SUNX

INSTRUCTION MANUAL (Connection and Operation)

Safety Laser Scanner

SD3-A1

ME-SD3A1CON No.0008-83V

About the instruction manual (connection and operation) of the SD3-A1 and the SD3SOFT instruction manual (software operation)

The instruction manual (connection and operation) for the **SD3-A1** contains important information on proper usage of laser scanner and usage in accordance with intended purpose. For additional information on the configuration of the **SD3-A1**, please refer to the **SD3SOFT** instruction manual (software operation).

It is essential to observe all information in the instruction manual (connection and operation) and in the instruction manual (software operation), especially the safety notes.

The instruction manual (connection and operation) and the instruction manual (software operation) must be kept in a safe place. They must be available during the entire period when the **SD3-A1** is in use. Documents are also automatically installed on the PC when **SD3SOFT** is installed and can be viewed at any time with the Help menu.

Safety and warning notices are identified by the symbol  .

References to important information are identified by the symbol  .

References to the safety of laser devices are identified with the symbol  .

SUNX Limited is not liable for damage caused by improper usage. The user must also be familiar with all the **SD3-A1** manuals to be able to use the system properly.

Version: V5.5

Contents

1 Approvals

1.1 Approval and declaration of EC conformity

EC type examination in accordance with
DIN EN 61496 - 1 and IEC 61496 - 3

TUV
PRODUCT SERVICE GMBH IQSE
Ridlerstr. 65 80339 Munich

1.2 Specialized technical terms and abbreviations

AGV	Automatic Guided Vehicle (FTS in German)
AOPD	Active Optoelectronic Protective Device
AOPDDR	Active Optoelectronic Protective Device responsive to Diffuse Reflection
EDM	External Device Monitoring Monitoring of external control parts (relay monitoring)
ESPE	Electro-Sensitive Protecting Equipment (BWS in German)
N.O.	Normal open contact
OSSD	Output Signal Switching Device Safety-relevant switch output
PC	Personal Computer
DZ	Detection Zone (SF in German)
Reset	Defined Reset or **SD3-A1**
RS-232	RS-232 interface
RS-422	RS-422 interface
ZP	Zone Pair (contains 1 × detection zone and 1 × warning zone) (FP in German)
WZ	Warning Zone (WF in German)

Table 1.2-1: Specialized technical terms and abbreviations

1.3 Guidelines and standards

The following guidelines and standards are of critical importance for the implementation of laser scanner. Guidelines providing particularly relevant information for users of such systems are marked with an asterisk (*).

Guideline / Standard	Designation	
European Guidelines		
98 / 37 / EG	Machine guideline	
73 / 23 / EWG	Low voltage guideline	
89 / 336 / EWG	EMC guideline	
A Standards		
ISO 12100-1 and 2	Safety of machinery - basic concepts	
ISO 14121	Safety of machinery - principles for risk assessment	*
B1 Standards		
ISO 13852	Safety of machinery - safety distances to prevent danger zones being reached by the upper limbs	*
ISO 13849-1	Safety of machinery - Safety related parts of control systems; Part 1: General principles for design	
ISO 13855	Safety of machinery. The positioning of protective equipment in respect of approach speeds of parts of the human body	*
B2 Standards		
IEC 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	
IEC 60825-1	Safety of laser products - Part 1: Equipment classification and requirements	
IEC 61496-1	Safety of machinery. Electro-sensitive protective equipment. General requirements and tests	*
IEC 61496-3	Safety of machinery - Electro-sensitive protective equipment - Part 3: Particular requirements for Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR)	*
C Standards		
DIN EN 775	Industrial robots - Safety	*
DIN EN 1525	Safety of industrial trucks - Driverless trucks and their systems	*
DIN EN 12895	Industrial trucks - Electromagnetic compatibility	

Guideline / Standard	Designation	
National Standards		
DIN 15185-2	Warehousesystems with powered industrials trucks	*

Table 1.3-1: Guidelines and standards

This list does not claim to be complete. In certain cases, the concrete requirements of the application will necessitate the application of additional guidelines and standards!

2 System Overview

2.1 Brief description and functional principle of the SD3-A1

The **SD3-A1** is an optical distance sensor that takes two-dimensional measurements. It could also be referred to as an optical area radar device. The sensor uses a rotating deflecting unit to periodically emit light pulses within a working range of 190°.

If these pulses strike a person or an object, the reflected light is received and evaluated by the **SD3-A1**. The scanner calculates the precise coordinates of the person or object based on the travel time of the reflected light and the current angle of the deflecting unit. If the person or object is within the bounds of a previously defined area called a detection zone, a safety-oriented switching function is performed. This switching function causes the semiconductor outputs to be switched OFF. The safety-oriented switching function cannot be reset until the detection zone is clear. Depending on the operating mode, the reset can be initiated either automatically or manually.

DZ = Detection zone, max. 4m
WZ = Warning zone, max. 15m
a = Maximum registration of measurement values, max. 50m
b = Detection zone programmed in the **SD3-A1** (example)
c = Warning zone programmed in the **SD3-A1** (example)
d = Configurable detection zone and warning zone expansion (-5°)
e = Configurable detection zone and warning zone expansion (+5°)
f = Object in the detection zone

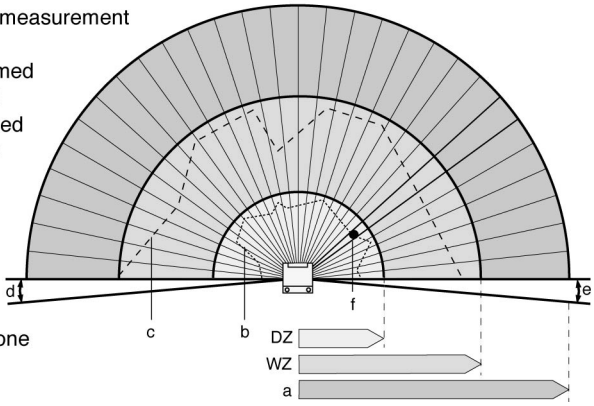


Fig. 2.1-1: The 190° angle range of the **SD3-A1** is divided into 0.36° angle segments.

A laser diode coupled with transmitter optics produces focused light pulses. These pulses are projected across the monitored surface by a rotating mirror in such a way that a light pulse is triggered in each of the angle segments within 40ms (scanning rate: 25 scans/s).

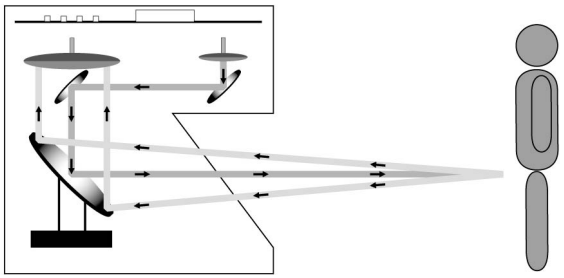


Fig. 2.1-2: Functional principle of the **SD3-A1**

The **SD3-A1** can detect people up to a distance of 4.0m even if they are wearing very dark clothing or exhibit a low degree of reflectance. Dangerous movements are brought to a standstill by two failsafe semiconductor outputs.

Objects (min. 150 × 150mm) are detected up to a distance of 15m (corresponds to the warning zone) and signaled by way of a non-safety-related semiconductor output.

Eight programmable zone pairs (each of which consists of one detection zone and one warning zone) enable the scanner to be optimally adapted to the needs of each particular application.

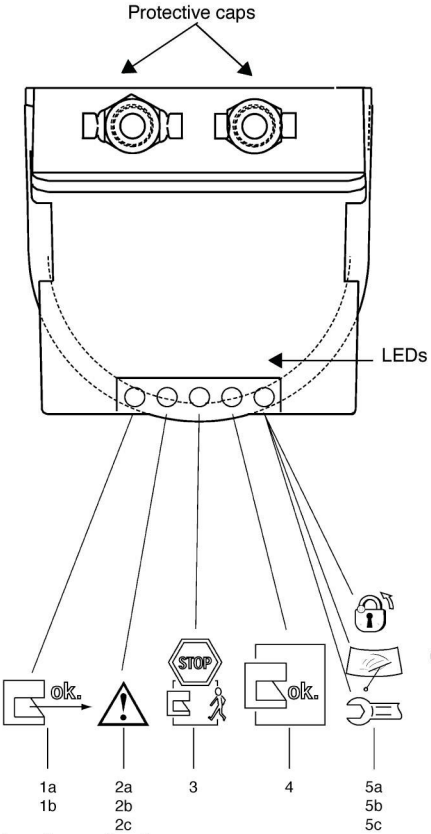
The **SD3-A1** can be implemented not only on machines and systems (stationary safeguarding of danger zones), but also on vehicles (mobile safeguarding of transport vehicles).

