

Safety mats SM and SM11



EN | Product information

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Table of contents

Definitions	3
Pressure-sensitive protective device	3
Operation principle of 2-wire-technology	4
Operation principle of 4-wire-technology	6
Safety.....	7
Intended use	7
Limits	7
Exclusions	7
Selecting the appropriate product line	8
Other safety aspects	8
Design	9
Design of the SM	9
Design of the SM11	9
Available sizes	9
Effective actuation area	10
Connection	11
Cable exit.....	11
Cable connection	11
Wire colours.....	13
Connection examples	13
Sensor surface.....	14
Sensor surface of the SM.....	14
Sensor surface of the SM11	15
Resistance	15
Mounting.....	17
Overview of fixing materials.....	17
Fixing the SM with GM 1	18
Fixing the SM with GM 5.....	20
Fixing the SM11	21
Calculation of the necessary actuation area	23
Calculation examples	23
Customised designs.....	24
Special shapes.....	24
Special versions.....	24
Maintenance and cleaning.....	24
Technical data.....	25
Conformity	26

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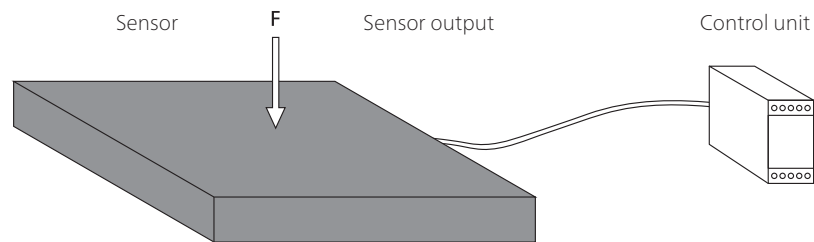
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Definitions

Pressure-sensitive protective device

A pressure-sensitive protective device consists of one or more pressure-sensitive sensors, a signal processing unit, and one or more output signal switching devices. The control unit is made up of the signal processing unit and output signal switching device(s). The pressure-sensitive protective device is triggered when the sensor is activated.

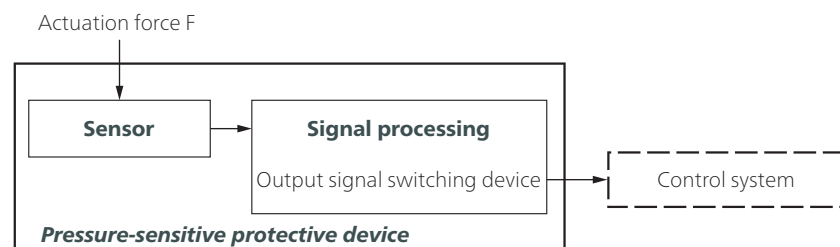


Sensor

The sensor is the part of the pressure-sensitive protective device that generates a signal when the actuation force F is applied. Mayser safety systems feature a sensor whose actuation area is deformed locally.

Signal processing

The signal processing unit is the part of the pressure-sensitive protective device that converts the output signal of the sensor and controls the status of the output signal switching device. The output signal switching device is the part of the signal processing unit which is connected to the downstream control system and which transmits safety output signals such as STOP.

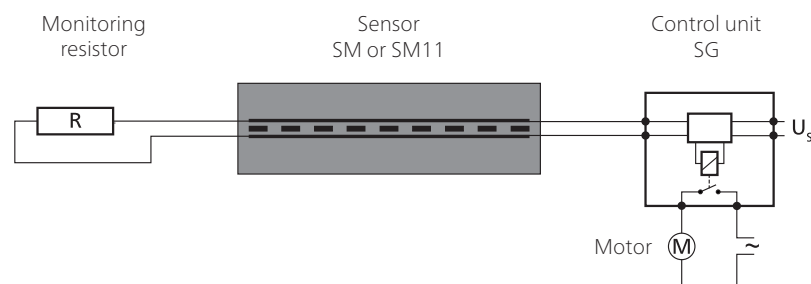


Tip: Terms are defined in ISO 13856-1 Section 3.

Criteria for selecting the sensor type

- Category according to ISO 13849-1
- Performance level of the pressure-sensitive protective device = at least PL_r
- Temperature range
- Degree of protection in accordance with IEC 60529:
IP65 is the standard for safety mats.
Higher degrees of protection must be checked individually.
- Environmental influences such as swarf, oil, coolant, outdoor use...
- Is it necessary to detect people who weigh < 35 kg?

Operation principle of 2-wire technology



The monitoring resistor must be compatible with the control unit. The standard type is 8k2.

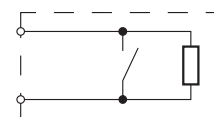
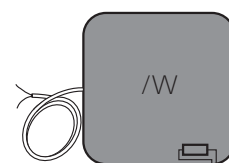
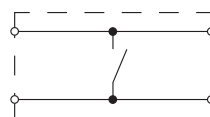
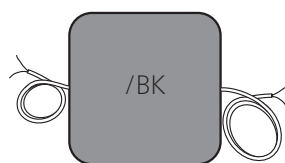
For your safety:

The sensor and connection cables are constantly monitored to ensure they are functioning correctly. Monitoring relies on controlled bridging of the contact surfaces with a monitoring resistor (closed-circuit principle).

