up to 2000 m above MSL,<br>Reduced isolation data for altitudes > 2000 ... 4000 m above MSL | |
| **Temperature class according to EN 50155** | OT4, ST1/ST2 (+ 15 K/10 min.) | |
| **Class of rapid temperature change according to EN 50155** | H1 | |
| **Permissible temperatures** at $U_{HE}/I_{out}/R_M$: | | |
| | Single operation, air gap >15 mm (0.59″) | Side-by-side operation; air gap < 15 mm (0.59″); max. 3 devices |
| at ±24 V/75 mA DC/0 Ω | -40 ... 75 °C (-40 ... 167 °F) | -40 ... 55 °C (-40 ... 131 °F) |
| at ±24 V/75 mA DC/133 Ω | -40 ... 85 °C (-40 ... 185 °F) | -40 ... 65 °C (-40 ... 149 °F) |
| at ±24 V/50 $mA_{rms}$/0 Ω | -40 ... 85 °C (-40 ... 185 °F) | -40 ... 70 °C (-40 ... 158 °F) |
| at ±15 V/75 mA DC/0 Ω | -40 ... 85 °C (-40 ... 185 °F) | -40 ... 75 °C (-40 ... 167 °F) |
| at ±15 V/50 $mA_{rms}$/200 Ω | -40 ... 85 °C (-40 ... 185 °F) | -40 ... 85 °C (-40 ... 185 °F) |
| **Transport/storage** | -50 ... 90 °C (-58 ... 194 °F) | |
| **Relative humidity** (operation, storage, and transport) according to EN 50125 | | |
| Annual mean value | ≤ 75 % | |
| Continuous operation | 15 ... 75 % | |
| Continuously for 30 days a year | 75 ... 95 % | |
| Occasionally on the other days | 95 ... 100 % | |
| **Pollution degree** | | |
| P45***K2***[1]: | PD2 | |
| P45***K2*1*[1]: | PD3A[2] (only EN 50124-1) | |

## 6.10 Device

| | | |
|---|---|---|
| **Weight** | | |
| P45***K2*0*[1] | Without partition | Approx. 370 g |
| | With partition | Approx. 390 g |
| P45***K2*1*[1] | | Approx. 500 g |
| **Screw tightening torques** | M5 input terminals | 1 ... 3 Nm |
| | Output screw terminals | 0.6 Nm |
| | Vertical on mounting plate 2 x M6 | 5 Nm |
| | Horizontal on mounting plate 3 x M6 (max. 3 devices stacked) | 3 Nm |

1) The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

2) Also note the requirements under → *Avoiding Electric Shocks and Fires, p. 6*.

## 6.11 Further Data

| | | | |
|---|---|---|---|
| **EMC** | | | |
| Rail applications | EN 50121-1, EN 50121-3-2, EN 50121-5 | | |
| Industrial applications | EN 61326-1, EN 61326-3-1 | | |
| Emitted interference | Class B (up to 110 V DC/to 230 V AC) | | |
| Immunity to interference | Industrial applications | | |
| **Mechanical load<br>Vibration and shock<br>according to EN 61373, IEC 61373** | Category 1, Class B<br>tested by independent test laboratory | | |
| **Fire protection according to EN 45545-1, EN 45545-2, EN 45545-5** | For exterior applications (combustible mass < 400 g) up to HL3[1)] | | |
| | For interior applications: Installation in enclosed and fire-protected control cabinets | | |
| | Certified by independent test laboratory | | |
| **Service life** | 20 years, L4 according to EN 50155 | | |
| **Design** | Surface mount housing, optionally with mounting on 35 mm DIN rail | | |
| **Contact protection** | | | |
| | | Input | Output/power supply |
| P45***K2*0*[2)]: | | IP00 | IP20 |
| P45***K2*1*[2)]: | | IP54 | IP20 |
| **Encapsulation** | Electronics completely encapsulated by potting with a silicone-free polyurethane casting resin | | |
| **Hazardous substances** | It contains no hazardous substances according to the REACH Regulation (EC 1907/2006, 1688/2016).<br>The restriction of hazardous substances according to the RoHS Directive (2011/65/EU) is complied with. | | |
| **Functional safety**[3)] | | | |

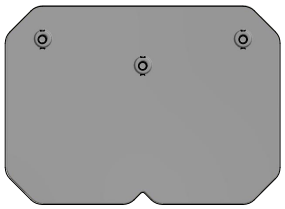
1) For more information, see → *Material Evaluation, p. 35*

2) The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

3) For more information, see → *Specifications (Functional Safety), p. 39*

# 7 Appendix

## 7.1 Accessories



Partition, ZU1471

To increase the clearances. Is installed near the input's high voltage contacts.