Due to its wide range of measurement and its non-contact, electro-sensitive measurement principle, the **SD3-A1** can be effectively used as a protective device for virtually any application.

2.2 Special features of the SD3-A1

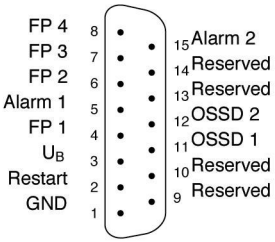
- Eight freely programmable detection zones (up to a maximum of 4m)
- Eight freely programmable warning zones (up to a maximum of 15m)
- Expanded monitoring range of up to 190°
- ConfigPlug for **easy device exchange without configuration expense**
- Compact design (W × D × H: 140mm × 135mm × 155mm)
- Light weight (2kg)
- Low power consumption requirements (300mA, plus the load at the outputs)
- Two types of interfaces at one Sub-D jack (RS-232 and RS-422)
- User-friendly software

Status displays on the **SD3-A1**

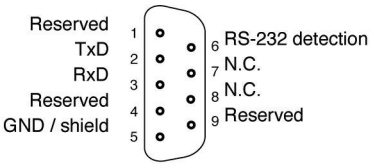


1a = Sensor function
1b = Errors on the zone pair control inputs, Light flashing at 2Hz
2a = Warning zone is occupied
2b = Optical window is dirty, Light flashing at 2Hz
2c = ConfigPlug configuration not compatible, Light flashing at 4Hz
3 = OSSDs are turned OFF
4 = OSSDs are turned ON
5a = Restart inhibit locked, Continuous light
5b = Optical window is dirty, Light flashing at 2Hz
5c = Fault, light flashing at 4Hz

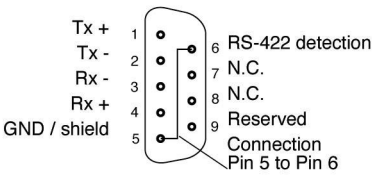
Assignment of interface X1



Assignment of interface X2 as RS-232 port



Assignment of interface X2 as RS-422 port



3 Safety Notes and Usage in Accordance with Intended Purpose

3.1 General safety notes

The protective function of the devices can be negatively affected, however, if they are used improperly or not in accordance with their intended purposes. If this occurs, it may not be possibly to safeguard danger areas completely or at all, which may result in danger to life and / or limb for persons who are in the general area of the machines or systems.

Caution – laser radiation!
The **SD3-A1** is a laser device belonging to laser class 1. The valid legal and local regulations for operating laser systems must be complied with.
Avoid positioning the scanner at eye level.

3.2 Usage requirements and usage in accordance with intended purpose

The relevant regulations for machine safety apply for the use of the laser scanner **SD3-A1**. Responsible authorities (for example professional trade unions, OSHA) are also available for questions related to safety. In general, the following usage requirements must be observed:

- If the scanner is enclosed in a protective housing, additional window material, such as plastic or glass must not be used as it may impair the detection.
- Avoid touching the scanner optical window and the six diffusing light screens.
- The **SD3-A1** is not suitable for use as a protective device:
  - if it is possible that dangerous fluids will be spewed out or objects will be ejected.
  - for machines with long braking times (max. depth of the detection zone: 4m)
- The **SD3-A1** corresponds to Type 3 in accordance with IEC 61496-1 and 3. A safety category of 3 in accordance with EN 954-1 can be achieved with the **SD3-A1** if all other elements in the safety chain are set up to stop the dangerous motion in accordance with that safety category.
- The electrical connection of the **SD3-A1** to the control system must only be made by an electrician.
- The 24V DC (+20% / -30%) power supply must be ensured by a safe network disconnect in accordance with IEC 742. The same requirements apply to all connected input and output circuits.

- The 24V DC power must be supplied to the scanner through a separate branch with a 1.25A delayed action fuse in the control cabinet.
- You must ensure that protective caps are screwed onto interfaces X1 and X2. This will protect the interfaces against dust.
- The safety output has a double design. The two OSSDs must always be included in the shut-off circuit of the machine in such a manner that either of the two is completely sufficient by itself to turn OFF the motion that presents a danger.
- The alarm output 1 (Pin 5 on X1) must not be used to switch safety-related signals.
- System tests (of the scanner, machine, control components and switch components) may only be performed when they do not result in potential hazards for people.
- Tampering with or making changes to the **SD3-A1** can result in the loss of the safety function.
- Only expert trained personnel is allowed to perform startup, maintenance, parameter settings or detection zone configurations. Familiarity with the safety notes in this instruction manual (connection and operation) and in the instruction manual (software operation) for the "**SD3SOFT**" program constitutes part of this expert knowledge.
- The password required for configuring safety-relevant parameters must be kept in a secure location by the safety official. Information about password levels can be found in the instruction manual (software operation) for the "**SD3SOFT**".
- If the machine is designed for start interlock / manual restart, all detection zones must be checked before enable - no one is permitted in the danger area.

3.3 Restrictions for use

- Glass, highly reflective materials such as mirrors (reflectance > 10.000%), or objects that do not reflect any light back to the sensor can falsify the measurement result. More information is available in Chapter 5.3.5.
- Do not expose the **SD3-A1** to flying sparks (for example a welding flash). Doing so may cause damage to the optical window.
- Vapor, smoke, dust and all particles visible in the air have a significant negative effect on measurement values and will result in the semiconductor outputs being turned OFF.
- Avoid extreme variations in temperature.

- Make sure that the following types of light sources are not present on the scanning plane:
  - Laser light from one or more other scanners or sensors
  - Infrared light
  - Fluorescent light
  - Stroboscopic light

  Please consider as well Chapter 5.2.
- It must not be used for vehicles with internal combustion engines.
- The **SD3-A1** is conceived for use inside enclosed spaces and with the operating parameters listed in the technical specifications (temperature, humidity, shock, vibration, etc.). Please refer to the list of parameters in Chapter 13.
- Avoid having reflective surfaces (such as glass, mirrors, retro-reflectors, etc.) at fixed contours in the scanning plane. If this is not possible, an additional detection zone must be provided.

3.4 Information related to detection zone changeover

If alternating operation is included in the design, and thus detection zone changeover, the activation and effect of the detection zone in question must match the alternating operating mode.

- The new detection zone must be activated before turning OFF the previous detection zone. The time at which the changeover is made must be based on a risk analysis.
- Braking paths, response and coast-down times must be taken into consideration (for example overlapping detection zones).
- A “Start interlock” function is provided.
- If the machine has a restart key, it must not be possible to operate it from inside the detection zones. All danger areas must be visible from the position of the button. Before releasing the start / restart interlock, all detection zones must be tested. No one is permitted inside the danger areas.
- There must be no unmonitored zones inside the danger areas.
- There must be no possibility for direct access to the danger area that shortens the necessary safety distance (use a protective grid, for example).
- The information on required detection zone additions in Chapter 5 must be observed.

3.5 General information related to determining detection zone contours

- Shadow effects (e.g. surfaces or areas located behind stationary objects) must be considered. As a rule, insufficient safeguarding must be adequately supplemented by further safety measures such as protective grid, light curtains, and the like!
- Access to the detection zone in the dangerous area is not permitted.
- When setting the dimensions of the detection zone, you must comply with the formulas cited in Chapters 5.4.8 and 5.7.9! Be sure to comply with higher-level machine standards (e.g. DIN EN 1525) if applicable.
  These contain individual specifications, for example, on points of access to the danger zone and, if applicable, detection zone additions that must be given special consideration.
  They also provide information on how to measure safety distances at machines.
- Detection zones with a radius smaller than 20cm (at or close to the scanner) are not admissible. 20cm is the preset minimum contour.
- When setting the dimensions of the detection zones, please comply with the maximum angle range stated in the technical specifications (Chapter 13.11).
- Needle-shaped detection zone contours are not permitted, since they do not ensure any protective effect. For additional information, please refer to the **SD3SOFT** user software (Chapter entitled “Definition of detection zones”).
- Due to possible measurement errors, every detection zone has an additions area in which detection is not guaranteed under all conditions. Please consider as well Chapter 5.3.5. Read Chapter 5.4.6 and 5.7.7 for information on optimizing system availability.
- The required safety distances must be taken into account when making detection zone configurations. Safety distances are calculated according to formulas found in either the machine-specific C standards or the general B standards IEC 61496-3 in combination with DIN EN 999 (see Section 2 and 5 of the standard). Tolerance fields and / or additions (make sure to consider Chapter 5.4 and 5.7).
- After the detection zones have been set, make a printout of the following information:
  - Detection zone contour with the X and Y coordinates
  - Date
  - Serial number of the scanner
  - Name of the safety official
- When calculating the additions, be sure to consider whether the dust algorithm is deactivated or activated (see Chapter 5.3.5).