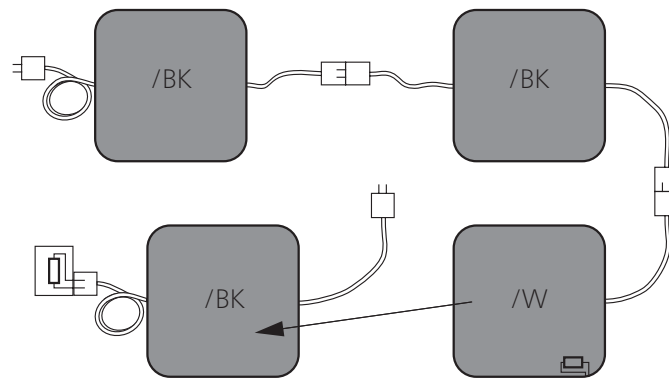
Types

/BK With cables on both sides for use as a through sensor or with an external monitoring resistor for use as an end sensor

/W With an integrated monitoring resistor for use as an end sensor



Sensor combination

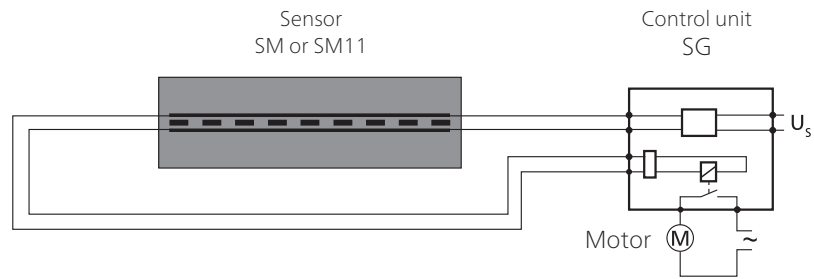


Version with external resistor, therefore
no variety of models

Combination:

- Connection of more than one sensor
- Only one control unit required
- Safety mats can be combined to create an overall surface of any size and shape

Operation principle of 4-wire technology



The 4-wire technology can only be used together with control unit SG-EFS 104/4L.

For your safety:

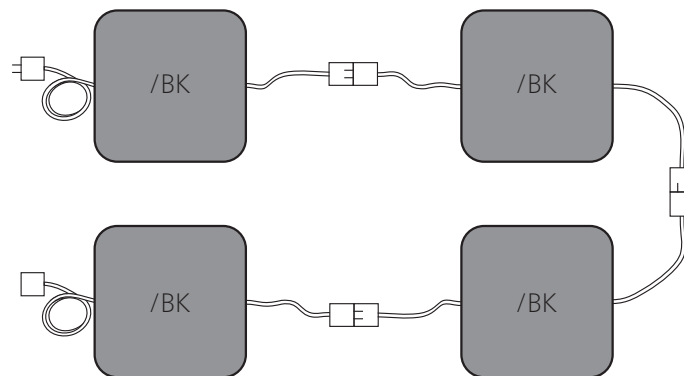
The sensor and connection cables are constantly monitored to ensure they are functioning correctly. Monitoring relies on signal transmission feedback – without a monitoring resistor.

Types

/BK With cables on both sides for use as a through sensor



Sensor combination



Combination:

- Connection of more than one sensor
- Only one control unit required
- Safety mats can be combined to create an overall surface of any size and shape

Safety

Intended use

A safety mat detects a person standing on it or who steps onto it. It is a flat protective device that is capable of monitoring when somebody is present. Its purpose is to prevent possible hazardous situations for personnel within a danger zone.

Typical areas of application are moving parts on machines and systems.

Safe operation of a safety mat depends entirely on

- the surface condition of the mounting surface,
- the correct selection of the size and resistance rating as well as
- correct installation.

Tip: This is illustrated clearly by Figures B.1 and B.2 in ISO 13856-1.

Due to the design, the actuation area is actually smaller than it looks because of the non-sensitive edges. Once these have been allowed for, what remains is the effective actuation area (see chapter *Effective actuation area*).

Limits

- No more than 10 /BK-type sensors can be connected to one control unit.
- No more than 9 /BK-type sensors and 1 /W-type sensor can be connected to one control unit.
- Max. system size: 15 m²
= max. quantity × max. sensor size

Exclusions

Sensors are not suitable for:

- Detecting walking aids
- Detecting people who weigh less than 20 kg
- Driving on with industrial trucks

Sensor SM with GM 5 is not suitable for:

- Detecting people who weigh less than 35 kg

Sensor combinations are not suitable for:

- Detecting people who weigh less than 35 kg

Selecting the appropriate product line

The size and shape of safety mats can be customised to create a bespoke solution. SM safety mats are highly resistant to environmental influences and normal chemical influences.

If your sensor requirements are lower, our SM11 or SM8 safety mat products may be right for you.

Other safety aspects

The following safety aspects relate to pressure-sensitive protective devices consisting of a sensor and a control unit.

Performance Level (PL)

The PL has been determined using the procedure defined by ISO 13849-1.

Fault exclusion according to ISO 13849-2 Table D.8: Non-closing of contacts in the case of pressure-sensitive protective devices according to ISO 13856. In this case, the diagnostic coverage (DC) is not calculated or taken into account when determining the PL. Assuming a high $MTTF_D$ value for the control unit, a performance level of up to PL d can be achieved by the safety mat system (pressure-sensitive protective device) as a whole.

Is the protective device suitable?

First, the integrator must decide what PL_r is required for the hazard. After that, they must select the protective device.

Finally, the integrator needs to check whether the category and PL of the selected protective device are appropriate.

Risk and safety assessment

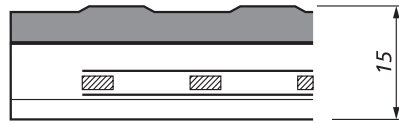
For the risk and safety assessment of your machine, we recommend ISO 12100 "Safety of machinery — General principles for design".

Without reset function

When a protective device without reset function is used (automatic reset), the reset function must be provided in some other way.

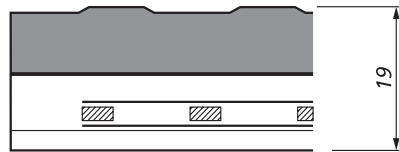
Design

Design of the SM



SM with GM 1

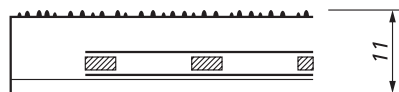
Moulded onto a plastic plate.
The rubber studded covering provides the necessary non-slip properties and ensures mechanical protection.