Jumper, ZU1474

For connection (parallel installation) of the input screw terminals of two devices. Is installed on the screwed contact.

## 7.2 Standards and Directives

The devices have been developed in compliance with the following standards and directives:

| **Directives** |
|---|
| Directive 2014/30/EU (EMC) |
| Directive 2014/35/EU (Low voltage) |
| Directive 2011/65/EU (RoHS) |
| Directive 2012/19/EU (WEEE) |
| Regulation (EC) No. 1907/2006 (REACH) |

The current standards and directives may differ from those specified here. The standards applied are documented in the Declaration of Conformity and the corresponding certificates. You can find these at www.knick.de under the corresponding product.

| **Standards** | |
|---|---|
| **Rail applications** | EN 50155, EN 50153, EN 50123-7-1, EN 50123-7-3 |
| Resistance to vibration and shock | EN 61373, IEC 61373 |
| Fire protection | EN 45545-1, EN 45545-2, EN 45545-5 |
| EMC | EN 50121-1, EN 50121-3-2, EN 50121-5 |
| Isolation requirements | EN 50124-1, UL 347A |
| Climate | EN 50125-1, EN 50125-3 |
| **Industrial applications** | EN 61010-1 |
| EMC | EN IEC 61326-1, EN 61326-3-1 |
| Functional safety (P45**1K2*** only) | EN IEC 61508 |
| Isolation requirements | EN 50178, UL 347A, EN 61010-1, EN IEC 60664-1 |
| Restriction of hazardous substances/RoHS | EN IEC 63000 |

## 7.3 Material Evaluation

The P45000 transducers with their combustible materials meet the material requirements according to EN 45545-2 when installed on the exterior of rail vehicles. These include underfloor and roof containers. In the interior of rail vehicles, the transducers must be mounted in closed and fireproof control cabinets.

The combustible materials are shown in the following list. Listed components were evaluated according to their fire characteristics and fulfill hazard level HL 3. Components not included on the list were evaluated and grouped according to Grouping Rule 1.

The components on the PCB required for the function meet the primary requirements from section 4.1 of EN 45545-2 (see section 4.7).

| Component Description | Weight in g (Approx.) | Rule/Requirement | Result | Hazard Level |
|---|---|---|---|---|
| **P45***K2*0* variant**[1)] | | | | |
| PCB | 26 | EL9/R24 | Fulfilled | HL 3 |
| Enclosure | 109 | EL10/R26 | Fulfilled | HL 3 |
| Partition | 22 | EL10/R26 | Fulfilled | HL 3 |
| Potting compound | 175 | GR1/none | Exterior | n/a |
| Base latch | 5 | GR1/none | Exterior | n/a |
| **P45***K2*1* variant**[1)] | | | | |
| PCB | 26 | EL9/R24 | Fulfilled | HL 3 |
| Enclosure | 109 | EL10/R26 | Fulfilled | HL 3 |
| Partition | 22 | EL10/R26 | Fulfilled | HL 3 |
| Cable | 150 | EL1A/R15<br>EL1B/R16 | Fulfilled<br>Fulfilled | HL 3<br>HL 3 |
| Potting compound | 175 | GR1/none | Exterior | n/a |
| Base latch | 5 | GR1/none | Exterior | n/a |
| Cable support sleeves | 4 | GR1/none | Exterior | n/a |

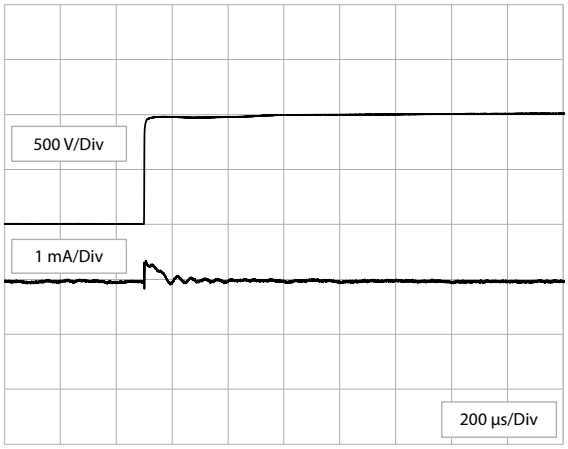
| **Legend for flammable materials list according to EN 45545-2** | |
|---|---|
| EL9 | Listed component: Printed circuit board |
| EL10 | Listed components: Electrotechnical and electronic low-voltage components |
| GR1 | Grouping Rule 1 |
| HL | Hazard level |
| n/a | Not applicable |
| R24, R26 | Sets of requirements in accordance with Table 5 Material requirements |