- When calculating the safety distances, be sure to consider all delay times, such as the response time of the scanner, response time of the control elements, and braking times and / or stopping times of the machine / system or AGV! Variations in delay time caused by factors such as reduced braking power must also be taken into consideration.
- The effectiveness of the switch-off function must be tested along the defined contour of the detection zone during the initial startup and subsequent to any changes made to a machine or system.
- The effectiveness of the switch-off function must be tested for the detection zone contours along the entire driving route during the initial startup and following any changes made to an AGV.
- In the event that there is insufficient room available to allow the full dimensions of a detection zone, for example because of the position of the scanner, additional safety measures (e.g. protective grids) must be installed.
- Following each definition of and change to the detection zones, the configuration must be checked to see whether the possibility of people standing in the danger zone as well as any barriers provided have been considered by an appropriate layout of the detection zone(s).

3.6 Additional safety notes for stationary use

- If the danger zone can be accessed from the side, and if the detection zone cannot be extended sufficiently in this direction, additional safety measures (e.g. protective grids) must be installed.
- We recommended marking the contour of the detection zone on the floor by painting a colored line or applying colored adhesive tape.
- Check the mounting regularly (in particular, the angle of inclination) in order to guarantee the reliability of detection.

3.7 Additional safety notes for mobile use

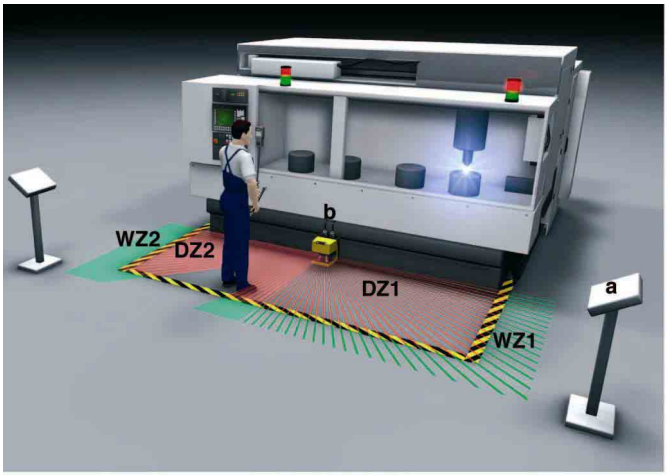
- There are additional requirements for the use of scanners on automatic guided vehicles (AGV) and transporter trolleys according to DIN EN 1525.
- If possible, expanded detection zones to each side should be provided in order to safeguard access from the side and directly in front of the vehicle.
- If is it not possible to completely safeguard the contour of the vehicle including its trailer and the dimensions of its load while making curves, additional protective devices such as switch strips must be attached to the side of the vehicle.
- There must be a minimum safety distance S_{AB} of 500mm to the side of the vehicle on both sides. A one-sided minimum safety distance is admissible in certain exceptional cases. The specifications of DIN EN 1525 must be complied with.
- The basic value of the detection zone width for an AGV corresponds to the maximum vehicle width including the trailer and the dimensions of the load plus the detection zone additions Z_S. Furthermore, the greatest possible lateral shift of the AGV while making curves must be considered when defining detection zones.
- If the **SD3-A1** is mounted on vehicles, the mounting (especially the angle of inclination), the vehicles' braking power, and if applicable, play in the vehicle guidance (the difference between the optimum and actual line of guidance) must be regularly checked in order to guarantee the reliability of detection.

4 Applications for the SD3-A1

Due to its continuous coverage of the area, its wide range, and the ability to select among eight zone pairs, the **SD3-A1** is able to handle even complex applications.

4.1 Stationary safeguarding of the danger area

The **SD3-A1** is used to safeguard dangerous working areas at machines and systems where both constant and variable demands are placed on the geometrical shape of the detection zone. The aim is to prevent people from entering the danger zone or reaching the danger point with their upper and / or lower extremities, at the same time without impeding the production process.
The **SD3-A1** can be mounted directly at the machine table or on the side or in front of the machine.



DZ1 = Detection zone 1, activated
DZ2 = Detection zone 2, deactivated
WZ1 = Warning zone 1, activated
WZ2 = Warning zone 2, deactivated

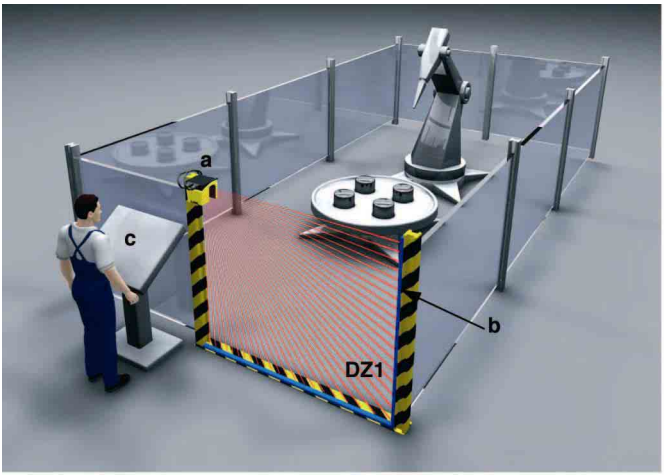
a = Emergency stop and manual restart interlock
b = **SD3-A1**

Fig. 4.1-1: Danger area guarding at stationary machinery with two alternating work areas

Please comply with the safety notes in Chapter 3 and Chapter 5.4.7. For an example of how to calculate detection zone measures, please refer to Chapter 5.4.8.

4.2 Access guarding by passage monitoring

Access guarding by passage monitoring (whole body trip control) is a suitable method when the access to a machine or to a hazardous zone can be precisely defined in structural terms, and there is no other unprotected access to the area. It is best to mount the laser scanner above the passage in question, in vertical alignment. In order to secure the protective equipment, laser scanner and fence against inadvertent misadjustment and manipulation, the detection zones of the **SD3-A1** must be defined on the basis of a reference boundary. In this operating mode, the scanner will use the polled environment as a reference and so check for changes in the layout of the protective equipment, as well as checking every one of the individual measurements it carries out with a view to detecting an intrusion. An example of the configuration of the **SD3-A1** to give access protection by passage monitoring will be found in Chapter 5.5.



a = **SD3-A1** DZ1 = Detection zone 1, enabled

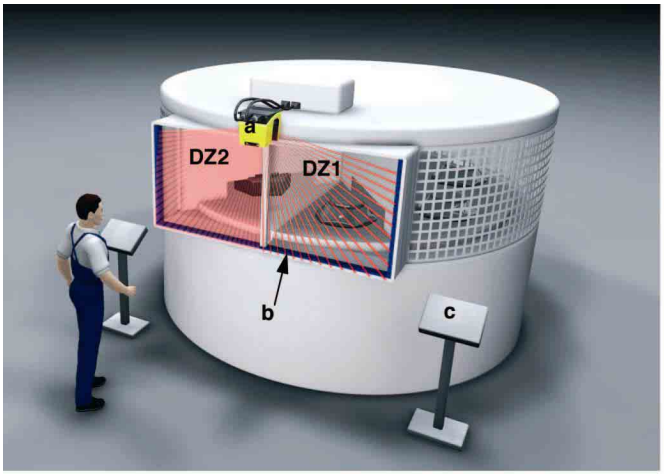
b = Reference boundary of the detection zone

c = Emergency stop and triggering of the manual restart interlock

Fig. 4.2-1: Access guarding by whole body trip control with system check of a reference boundary