SM with GM 5

Moulded onto a plastic plate.
The high-strength rubber studded covering provides the necessary non-slip properties and ensures a high level of mechanical protection.

Design of the SM11

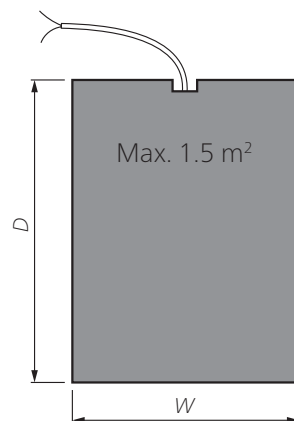


SM11

Moulded onto a plastic plate.
The surface texture provides the necessary non-slip properties and ensures mechanical protection.

Available sizes

Sensors are available up to a max. size of 1.5 m².
The side lengths must be within a range of 200 to 3000 mm.



W: Width (broad side)

D: Depth (long side)

$$W \times D \leq 1.5 \text{ m}^2$$

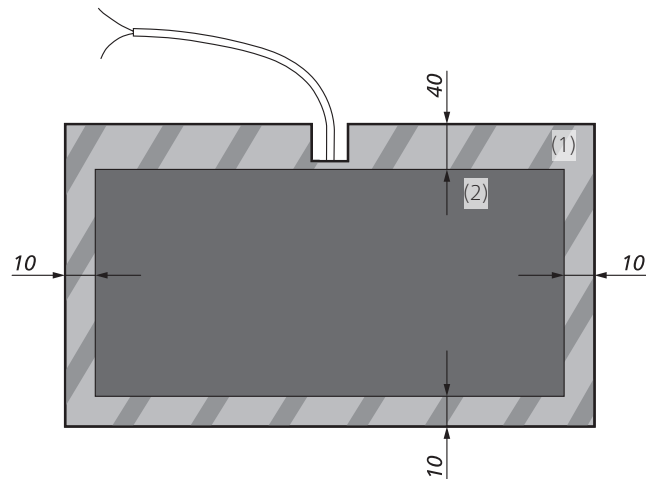
The cable exit can be on the broad or long side.

According to ISO 13855, the minimum depth to the danger zone must be taken into account (see chapter *Calculation of the necessary actuation area*).
The non-sensitive edges must be taken into account (see chapter *Effective actuation area*).

Effective actuation area

A non-sensitive edge (1) surrounds the effective actuation area (2):

- 40 mm = on the cable exit side
- 10 mm = on the remaining sides



Sensor combinations

When sensor combinations are used:

- Only the sides with 10 mm edges should be placed next to one another.
- Each side is only allowed to touch one other sensor.

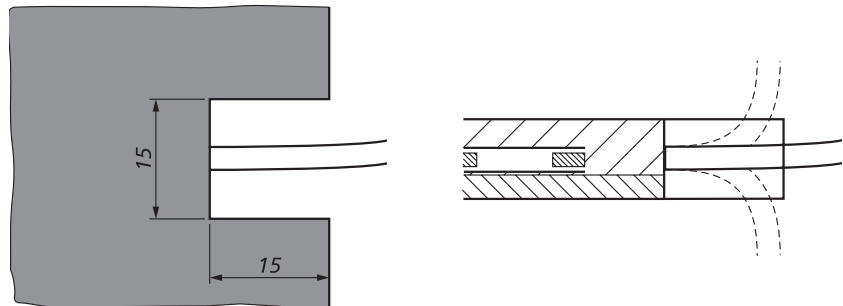
Connection

Cable exit

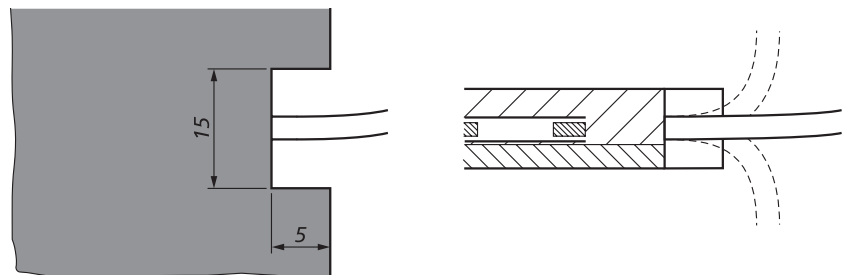
The multifunction cut-out also allows the cable to be laid so that it exits upwards or downwards.

The cable exit is located in the middle of the side.

SM cable exit

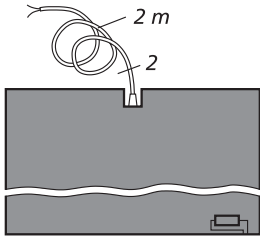
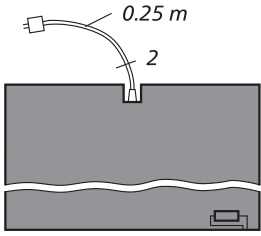
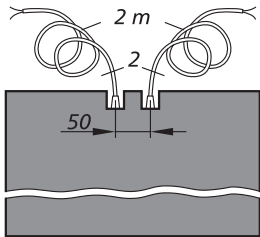
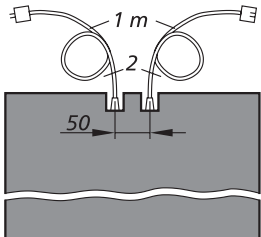
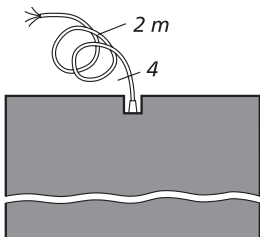
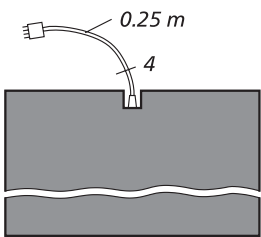