[1)] The individual product type can be determined from the order description, indicated on the narrow side of the product (device front), and the product key. → *Product Code, p. 7*

## 7.4 Common-Mode Response

P45000 common mode response (typical) at 1000 V step with 6 kV/µs

$U_{in,n}$ = 3000 V, $I_{out,n}$ = 50 mA, R = 100 Ω



# 8 SIL Manual (P45**1K2***)

## 8.1 General Description

High voltage transducers in the P45000 series have been developed for use in SIL-2 and SIL-3 circuits. The high voltage transducers detect certain internal faults (e.g., undervoltage, transmission failure) and set the output to a defined value as a fault response. (→ *Safety Sub-Function, p. 39*).

## 8.2 Determined Safety Characteristics

Calculation of safety-related characteristics according to IEC 61508-6. Failure rate prediction according to EN/IEC 61709 (SN 29500) for stationary continuous operation (ground benign) at an average ambient temperature of 45 °C in accordance with the environmental conditions in a typical industrial environment.
The stated values deteriorate at higher ambient temperatures.

### Single Operation

| Parameter | Characteristic | Explanation |
|---|---|---|
| Demand mode | High/continuous | High/continuous demand mode |
| Device type | Type A | |
| Operating mode | 10 ... 50 mA | |
| $\lambda_{total}$ | 486 FIT[1)] | Total failure rate |
| $\lambda_S$ | 222 FIT[1)] | Safe failure rate |
| $\lambda_D$ | 264 FIT[1)] | Dangerous failure rate |
| $\lambda_{DU}$ | 163 FIT[1)] | Dangerous undetected failure rate |
| $\lambda_{SD}$ | 222 FIT[1)] | Safe undetected failure rate |
| $\lambda_{DD}$ | 103 FIT[1)] | Dangerous detected failure rate |
| SFF | 66.63 % | Safe failure fraction |
| DC | 38.65 % | Diagnostic coverage[2)] |
| $MTTF_D$ | 235 years[3)] | Mean operating period to dangerous failure at an average operating temperature of 45 °C (113 °F) |
| SC for SIL | 2 (1oo1),<br>3 (1oo2) | Systematic capability for safety integrity level according to EN 61508 |
| MTTFD | 72 h | Mean time to restore |
| MRT | 72 h | Mean repair time |

| Probability of failure per hour | |
|---|---|
| $PFH_{1oo1}$<br>(1/h) | $1.62 \times 10^{-7}$<br>16.2 %[4)] (SIL 2) |
| $PFH_{1oo2}$<br>(1/h) | $1.62 \times 10^{-8}$<br>16.2 %[4)] (SIL 3) |

| Proof test interval | 1 year | 2 years | 3 years |
|---|---|---|---|
| $PFD_{1oo1}$ | $7.36 \times 10^{-4}$ | $1.46 \times 10^{-3}$ | $2.21 \times 10^{-3}$ |
| $PFD_{1oo2}$ | $7.36 \times 10^{-5}$ | $1.46 \times 10^{-4}$ | $2.21 \times 10^{-4}$ |

1) FIT = failure per $10^9$ hours (Failures in Time)

2) Diagnostic coverage: $DC = \lambda_{DD}/(\lambda_{DU} + \lambda_{DD})$

3) Calculation for the worst case at high or continuous requirement rate. The failure rates of the electronic components increase after an operating period of 8 to 12 years, whereby the derived PFD and PFH values will deteriorate (IEC 61508-2, Edition 2.0, 7.4.9.5, note 3).

4) Relative fraction of the permissible PFH/PFD of the safety function

**Side-by-Side Operation**

| Parameter | Characteristic | Explanation |
|---|---|---|
| Demand mode | High/continuous | High/continuous demand mode |
| Device type | Type A | |
| Operating mode | 10 … 50 mA | |
| $\lambda_{total}$ | 747 FIT[1)] | Total failure rate |
| $\lambda_S$ | 339 FIT[1)] | Safe failure rate |
| $\lambda_D$ | 409 FIT[1)] | Dangerous failure rate |
| $\lambda_{DU}$ | 248 FIT[1)] | Dangerous undetected failure rate |
| $\lambda_{SD}$ | 339 FIT[1)] | Safe undetected failure rate |
| $\lambda_{DD}$ | 161 FIT[1)] | Dangerous detected failure rate |
| SFF | 67 % | Safe failure fraction |
| DC | 39 % | Diagnostic coverage[2)] |
| $MTTF_D$ | 153 years[3)] | Mean operating period to dangerous failure at an average operating temperature of 45 °C (113 °F) |
| SC for SIL | 2 (1oo1),<br>3 (1oo2) | Systematic capability for safety integrity level according to EN 61508 |
| MTTFD | 72 h | Mean time to restore |
| MRT | 72 h | Mean repair time |