4.3 Safeguarding of danger points based on hand and arm protection

If the machine operator, in close proximity to the danger zone, needs to halt the hazardous movement of the machine or to coordinate the handling of workpieces or their removal from the machine, the machine must be provided with protection at the danger point. To safeguard danger points in this way a protective system needs to be installed. The **SD3-A1** is certified as a system providing hand and arm protection, and is able in such a situation to guarantee flexible safety conditions in the workplace. This may be combined with alternation of the detection zones. In order to safeguard the protective equipment, laser scanner and side-mounted panels (which serve as a reference and provide additional access protection) against inadvertent misadjustment or manipulation, the detection zones of the **SD3-A1** must be defined on the basis of a reference boundary. An example of the configuration of the **SD3-A1** for the protection of danger points based on hand and arm protection may be found in Chapter 5.6.



a = **SD3-A1** b = Reference boundarys of the detection zones

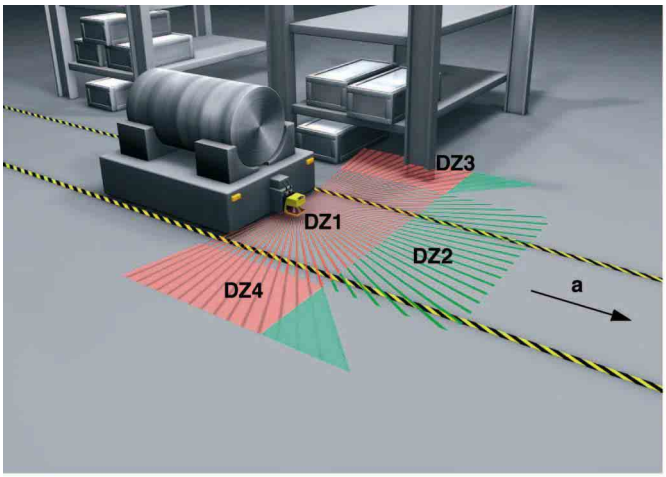
DZ1 = Detection zone 1, enabled DZ2 = Detection zone 2, disabled

c = Emergency stop and manual triggering of restart interlock, acknowledgement for switchover

Fig. 4.3-1: Safeguarding of danger points based on hand and arm protection with alternation of detection zones

4.4 Mobile safeguarding of automatic guided vehicles

For this application, the **SD3-A1** is installed on automatic guided vehicles in order to monitor the vehicle path. The aim is to detect people or objects in the path of the vehicle and to automatically bring the vehicle to a halt. Safety systems available up to now, such as bumpers or safety bars, have allowed only very low driving speeds to be maintained. In contrast, using the **SD3-A1** as a non-contact “advance bumper” results in the creation of a substantially larger safety zone.
The vehicles can move faster, and down times are reduced to the necessary minimum.



DZ1 = Detection zone 1 for slow speed

DZ2 = Detection zone 2 for high speed

a = Traveling straight ahead

DZ3 = Detection zone 3 for a route curving to the left

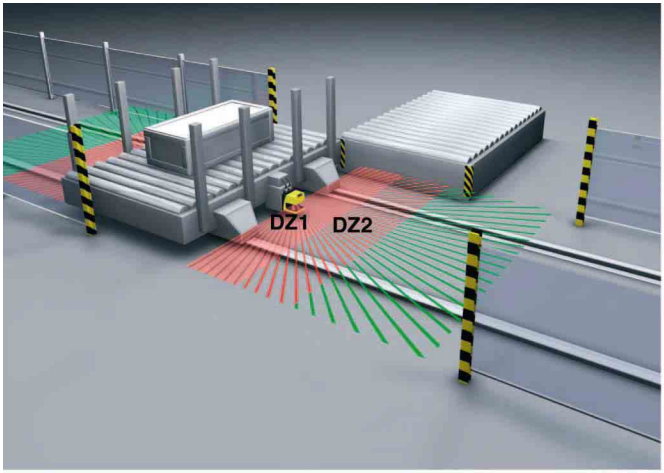
DZ4 = Detection zone 4 for a route curving to the right

Fig. 4.4-1: Safeguarding an automatic guided vehicle

Please comply with the safety notes in Chapter 3. For an example of how to calculate detection zone measures, please refer to Chapter 5.7.9.

4.5 Protecting transporter trolleys against collisions

Transporter trolleys are generally guided along a system of rails or grooves in the floor. Hence the vehicle paths are usually just slightly wider than the trolleys themselves. This represents an increased hazard for people, since it is impossible to get out of the way of the trolley. For this reason, transporter trolley are used in enclosed areas equipped with suitable access safeguarding.



DZ1 = Detection zone 1 for slow speed DZ2 = Detection zone 2 for slow speed

Fig. 4.5-1: Safeguarding a transporter trolley

Please comply with the safety notes in Chapter 3 and Chapter 5.7.8.
In these cases, the **SD3-A1** is used to detect people or objects in the vehicle path and then automatically bring the vehicle to a halt. Select “Manual restart” mode.

The demands placed on the geometrical shape of the detection zone are determined by the vehicle width, speed, stopping distance and response time. Here as well, factors such as additions in the direction of travel for tolerances in the measurement value and reduced braking power due to wear and tear must be taken into consideration.

4.6 Guarding the sides on AGVs

In addition to the danger area guarding of the path of an AGV application, in some cases it is also necessary to set up a side guarding. This side guarding detects people in the space between vehicle and conveyor, or detects people that stand on the conveyor edge in the vehicle area. Furthermore, the side guarding also enables the correct position of the load to be monitored, so that a transport with overhanging load is not initiated.

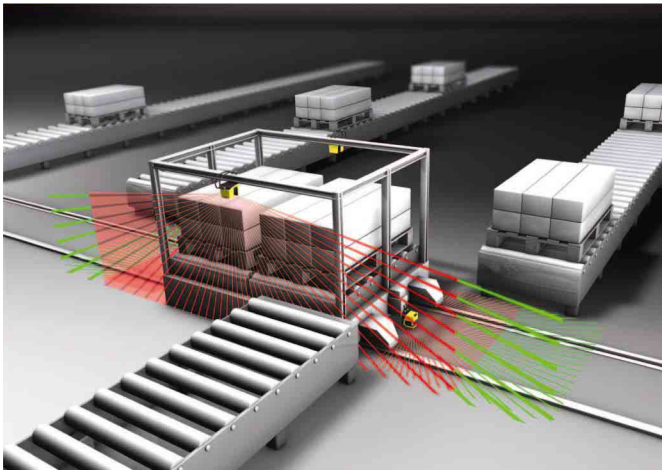


Fig. 4.6-1: Bild 6.3-1 guarding the sides on AGVs

Please observe the safety notes in Chapter 3. An example for the side guarding configuration on AGVs can be found in Chapter 5.7.9 and 5.7.10.

4.7 Other possible applications

- Object and contour measurement
- Logistics (counting, measuring, controlling)
- Projection control (e.g. in fully automatic parking ramps or lots)
- Safeguarding or monitoring enclosed spaces
- and many more

5 Information for Planning and Mounting

It is essential that the following key points be complied with so that the **SD3-A1** can provide optimum performance:

- The **SD3-A1** must be placed so that areas of access to the danger zone being monitored are completely covered by the detection zone.
- The mounting position of the scanner should provide protection from humidity, dirt and extreme temperatures below 0°C or over 50°C.
- The mounting position must be selected in such a way as to minimize the possibility of mechanical damage. Additional protective cover panels or safety bars must be installed at exposed positions.
- Reinforcements, cover panels, mounting niches, and other machine elements may not in any way impair the field of view of the scanner.
- If there are areas of shadow caused by fixed obstacles that were defined as part of the detection zone boundary, these should be safeguarded (e.g. by protective grids) in order to prevent people standing in them from being able to suddenly enter the detection zone. This point must be taken into account in the hazard analysis of the machine or system.
- Be sure that there are no retro-reflectors or highly reflective surfaces made of metal or ceramic in the area of the detection zone and at the height of the scanning plane. Such objects can cause measurement errors.
- In order to ensure a consistent detection height at every point of the detection zone, the scanner – and hence the scanning plane – must be placed parallel to reference section.
- If the “Restart interlock” function is included, the restart button must be located outside the detection zone in a place that is visible from the entire danger area.
- If the scanner is used without a start interlock or startup test with automatic start / restart, a startup warning (visual or acoustic) must be provided.
- The scanner must not be used as an aid for climbing. If there is any risk, a suitable diagonal protection (45°) should be set up.

Please comply with the safety notes in Chapter 3, Chapter 5.4.7 and 5.7.8.