SM11 cable exit



Cable connection

- Standard cable lengths
 $L = 2.0 \text{ m}$
- Maximum total cable length to the control unit
 $L_{\text{max}} = 100 \text{ m}$

Without plug (standard)	With plug (M8)
<ul style="list-style-type: none">• Suitable for universal use• Variable cable length	<ul style="list-style-type: none">• Service-friendly• Easy assembly• Secure connection• Watertight plug connection
/W-type sensor with 1 line	
	
<ul style="list-style-type: none">• As an individual /W-type sensor or a /W-type end sensor• Integrated resistor• 1 two-wire cable	
/BK-type sensor with 2 lines	
	
<ul style="list-style-type: none">• As a /BK-type through sensor• Without resistor• 2 two-wire cables	
/BK-type sensor with 1 line	
	
<ul style="list-style-type: none">• As a /BK-type through sensor• Without resistor• 1 four-wire cable	

Wire colours

Colour coding

- BK Black
- BN Brown
- BU Blue
- RD Red
- WH White

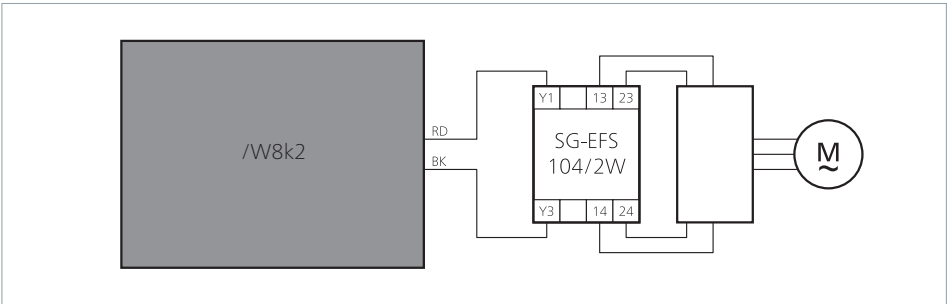
Without plug (standard)	With plug (M8)
/W-type sensor with 1 line	
/BK-type sensor with 2 lines	
/BK-type sensor with 1 line	

Connection examples

- Key:
- /W8k2 Sensor for 2-wire technology with resistor 8k2
 - /BK Sensor for 4-wire technology
 - M Motor

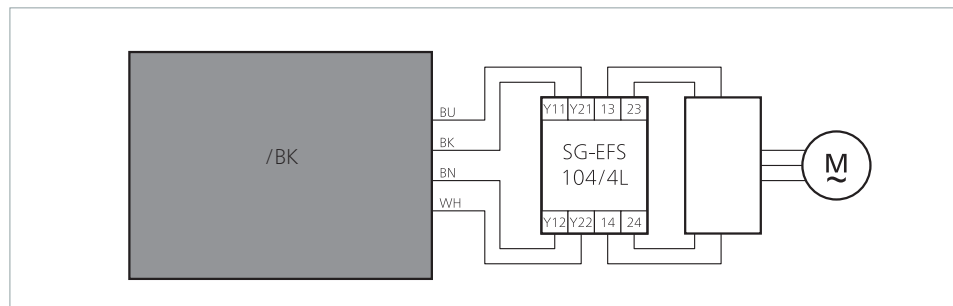
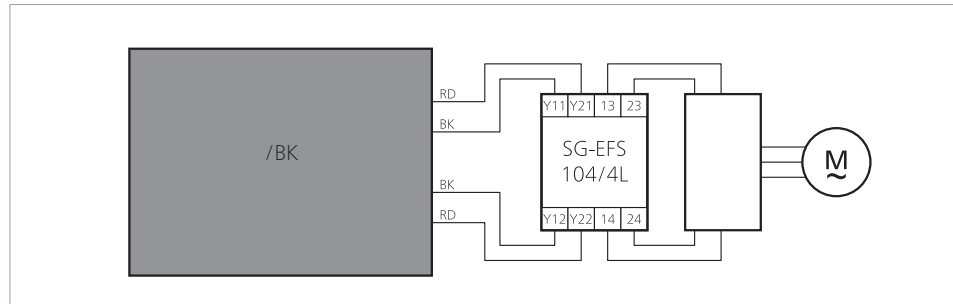
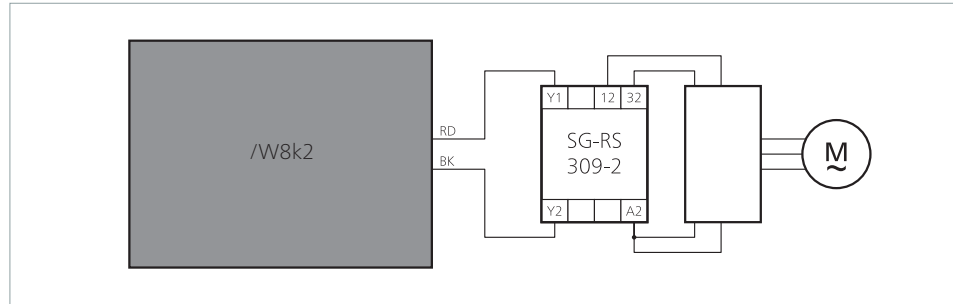
Colour coding

- BK Black
- RD Red



Colour coding

BK	Black
BN	Brown
BU	Blue
RD	Red
WH	White



Sensor surface

Sensor surface of the SM

The rubber studded covering is glued in place at the factory. It provides the necessary non-slip properties and ensures mechanical protection.