| Probability of failure per hour | |
|---|---|
| $PFH_{1oo1}$<br>(1/h) | $2.48 \times 10^{-7}$<br>24.8 %[4)] (SIL 2) |
| $PFH_{1oo2}$<br>(1/h) | $2.48 \times 10^{-8}$<br>24.8 %[4)] (SIL 3) |

| Proof test interval | 1 year | 2 years | 3 years |
|---|---|---|---|
| $PFD_{1oo1}$ | $1.13 \times 10^{-3}$ | $2.25 \times 10^{-3}$ | $3.39 \times 10^{-3}$ |
| $PFD_{1oo2}$ | $1.13 \times 10^{-4}$ | $2.25 \times 10^{-4}$ | $3.4 \times 10^{-4}$ |

## 8.3 Scope

This chapter is valid for high voltage transducers in the P45000 series that were ordered with the option "with SIL suitability". Whether a device is available with SIL suitability can be learned from the product code. The defined safety sub-function of the devices exists for the input signal range 10 … 50 mA (P45*11K2***). The high voltage transducers in the P45000 series from Knick Elektronische Messgeräte GmbH & Co. KG are certified by TÜV Rheinland Industrie Service GmbH.
→ *Product Code, p. 7*

## 8.4 Applicable Standards

The high voltage transducers can be used in safety-related applications up to SIL 2, with redundant operation up to SIL 3 (systematic suitability). The standards relevant to the intended use, such as EN 61508, must be applied.

1) FIT = failure per $10^9$ hours (Failures in Time)

2) Diagnostic coverage: DC = $\lambda_{DD}/(\lambda_{DU} + \lambda_{DD})$

3) Calculation for the worst case at high or continuous requirement rate. The failure rates of the electronic components increase after an operating period of 8 to 12 years, whereby the derived PFD and PFH values will deteriorate (IEC 61508-2, Edition 2.0, 7.4.9.5, note 3).

4) Relative fraction of the permissible PFH/PFD of the safety function

## 8.5 Safety Sub-Function

The high voltage transducer is used to measure a voltage, taking into account functional safety criteria. The voltage signal at the input is galvanically isolated and converted into a 10 ... 50 mA output signal. The input signals are transmitted linearly with the specified characteristics. The error signal is defined for the range of < 9 mA. This makes it possible to realize a safety sub-function, e.g., auto-off, when a threshold value is exceeded. For this purpose, the analog output signal must be filtered and evaluated. Low-pass filtering with $f_{-3dB} \leq 200$ Hz can be either analog or digital. In the case of double-channel, redundant use (1oo2), a comparison of values must be carried out and a safe state must be established when a tolerance is exceeded.

## 8.6 Signal Level for Measuring Signal and Failure Information

| Information | Signal Level |
|---|---|
| Measuring signal | 10 ... 50 mA |
| Failure information (error) | < 9 mA |

## 8.7 Maintenance and Repair

The devices are maintenance-free. The customer may request that the devices be recalibrated or adjusted at the factory. The electronics cannot be repaired, as the devices are potted.

## 8.8 Proof Test

The proof test is used to detect failures in a safety-related system. The correct functioning of the high voltage transducer must therefore be checked at appropriate intervals. The test intervals are determined, for example, when calculating each individual safety circuit of a plant (PFD values). The test is to be conducted in such a way that the proper functioning of the safety sub-function is proven by the interaction of all components.

### Checking the Function

1. Specify setpoints for the start-of-scale and full scale values, as well as an average value (e.g., 50 % value).
2. Check whether the measurement error is within the specified tolerances.

If the functional test proves negative, the high voltage transducer must be taken out of service and the process must be kept safe using other measures.