5.1 Attachment and dimensions

For attaching the **SD3-A1**, four drill holes are located at the back of the unit. Any laser scanner installation point is possible with mounting. The **SD3-A1** can, for example, also be mounted on the head or inclined facing down.
The mounting system **MS-SD3-1** is available as an accessory offering following advantages:

- Speeds up the mounting process by providing screws that are accessible from the front.
- Allows vertical inclinations of up to 9°, either up or down, infinitely adjustable within this range.
- Allows lateral tilting of up to approx. 9° to either side from the midpoint setting, infinitely adjustable within this range.
- Enables quick replacement of the scanner without requiring realignment.

For information on which parts and dimensions are required for mounting, please refer to Chapter 13.13 and 13.14.

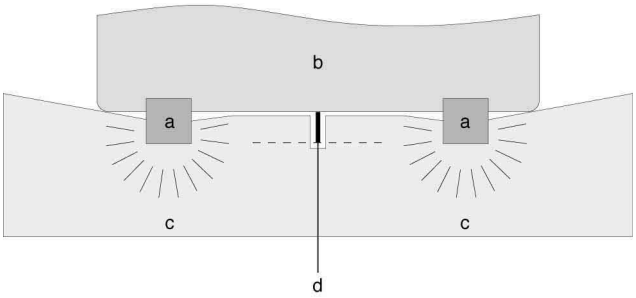
5.2 Installing adjacent laser scanners

The **SD3-A1** has been developed in a way that prevents several laser scanners from interfering with one other as much as possible.

An increase in the response time can, however, be caused by the installation of several adjacent laser scanners. If **none** of the constructive measures (section 5.2.1) described in the following sections or the specific adjustment (section 5.2.2) are implemented, **then the SD3-A1 response time set and shown in the configuration and diagnosis software (SD3SOFT) is extended by 40ms.** This extension in the response time must be taken into account when calculating the safety distance!

5.2.1 Constructive measures

The direct external light irradiation from laser scanners of the same kind (905nm laser light wavelength) in a line and at the same installation height can be prevented with shielding plates at scan level. Shielding, as high as the scanner front screen and flush with the front housing edge, is sufficient. The same also applies with installation in parallel alignment and overlapping of the scan levels.



a = **SD3-A1**
b = Machine (view from above)
c = Detection zones
d = Shield plate, flush with the housing

Fig. 5.2-1: Shielding to prevent direct irradiation

5.2.2 Adjusting adjacent laser scanners

In order to prevent faulty deactivation and scanners interfering with each other as much as possible, when using several laser scanners you must install these as shown in the following examples. Installation on the basis of the **MS-SD3-1** mounting system makes precise adjustment significantly easier.

Installation with height offset or a crossed alignment also prevents interference from beam reflections onto surrounding objects. When safeguarding danger zones, please also ensure that it is not possible to crawl under the detection zone, so that gaps do not occur with access guarding.

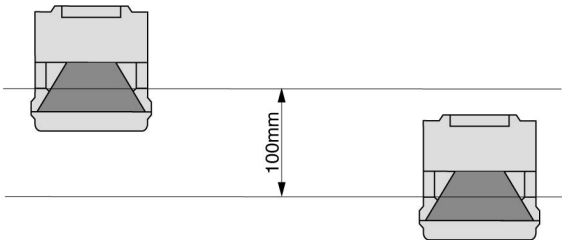


Fig. 5.2-2: Installation with height offset (parallel alignment)

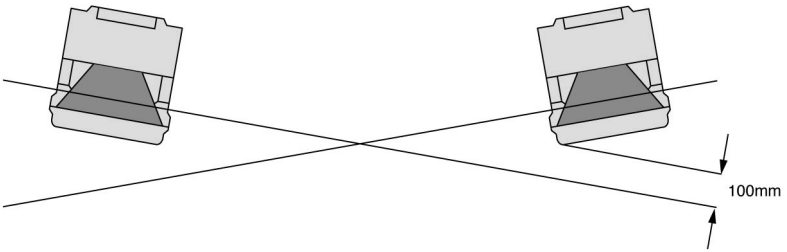


Fig. 5.2-3: Installation without height offset (crossed alignment)

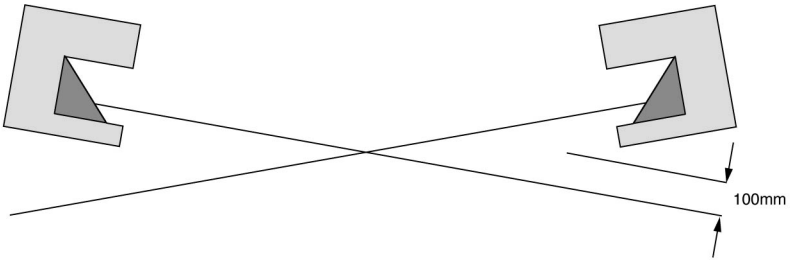


Fig. 5.2-4: Opposing installation without height offset (crossed alignment)

5.3 Information on setting the dimensions of detection zones

The hazards caused by machines and systems place a wide range of demands on safety distances and detection zones which must be appropriately defined.

5.3.1 Methods of configuring detection zones using the PC

With its **SD3SOFT** configuration and diagnostic software, the **SD3-A1** offers various methods for setting the configurations of detection zones.

Numerical input
A separate dialog within the user program "**SD3SOFT**" allows the right, left and front edges of the detection zone to be set using numerical values in mm.

Graphic input
A separate dialog within the user program "**SD3SOFT**" allows the basic contours of the detection zone to be entered. The contours can be adapted infinitely to the desired size of the detection zone. The following shapes are available:

- circle
- rectangle
- polygon

In addition, the contours can be infinitely varied by:

- changing
- limiting and
- deleting

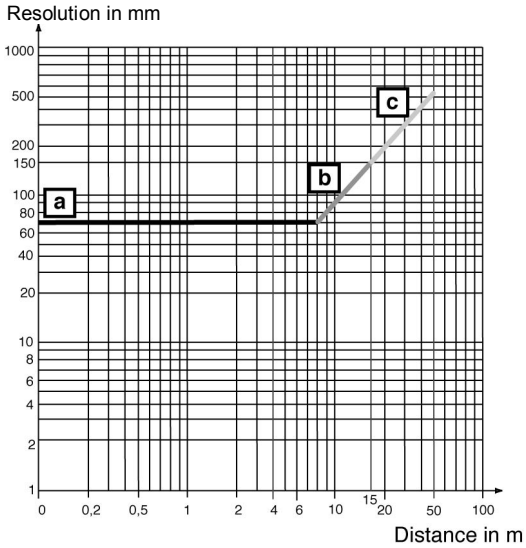
partial segments as desired

5.3.2 Range of the detection zone, resolution

The maximum range of the detection zone S_{MAX} 4m (including the additions) for an object with a diameter of 70mm and a reflectance factor of 1.8% (e.g. black corduroy). The reference point of the measurement is the axis of the rotating mirror on the scanner 64mm behind the front edge of the scanner.

5.3.3 Range of the warning zone, resolution

A maximum range of 10m is available for an object with a diameter of 100mm. The maximum available range for an object with a diameter of 150mm is 15m. Both of these figures assume a reflectance factor of 20%.

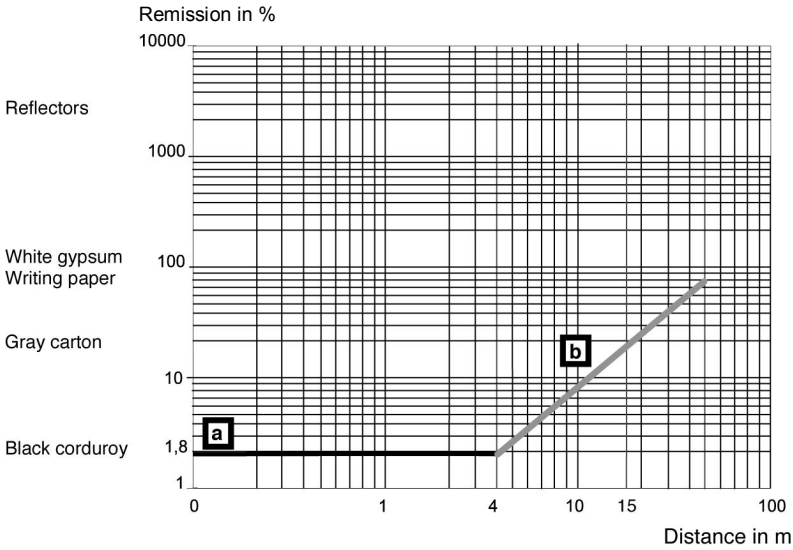


a = Detection zone
b = Warning zone
c = Measurement field

Fig. 5.3-1: Detecting objects in the detection zone and in the warning zone. The reference point of the distance measurement is the axis of the rotating mirror.