GM 1

Black covering with circular studs

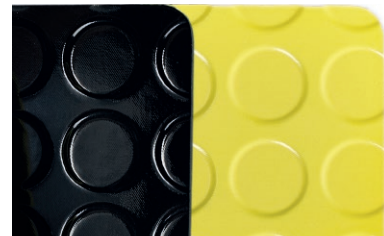
Yellow covering with circular studs

Material: NBR

Thickness: 4.5 mm ± 0.5

Max. size: 1.0 m × 10 m

1.2 m × 10 m



GM 5

Green covering with circular studs
With high mechanical strength
Material: NBR
Thickness: 9 mm ± 0.5
Max. size: 1.2 m \times 10 m

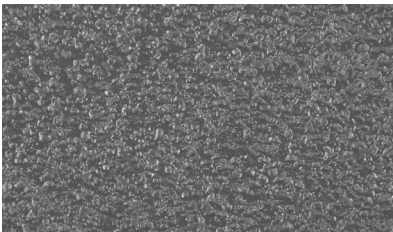


Sensor surface of the SM11

The rough surface texture is applied at the factory. It provides the necessary non-slip properties and ensures mechanical protection.

Surface texture

Grey
Material: PUR
Thickness: 1.0 mm



Resistance

The resistance ratings listed below (at a room temperature of 23 °C) depend on the sensor having:

- A rubber studded covering that is bonded face to face with the sensor (SM only)
- An undamaged surface (SM and SM11)

Physical resistance

	NBR (SM)	PUR (SM11)
DIN 53516: Abrasion	120 mg	< 150 mg
DIN 4102: Fire behaviour	B2	B2
Alternating climate stress conditions	+	+
UV resistance	\pm	+

Explanation of symbols:

- + = resistant
- \pm = resistant to a certain extent
- = not resistant

Chemical resistance

The sensor is resistant to a certain extent to normal chemical influences such as diluted acids and alkalis, as well as alcohol, over an exposure period of 24 hrs.

The values in the table are the results of tests carried out in our laboratory. You must always conduct your own practical tests to verify that our products are suitable for your specific area of application.

Explanation of symbols:

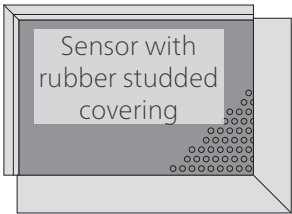
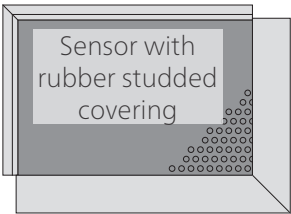
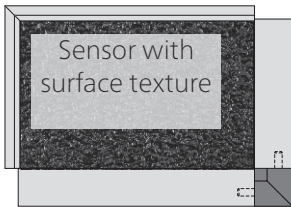
- + = resistant
- ± = resistant to a certain extent
- = not resistant

	NBR (SM)	PUR (SM11)
Acetone	+	–
Ammonia	+	+
Brake fluid	±	
Cutting emulsion	±	+
Acetic acid	±	
Greases	+	–
Caustic potash solution	+	
Cooling lubricant	+	±
Metal working oil	+	+
Methyl alcohol	±	–
Sodium hydroxide	+	
Cellulose thinner	±	–
Hydrochloric acid 10%	+	±
Suds	+	
Spirit (ethyl alcohol)	+	–
Water	+	+
Petroleum ether / petrol	+	–
Citric acid	+	
Drawing compound	±	–

Mounting

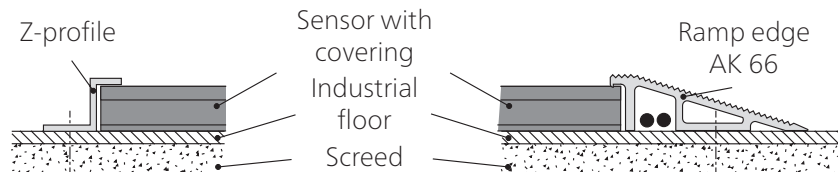
The sensors must be mounted immediately in front of the danger zone. They must be fixed in place using ramp edges, Z-profiles or cable conduits (optional), which must be screwed to the floor. Ramp edges are required on the access sides to minimise the risk of tripping.

Overview of fixing materials

SM with GM 1	SM with GM 5	SM11
Overall height 15 mm	Overall height 19 mm	Overall height 11 mm
Z-profile (machine side)	Z/1 profile (machine side)	Z/2-profile or AP 45 cable conduit (machine side)
		
Ramp edge AK 66 or AK 105 (access side)	Ramp edge AK 105/1 (access side)	Ramp edge AK 56 (access side)
Other fixing materials		
Sealing plug	–	Outer corner connector E1 AK 56
		Connecting wedge Vk AK 56
		Inner corner connector E2 AK 56

Fixing the SM with GM 1

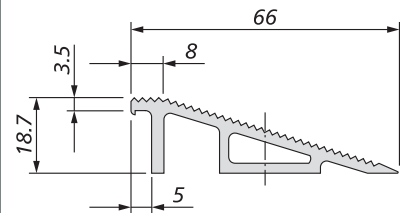
Ramp edge AK 66 with Z-profile



- Not suitable for plug-in cable connections
- Cable conduit for max. 2 cables

Aluminium ramp edge AK 66

- 1-piece with cable conduit
- For sensor combinations with up to 2 sensors
- Sensor without plug
- Aluminium ramp edge for sensors with GM 1
- Rod 3 m (7500053), rod 6 m (1000008) or fixed length

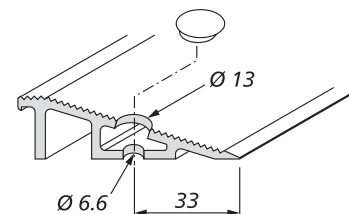


Stepped hole for AK 66

- For fixing aluminium ramp edge AK 66

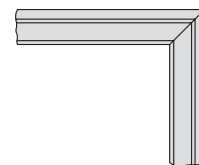
Sealing plug

- Seals the stepped hole (1000615)