## 8.9 Specifications (Functional Safety)

| Specifications (functional safety) | |
|---|---|
| Interference immunity requirements for safety-related systems EN 61326-3-1:2017 | |
| Reinforced insulation between input and output. Operate the device in such a way that the reinforced insulation is ensured. → *Isolation, p. 27* | |
| Signal transmission within specifications | |
| Single operation | SIL 2 (2 ) (HFT = 0) |
| Redundant operation (1oo2 configuration) | SIL 2 (SC 2), SIL 3 (SC 3) (HFT = 1) |
| Cutoff frequency of the low-pass filter provided | $f_{-3dB} \leq 200$ Hz |

# 9 Abbreviations

| | |
|---|---|
| 1oo1 | 1 out of 1 |
| 1oo2 | 1 out of 2 |
| A1/AX | Height class |
| EMC | Electromagnetic compatibility |
| H1 | Class of rapid temperature changes |
| HFT | Hardware fault tolerance |
| HL3 | Fire protection class according to EN 45545-2 |
| $HV_+$ | Positive potential of the high voltage |
| $HV_-$ | Negative potential of the high voltage |
| $I_{out}$ | Output current |
| $I_{out,failure}$ | Output current for error signaling (fail-safe mode) |
| $I_{out,max}$ | Maximum permissible output current |
| IPxx | Ingress protection, protection class against contact and ingress of foreign bodies and liquid |
| MSL | Mean sea level (MSL) |
| MTBF | Mean time between failures |
| MTTF | Mean time to failure |
| n.c. | Not connected |
| OT | Operating temperature class |
| OV | Overvoltage category |
| PD | Pollution degree |
| PFH | Probability of failure per hour |
| $Pwr_+$ | Power+, positive supply voltage |
| $Pwr_-$ | Power-, negative supply voltage |
| $R_{in}$ | Input resistance |
| $R_M$ | Load resistance |
| SC | Systematic capability |
| SIL | Safety integrity level |
| ST | Switch-on extended operating temperature |
| $U_{HE}$ | Supply voltage of the device (power supply) |
| $U_{in}$ | Nominal input voltage range |
| $U_{out}$ | Output voltage |
| WEEE | Waste from electrical and electronic equipment |

# Index


## A

Accessories 34
Ambient conditions 32
Applications 5

## B

Block diagram 12

## C

Characteristics, functional safety 37
Clearance and creepage distances 30
Commissioning 19
Common-mode rejection ratio 27
Connecting tubing 16
Connection terminals 13

## D

Design 9, 33
Dimension drawings 20
Dimension specifications 20
Dimensions 20
Directives 34
Disposal 19

## E

Electric shocks, avoiding 6
Electromagnetic compatibility 33
Environmental damage 5
Environmental factors 6
External dimensions 20

## F

Fields of application 5
Fire protection 33
Fires, avoiding 6
Function 12
Functional test 39

## G

Galvanic isolation 27

## H

Hazardous substances, waste disposal 33
Height class 32
Holes 21
Housing 33

## I

Industrial standards 34
Input 16, 25
Installation 14
Intended use 5
Introductory safety chapter 2
Isolation 27

## L

Live zero function 12
Load
- Dimensioning 22
- Maximum 22
- Minimum 23

## M

Maintenance 19
Markings 8
Material evaluation 35
Measuring function 12
Model designation 7
- Coding 7

Mounting 14

## N

Nameplate 8
Notes on safety information 2

## O

Operation 19
Options 9
Order code 7
Output 16

## P

Package contents 7
Personnel 5
Personnel requirements 5
Pollution degree 27, 32
Power supply 16, 27
Product code 7
- Example 7

Proof test, functional safety 39
Property damage 5
Push-in terminal 13

## Q

Qualified personnel 5

## R

Rail standards 34
Repair 19
- SIL 39

Residual risks 6
Returns 19
Reverse polarity protection, power supply 16
Risk assessment 6
RoHS 34
Routine test, isolation 27

## S

Safety chapter 5
Safety function, SIL 39
Safety instructions 2

Side-by-side operation
    Minimum load 24
    SIL 38
Standards 34
Standards, functional safety 38
Supplemental directives 2
Supply voltage 27
Symbols and markings 8

## T


Temperature class 32
Terminal assignments 13
Terminals 13
Troubleshooting 19
Tubing 16
Two-tier terminal 13
Type designation 7
Type test, isolation 27


## V


Variants 9
Versions 7


## W


Warnings 2

**Knick**
**Elektronische Messgeräte**
**GmbH & Co. KG**

**Headquarters**
Beuckestraße 22 • 14163 Berlin
Germany
Phone: +49 30 80191-0
Fax: +49 30 80191-200
info@knick.de
www.knick.de

**Local Contacts**
www.knick-international.com

Translation of the original instructions

Version 2 • This document was published on July 17, 2023.
The latest documents are available for download on our website under the corresponding product description.

TA-257.500-KNEN02

101055