5.3.4 Range of the measurement field

The maximum distance for contour measurement at a reflectance factor of 80% (white gypsum) is 50m.



a = Detection zone
b = Measurement field

Fig. 5.3-2: Detection of objects depending on the reflectance factor. The reference point of the distance measurement is the axis of the rotating mirror.

5.3.5 Required detection zone additions Z

The **SD3-A1** is equipped with a selectable dust algorithm to ensure optimum freedom from interference.

The following detection zone additions must be taken into account:

Addition Z_{SM} if dust suppression is deactivated	83mm
Addition Z_{SM} if dust suppression is activated	83mm (for a detection zone size < 3.5m) 100mm (for a detection zone size ≥ 3.5m)

Activation and deactivation of the function is performed by **SD3SOFT**.

If retro-reflectors or very shiny surfaces, such as polished or enameled metals or ceramics, may possibly be present in the scanning plane, the following table applies:

Addition Z_{REFL} if retro-reflectors or very shiny, surface-treated materials (e.g. metals and ceramics) are present in the scanning plane	0mm for reflectors more than 1.2m behind the detection zone line 110mm for reflectors up to 1.2m behind the detection zone line

$$\mathbf{Z = Z_{SM} + Z_{REFL}}$$

Z = Required detection zone addition, in mm
Z_{SM} = Measurement error of the scanner, in mm
Z_{REFL} = Addition for considering reflectors, in mm

5.4 Safeguarding stationary danger zones

Please comply with the safety notes in Chapter 3.

5.4.1 The purpose of safeguarding

is for protection:

- to protect people when entering a danger zone
- to protect people from reaching a danger point with their extremities
- to protect objects from the danger of collision due to variable machine or part movements.

5.4.2 Mounting position

The **SD3-A1** can be mounted either in a stationary position (e.g. on a wall or a machine) or on moving parts (e.g. machine table).

The qualified installer must ensure that the mounting position of the **SD3-A1** allows the danger zone to be monitored completely.

If a restart button is being used, make certain that the entire detection zone area can be viewed by the person pressing the button. It must not be possible to activate the button from the danger area.

Refer to the safety notes in Chapter 3.6 with regard to lateral access into the danger zone.

5.4.3 Mounting height

According to DIN EN 999, the lowest admissible height of the scanning plane for people, as measured from the base level, is calculated according to the following formula:

H_{MIN} = 15 × (d - 50mm)

H_{MIN} = Lowest admissible scanning plane from the base level

d = Resolution of the scanner in mm (object size = 70mm throughout the detection zone).

The admissible height range of the **SD3-A1** scanning plane lies between 0mm (presettings leg detection) and 1,000mm above the base level. If the application requires a scanning plane higher than 300mm, or if children have access to the area, the analysis of the danger zone must consider the hazard caused by persons crawling below the scanning plane.

5.4.4 Recommendations for mounting to prevent unmonitored zones

Unmonitored zones can result if the scanner is mounted onto a protruding attachment or if the contour of the machine / system is varied in depth.

5.4.4.1 Recessed installation (undercut) under the machine table

The undercut must be at least as deep as the zone not monitored by the detection zone lateral to and in front of the scanner. The minimum depth Z_{UMIN} is 135mm. If it is possible to recess the scanner, this is allowed up to a maximum of 40mm; the depth of the undercut is reduced by the depth value of the recess. If the mounting system is being used, the necessary dimensions of the undercut depth must be increased accordingly (see Chapter 13.13 and 13.14). The height of the undercut must be limited to prevent people from being able to step beneath it.

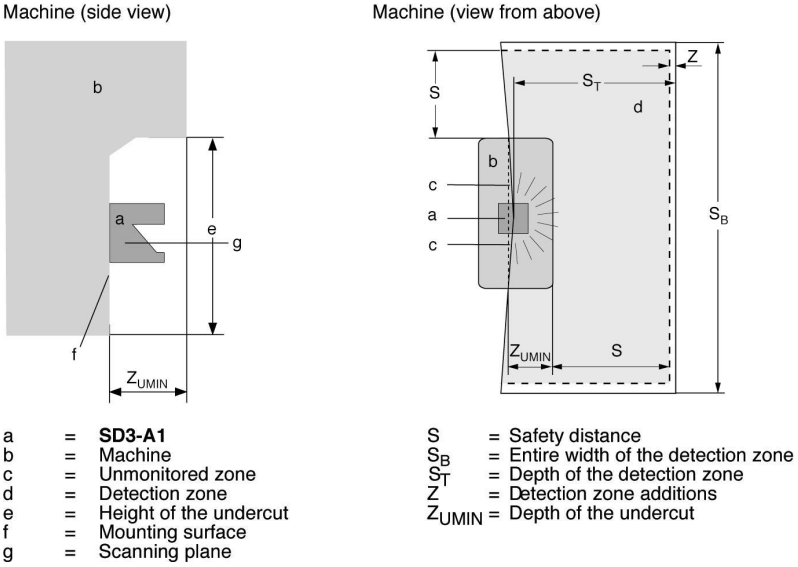


Fig. 5.4-1: Recessed scanner installation with undercut

The additional safeguarding required for the particular application must be taken into account.

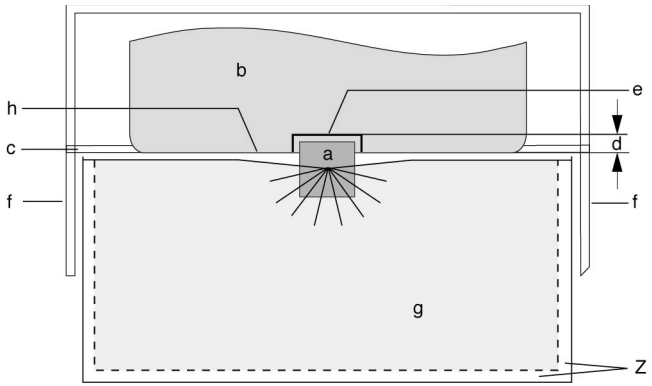
Please note that the undercut must cover any unmonitored zones.

5.4.4.2 Recessed installation within the machine contour

Furthermore, the scanner can be recessed into the contours of a machine. The recess can have a depth of up to 40mm without the mounting system **MS-SD3-1**, or up to 65mm with the mounting system **MS-SD3-1**. This is in reference to detection zones that cover an angle range of 180°. If it is not possible to comply with these values, or if unmonitored zones result due to the shape or movement of the machine, additional safety measures must be taken.

The effectiveness of the detection zones can be optimized by changing the depth at which the scanner is installed, or by adjusting the angle range (e.g. from 180° to 190°).

For information on how to configure the scanner in this way, please refer to the instruction manual (software operation) for the **SD3SOFT**.

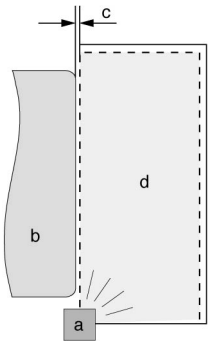


a	=	**SD3-A1**	f	=	Lateral access safe guarding, if needed
b	=	Machine			
c	=	Lateral access protection	g	=	Detection zone
d	=	Maximum recessing (40mm)	h	=	Front machine edge
e	=	Installation niche	Z	=	Detection zone addition

Fig. 5.4-2: Recessed installation within the machine contour

If it is not possible to mount the **SD3-A1** directly onto the machine, it can also be positioned lateral to or across from the machine.

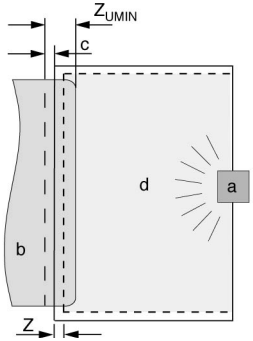
5.4.4.3 External mounting lateral to or across from the machine



a = **SD3-A1**
b = Machine
c = Distance, max. 35mm
d = Detection zone

Fig. 5.4-3: Lateral external scanner mounting without an undercut

If the machine contour runs parallel to the 90° beam of the laterally placed **SD3-A1**, the distance between the detection zone boundary and the machine may not exceed 35mm.



a = **SD3-A1**
b = Machine
c = Minimum distance from the environment
d = Detection zone
Z = Required detection zone additions
Z_{UMIN} = Minimum depth of the undercut

Fig. 5.4-4: Mounting the scanner across from the machine with an undercut

5.4.5 Additions

The axis of the rotating mirror (midpoint of the scanner) is of critical importance when configuring the detection zones. This axis is assigned a value of 64mm from the front edge of the scanner when calculating detection zones.