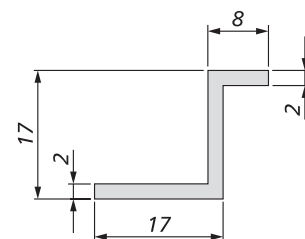
Mitre cut

- For corner connections

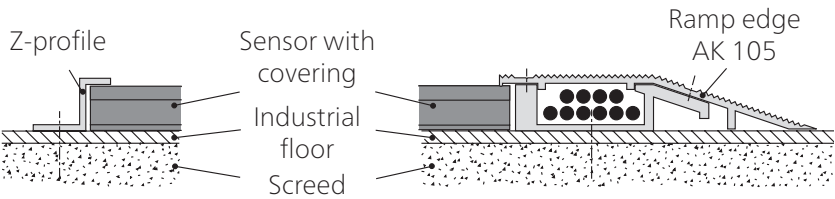


Aluminium Z-profile

- Edging at the machine or wall side
- Aluminium Z-profile for sensors with GM 1
- Aluminium Z-profile: Rod 3 m (7500054), rod 6 m (1000011) or fixed length



Ramp edge AK 105 with Z-profile

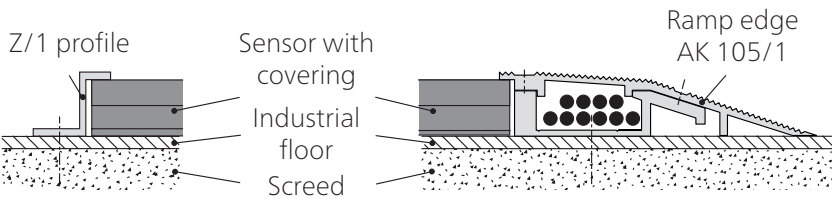


- Suitable for plug-in cable connections
- Cable conduit for max. 10 cables

<p>Aluminium ramp edge AK 105</p> <ul style="list-style-type: none">• 2-piece with cable conduit• For sensor combinations• Sensors with or without plugs• Aluminium ramp edge AK 105 for sensors with GM 1• Aluminium ramp edge AK 105: Rod 3 m upper and lower sections (7500052), rod 6 m upper section (1000009), rod 6 m lower section (1000010), or fixed length	
<p>Mitre cut</p> <ul style="list-style-type: none">• For corner connections	
<p>Aluminium Z-profile</p> <ul style="list-style-type: none">• Edging at the machine or wall side• Aluminium Z-profile for sensors with GM 1• Aluminium Z-profile: Rod 3 m (7500054), rod 6 m (1000011) or fixed length	

Fixing the SM with GM 5

Ramp edge AK 105/1 with Z/1-profile



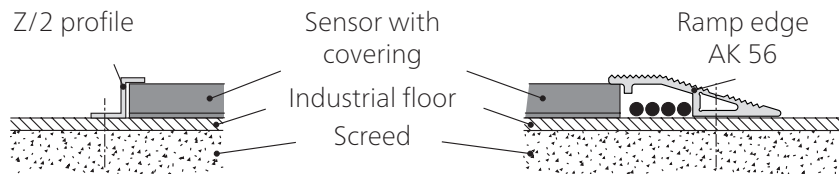
- Suitable for plug-in cable connections
- Cable conduit for max. 10 cables

Ramp edge AK 105/1 and Z/1-profile only suitable for sensors with GM 5.

<p>Aluminium ramp edge AK 105/1</p> <ul style="list-style-type: none">• 2-piece with cable conduit• For sensor combinations• Sensors with or without plugs• Aluminium ramp edge AK 105/1 for sensors with GM 5• Aluminium ramp edge AK 105/1: Rod 3 m upper and lower sections (7500224), rod 6 m upper section (1000992), rod 6 m lower section (1000010), or fixed length	
<p>Mitre cut</p> <ul style="list-style-type: none">• For corner connections	
<p>Aluminium Z/1-profile</p> <ul style="list-style-type: none">• Edging at the machine or wall side• Aluminium Z/1-profile for sensors with GM 5• Aluminium Z/1-profile: Rod 3 m (7500738), rod 6 m (1001478) or fixed length	

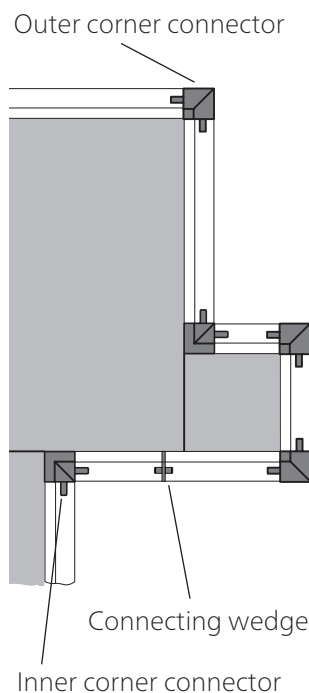
Fixing the SM11

Ramp edge AK 56 with Z/2-profile



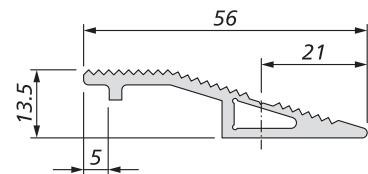
- Not suitable for plug-in cable connections
- Cable conduit for max. 4 cables

Example:



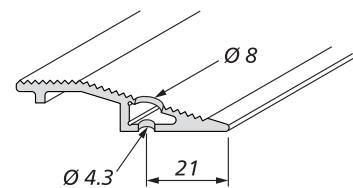
Aluminium ramp edge AK 56

- 1-piece with cable conduit
- For sensor combinations
- Sensors with or without plugs
- Rod 3 m (7501014), rod 6 m (1002684) or fixed length



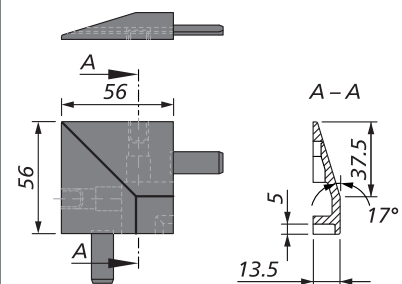
Stepped hole for AK 56

- For fixing ramp edge AK 56



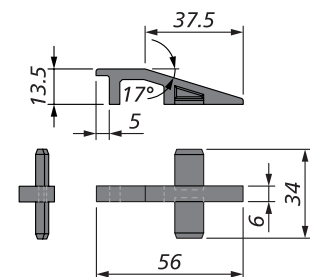
Outer corner connector E1 AK 56

- For connecting the corners of ramp edge AK 56
- Material: Black plastic (1002751)



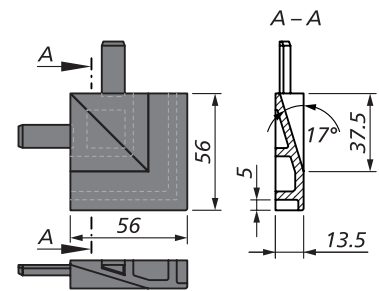
Connecting wedge Vk AK 56

- For connecting several ramp edges AK 56 lengthwise
- Material: Black plastic (1002996)



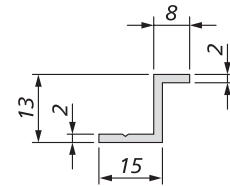
Inner corner connector E2 AK 56

- For connecting the corners of ramp edge AK 56
- Material: Black plastic (1002752)



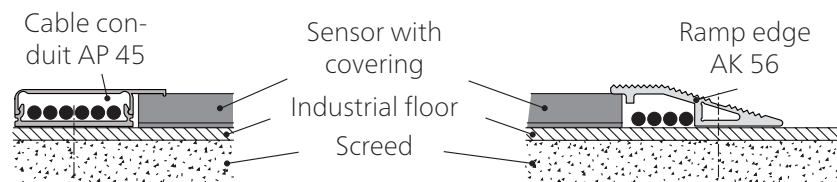
Aluminium Z/2-profile

- Edging at the machine or wall side
- Rod 3 m (7500385), rod 6 m (1001666) or fixed length



Optional: Ramp edge AK 56 with cable conduit AP 45

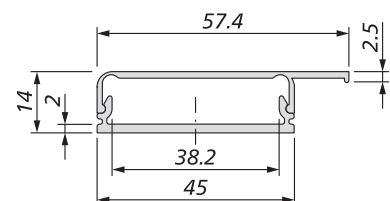
Instead of using a Z/2 profile, you can also use cable conduit AP 45 to fix the sensor in place.



- Cable conduit AP 45 instead of Z/2-profile
- Suitable for plug-in cable connections
- Cable conduit AP 45 for max. 6 cables

Aluminium cable conduit AP 45

- 2-piece cable conduit
- For sensor combinations
- Sensors with or without plugs
- Upper section is clipped into lower section
- Rod 3 m upper section (1002546), rod 3 m lower section (1002547) or fixed length upper and lower sections



Calculation of the necessary actuation area

According to ISO 13855, the effective actuation area that is required with reference to the danger zone is calculated using the following formula:

S = Minimum distance between the danger zone and the furthest edge of the sensor [mm]

K = Approximation parameter [mm/s]

T = Follow-through of the complete system [s]

t₁ = Response time of the protective device

t₂ = Stopping time of the machine

C = Safety margin [mm]

H = Step height [mm]

$$S = (K \times T) + C \quad \text{where:} \quad \begin{aligned} K &= 1600 \text{ mm/s} \\ T &= t_1 + t_2 \\ C &= 1200 \text{ mm} - 0.4H \end{aligned}$$

With installation at floor level

H = 0; thus:

$$S = (1600 \text{ mm/s} \times T) + 1200 \text{ mm}$$

With installation on a step

H ≠ 0; thus:

$$S = (1600 \text{ mm/s} \times T) + (1200 \text{ mm} - 0.4H)$$

Calculation examples

Calculation example 1

A safety mat detects when someone inadvertently accesses the danger zone of an automated movement. The mat is installed at floor level, i.e. H = 0.

The follow-through time of the movement is 300 ms, the response time of the protective device is 18 ms.

$$\begin{aligned} S &= (1600 \text{ mm/s} \times (300 \text{ ms} + 18 \text{ ms})) + 1200 \text{ mm} \\ S &= (1600 \text{ mm/s} \times 0.318 \text{ s}) + 1200 \text{ mm} \\ S &= 509 \text{ mm} + 1200 \text{ mm} \\ S &= 1709 \text{ mm} \end{aligned}$$

Calculation example 2

The same conditions as Example 1, except that there is a step with a height of 150 mm leading up to the danger zone that has to be dealt with.

$$\begin{aligned} S &= (1600 \text{ mm/s} \times (300 \text{ ms} + 18 \text{ ms})) + (1200 - (0.4 \times 150)) \text{ mm} \\ S &= (1600 \text{ mm/s} \times 0.318 \text{ s}) + (1200 - 60) \text{ mm} \\ S &= 509 \text{ mm} + 1140 \text{ mm} \\ S &= 1649 \text{ mm} \end{aligned}$$

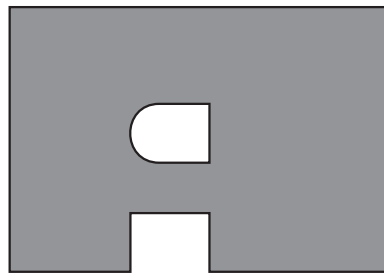
Customised designs

Special shapes



e.g. different corner shapes

Different shapes such as circles, circle segments, trapeziums etc. are possible.



e.g. cut-outs

Mats can be ready-manufactured with cut-outs, e.g. for machine feet, switch cabinets, and so on.