Add 83mm or 100mm for the maximum radial measurement error Z_{SM} as described in Chapter 5.3.5.

Add an addition Z_{REFL} as described in Chapter 5.3.5 if reflectors could be present in the area.

Please note that safety additions must principally be added to the safety distance throughout the entire detection zone.
In other words, additions may not be added to just one side or only to certain sections.

Please consult the operating instructions provided by the machine or system manufacturer.

5.4.6 System availability

There must be a buffer distance of 83mm between the surrounding contour and the detection zone contour (including the additions). This distance increases the up-time of the machine or system since it prevents the surrounding contour from being detected as relevant for generating a switch-off signal. If there is an undercut across from the scanner that is impossible for a person to step beneath (see Fig. 5.4-4), the depth of the undercut can be calculated according to the following formula:

$$\mathbf{Z_{UMIN} = Z + 83mm - d}$$

Z_{UMIN} = Depth of the undercut, in mm
Z = Required detection zone additions, in mm
d = Resolution of the scanner (d = 70mm)

This is possible since it is absolutely certain that a person will be detected in front of the undercut.

Furthermore, the dust algorithm of the **SD3-A1** can be implemented if floating particles may be present in the area. This algorithm, which can be activated in the user program "**SD3SOFT**", prevents the machine or system from being switched OFF unintentionally. Please note Chapter 5.3.5.

If the danger zone analysis allows a multiple evaluation, detection errors caused by floating particles can be decreased. The number of evaluations that is decisive for the response time of the scanner (T_{SCAN}), and thus also requires a larger detection zone, can be set in the user program "**SD3SOFT**".
In the event of an error event that lasts only briefly (for example the effect of extraneous light) the scanner performs a one-time reboot. If automatic startup / restart are activated, the scanner turns the OSSDs back ON after this brief error event, and after the detection zone has been free for about 25s. This one-time reboot results in an additional increase in availability. This function does not have any effect if detection zone activation is faulty. If startup test, startup interlock and / or manual restart are included, they will not be removed.

Safety notes:
Automatic startup / restart must only be used in cases where there is absolutely no possibility that the effective detection zone could be entered or bypassed in some other way. Depending on the hazard assessment, visual and / or acoustic startup warnings should be provided.

If parameters are set for the function “Manual restart”, the required enable from the startup / restart button affects all detection zones and is independent of any detection zone changeover. If the current detection zone is manually enabled, this enable also applies even if the system switches to another detection zone and this detection zone becomes free! If startup / restart interlock is in effect in the current detection zone, it is also in effect for the other detection zone to which the system switches even if this detection zone is free.

5.4.7 Restart interlock

The **SD3-A1** is equipped with a restart interlock function. You can select or deselect this function as needed to connected restarting of the machine to a manual approval. It affects all detection zones and does not depend on any detection zone changeovers. For information on how to configure the scanner appropriately, please refer to **SD3SOFT** (Section: “Safety-relevant parameters” folder).

The restart button must be mounted so that

- the entire danger zone (or detection zone area) can be viewed from the operating position.
- it is not possible to directly step or reach into the danger zone or danger point from the operating position.

The button refer to the areas to be enabled in a easily understandable manner.
Please comply with the safety notes in Chapter 3 and 5.4.6.

5.4.8 Calculating the detection zone dimensions for safeguarding an area

According to **IEC 61496-3** and **DIN EN 999**, the following formulas apply for calculating the safety distance and the minimum depth of the detection zone when the direction of approach runs parallel to the detection zone:

$S = (K \times T) + C$
$C = 1{,}200\text{mm} - 0.4H$

$C_{MIN} = 850\text{mm}$
$H_{MIN} = 15\ (d - 50\text{mm})$
$H_{MAX} = 1{,}000\text{mm}$

- S = Safety distance, minimum distance from the danger zone to the point of detection, to the plane of detection, or to the detection zone, in mm
- K = Approach speed of a person or a person's body parts (1,600mm/s), in mm/s
- T = Lag time of the entire system (response time and braking time until standstill), in s
- C = Safety-related constant to consider entry into the danger zone before the protective device is triggered, in mm
- C_{MIN} = Minimum value of the safety-related constant (850mm), in mm
- H = Height of the scanning plane from the reference point, in mm
- H_{MIN} = Minimum height of the scanning plane from the reference plane, in mm
- H_{MAX} = Maximum height of the scanning plane from the reference plane, in mm
- d = Resolution of the scanner (70mm throughout the detection zone), in mm

5.4.8.1 Additions and minimum depth of detection zone

The sum of the system-specific and application-specific detection zone additions (see Chapter 5.3.5) is calculated according to the following formula:

$$Z_{TOT} = Z_{SM} + Z_{REFL} + Z_{AU}$$

Z_{TOT} = Sum of the system-specific and application-specific detection zone additions, in mm

Z_{SM} = Scanner measurement error, in mm

Z_{REFL} = Addition of the reflectors taken into account, in mm

Z_{AU} = Addition for application-specific undercut, in mm

The depth of the detection zone, with reference to the direct distance between the danger zone and the detection point or line, is calculated according to the following formula:

$$S_T = (K \times (T_{SCAN} + T_{MACH} + (T_{LAG} \times L_{LAG}))) + C + Z_{TOT}$$

S_T = Depth of detection zone, distance from danger area to detection point or line, including system and application-specific additions, in mm

K = Approach speed of a person or a person's body parts (1,600mm/s), in mm/s

T_{SCAN} = Response time of the scanner, in s

T_{MACH} = Response time of the machine or system, in s

T_{LAG} = Lag time of the entire system, in s

L_{LAG} = Factor for increase in lag time

C = Safety-related constant, in mm

5.4.8.2 Maximum range of detection zone

$$S_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$$S_{BDIFF} = G_{BDIFF} + S + Z$$

S_{MAX} = Maximum range of the detection zone considering the diagonals, in mm

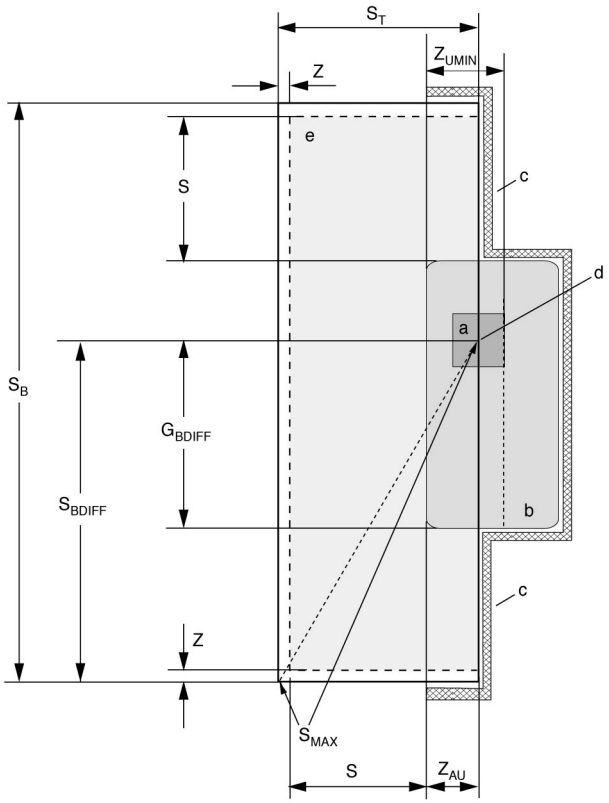
S_T = Depth of the detection zone, in mm

S_{BDIFF} = Largest width of the detection zone between the axis of the rotating mirror and the outer edge of the detection zone, in mm

G_{BDIFF} = Largest width of the danger zone between the axis of the rotating mirror and the boundary of the danger zone, in mm

S = Safety distance, minimum distance from the danger zone to the point of detection, to the plane of detection, or to the detection zone, in mm