Special versions

Special versions are available for particular ambient conditions, e.g. aggressive substances (fuels, solvents etc.).

Maintenance and cleaning

The sensors are virtually maintenance-free.

The control unit also monitors the sensor at the same time.

Regular inspection

Depending on the operational demands, the sensors must be inspected at regular intervals (at least monthly)

- for proper functioning,
- for damage and
- for correct fixing.

Cleaning

If the sensors become dirty, they can be cleaned with a mild cleaning product.

Technical data

	Safety mat SM/W or SM11/W with control unit SG-EFS 104/2W	Safety mat SM/BK or SM11/BK with control unit SG-EFS 104/4L	Sensor* SM/W, SM/BK or SM11/W, SM11/BK (without control unit)
Testing basis	ISO 13849-1, ISO 13856-1		ISO 13856-1
Switching characteristics at $v_{\text{test}} = 250 \text{ mm/s}$			
Switching operations at 0.1 A	$> 4 \times 10^6$	$> 4 \times 10^6$	$> 4 \times 10^6$
Actuation forces			
Test piece (cylinder) Ø 11 mm	$< 300 \text{ N}$	$< 300 \text{ N}$	$< 300 \text{ N}$
Test piece (cylinder) Ø 80 mm	$< 300 \text{ N}$	$< 300 \text{ N}$	$< 300 \text{ N}$
Test piece (cylinder) Ø 200 mm	$< 600 \text{ N}$	$< 600 \text{ N}$	$< 600 \text{ N}$
Response time	23 ms	DC: 38 ms	8 ms
Safety classifications			
ISO 13856: reset function	With/without	With/without	–
ISO 13849-1:2015	Category 3 PL d	Category 3 PL d	Category 1
MTTF _D (pressure-sensitive protective device)	257 a	100 a	–
B _{10D} (sensor)	6×10^6	6×10^6	6×10^6
n _{op} (assumption)	52560/a	52560/a	–
Mechanical operating conditions			
Sensor size	Max. 1.5 m ²	Max. 1.5 m ²	Max. 1.5 m ²
Side length (min./max.)	200 mm / 3000 mm	200 mm / 3000 mm	200 mm / 3000 mm
Cable length (min./max.)	10 cm / 100 m	10 cm / 100 m	10 cm / 100 m
Static load (up to 8 h)			
SM with GM 1	Max. 800 N/cm ²	Max. 800 N/cm ²	Max. 800 N/cm ²
SM with GM 5	Max. 1200 N/cm ²	Max. 1200 N/cm ²	Max. 1200 N/cm ²
SM11	Max. 800 N/cm ²	Max. 800 N/cm ²	Max. 800 N/cm ²
Driving on with industrial trucks	Not suitable	Not suitable	Not suitable
Tensile load, cable (max.)	100 N	100 N	100 N
IEC 60529: degree of protection			
Sensor	IP65	IP65	IP65
Control unit	IP20	–	–
Max. humidity (23 °C)	95% (non-condensing)	95% (non-condensing)	95% (non-condensing)
Operating temperature			
Individual sensor SM	–5 to +55 °C	–5 to +55 °C	–5 to +55 °C
Individual sensor SM11	–20 to +55 °C	–20 to +55 °C	–20 to +55 °C
Sensor combination	+5 to +55 °C	+5 to +55 °C	+5 to +55 °C
Storage temperature	–20 to +55 °C	–20 to +55 °C	–20 to +55 °C
Weight			
SM with GM 1	17.3 kg/m ² (without control unit)	17.3 kg/m ²	17.3 kg/m ²
SM with GM 5	23.9 kg/m ² (without control unit)	23.9 kg/m ²	23.9 kg/m ²
SM11	12.0 kg/m ² (without control unit)	12.0 kg/m ²	12.0 kg/m ²

* See footnote on page 26.

	Safety mat SM/W or SM11/W with control unit SG-EFS 104/2W	Safety mat SM/BK or SM11/BK with control unit SG-EFS 104/4L	Sensor* SM/W, SM/BK or SM11/W, SM11/BK (without control unit)
Electrical operating conditions			
Connection cable	Ø 5.0 mm PVC 2× 0.5 mm ²	Ø 5.0 mm PVC 2× 0.5 mm ² or 4× 0.34 mm ²	Ø 5.0 mm PVC 2× 0.5 mm ² or 4× 0.34 mm ²
Sensor	24 V DC / max. 100 mA	24 V DC / max. 100 mA	24 V DC / max. 100 mA
Number of sensors	Max. 10 in series (9× /BK + 1× /W)	Max. 10 in series (10× /BK)	Max. 10 in series (9× /BK + 1× /W)
Dimensional tolerances			
Length dimension	ISO 2768 – c		
Perpendicularity	ISO 2768 – c		

* If you combine sensors with control units and thereby place pressure-sensitive protective devices on the market, you should observe the basic requirements according to ISO 13856.
As well as meeting technical requirements, this also means – in particular – observing any that relate to marking and information for use.
Declarations of Conformity only apply to pressure-sensitive protective devices. In the case of sensors that are going to be used to make pressure-sensitive protective devices, Declarations of Incorporation are issued instead.

Conformity



The CE symbol indicates that this Mayser product complies with the relevant EC directives and that the stipulated conformity assessments have been carried out.

The design type of the pressure-sensitive protective device complies with the basic requirements of the following directives:

- 2006/42/EC (Safety of Machinery)
- 2011/65/EU (RoHS)
- 2014/30/EU (EMC)

The Declaration of Conformity is available in the Downloads section of our website: www.mayser.com.