Z = Required detection zone additions, in mm



a = **SD3-A1**
b = Dangerous machine / danger zone
c = Safety fence to prevent stepping behind
d = Axis of the rotating mirror
e = Detection zone
G_{BDIFF} = Largest width of the hazardous zone
S = Safety distance
S_B = Entire width of the detection zone
S_{BDIFF} = Largest width of the detection zone
S_{MAX} = Maximum geometrical distance
S_T = Depth of the detection zone
Z_{AU} = Detection zone addition, application-specific
Z = Detection zone additions
Z_{UMIN} = Undercut

Fig. 5.4-5: Considering the maximum measurement distance when safeguarding an area

5.4.8.3 Sample calculation of the depth of a detection zone

This example is based on the following application data (see 5.4-5):

Largest width between the axis of the rotating mirror and the boundary of the danger zone	G_{BDIFF}	700mm
Access speed	K	1,600mm/s (constant)
Response time of the **SD3-A1** (adjustable)	T_{SCAN}	0.08s
Response time of the machine or system	T_{MACH}	0.1s
Stopping time or lag time of the machine or system	T_{LAG}	0.5s (time for braking the dangerous movement until standstill)
Factor for increase in lag time	L_{LAG}	1.1 (fixed addition to account for increased lag time)
Addition for system-specific measurement error	Z_{SM}	83mm (when dust algorithm is switched OFF)
Addition caused by the mounting position that is selected	Z_{AU}	125mm (distance between the front edge of the undercut to the beam axis of the scanner)
Height of the sensor scanning plane	H	300mm
Safety-related constant	C	1,200mm – 0.4 × Height H = 1,080mm

The formula
$$\mathbf{S = (K \times (T_{SCAN} + T_{MACH} + (T_{LAG} \times L_{LAG}))) + C}$$
results in a safety distance of:

$$\mathbf{S = (1{,}600mm/s \times (0.08s + 0.1s + (0.5s \times 1.1))) + 1{,}080mm = 2{,}248mm}$$

The formula
$$\mathbf{S_T = S + Z_{SM} + Z_{AU}}$$
results in the detection zone depth:

$$\mathbf{S_T = 2{,}248mm + 83mm + 125mm = 2{,}456mm}$$

5.4.8.4 Sample calculation of a maximum range of a detection zone

The formulas:

$$S_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$$S_{BDIFF} = G_{BDIFF} + S + Z_{SM}$$

yield, under consideration of the width of the danger zone results in the maximum distance to be monitored:

$$S_{MAX} = \sqrt{2{,}456\text{mm}^2 + 3{,}031\text{mm}^2}$$

$$S_{BDIFF} = 700\text{mm} + 2{,}248\text{mm} + 83\text{mm} = 3{,}031\text{mm}$$

$$S_{MAX} = 3{,}901\text{mm}$$

5.4.8.5 Sample calculation of an undercut

This example is based on the following application data. If the scanner is mounted across from the machine (see Fig. 5.4-4), the undercut dimension can be reduced by d = 70mm.

The formula
$Z_{UMIN} = Z + 83\text{ mm} - d$

results in a minimum undercut:
$Z_{UMIN} = 83\text{ mm} + 83\text{ mm} - 70\text{ mm} = 96\text{ mm}$

It is not allowed for a person to be able to step beneath the undercut.

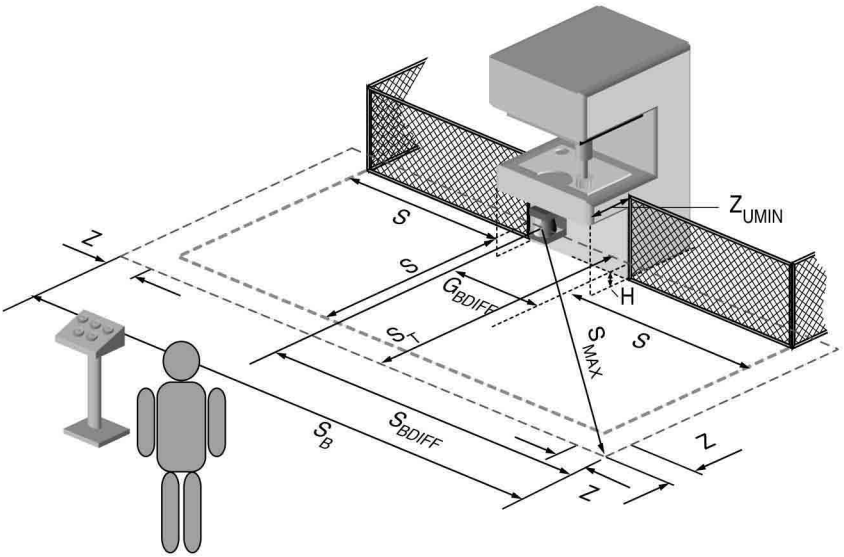


Fig. 5.4-6: The undercut

5.5 Access protection

Please have regard to the general safety notes in Chapter 3.

5.5.1 Object of protection

The object of protection is the safeguarding

- of individuals when they access a danger zone.

The **SD3-A1** will detect the passage of individuals and the intrusion of an entire human body into the scanning field of the laser scanner.

5.5.2 Installation position

Access protection is based on passage monitoring. This is a suitable system when the access to a machine or to a hazardous zone can be precisely defined in structural terms, and there is no other unprotected access to the area. In addition, the danger area must be open to inspection, and the button for manual triggering of the restart interlock must be situated outside the area. It is best if the laser scanner is firmly installed above the passage in question, in vertical alignment and in such a way that it cannot be manipulated. Care must be taken to ensure that the positioning of the laser scanner **SD3-A1** does not leave any areas through which a person might slip through without being detected. The distance of the scanning field limiting the passage and the boundaries of the detection zone must be defined in such a way that no gaps measuring more than 150mm can arise.

5.5.3 Safety-relevant settings, and calculation of the safety distance

To safeguard the protective equipment against inadvertent misadjustment or manipulation, the detection zones of the **SD3-A1** must be defined on the basis of a reference boundary. In addition, the response time must be defined as 80ms and the restart interlock must be set.
To enable the system to recognize an entire human body, the laser scanner must have a resolution of 150mm. These safety-related settings will be automatically enabled in the **SD3SOFT** configuration and diagnosis software when the presetting ”Passage monitoring” has been selected.

For effective passage monitoring, a safety distance S must be observed between the detection zone of the laser scanner and the danger zone. The **SD3-A1** can fulfill its protective function only if it has been installed and positioned in such a way as to allow for an adequate safety distance. The safety distance ensures that no body part whatever can reach the danger point until the hazardous movement of the machine has come to a complete standstill.

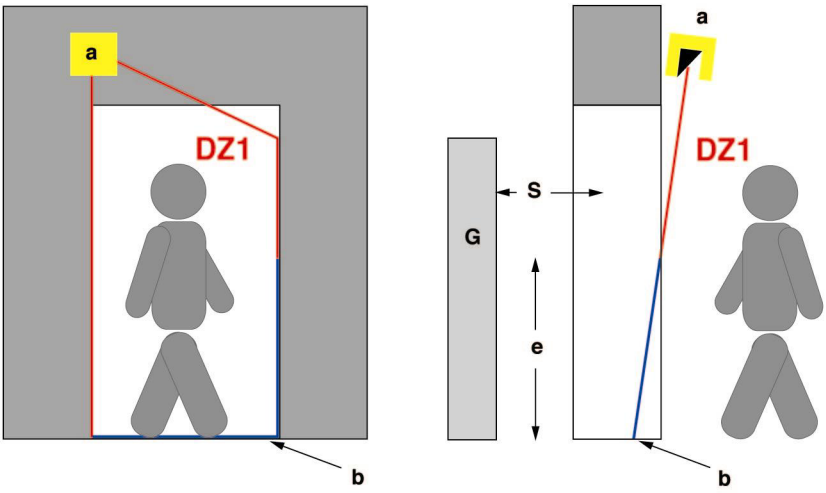
The safety distance for an access protection system may be calculated, based on EN 999 by means of the following formula:

S = K × T + C

S	=	Safety distance, in mm	
K	=	Approach velocity, in mm/s	Here = 1,600mm/s
T	=	Overall time of delay, in s, a total consisting of:	
		Response time of the laser scanner	Here = 80ms
		Overtravel time of the machine including the controls	Based on measurement of overtravel time
C	=	Added margin on account of the possibility of manual intrusion	Here = 850mm

Please also have regard, in this connection, to the diagrams given in this chapter.

5.5.4 Definition of the reference boundary



a	=	**SD3-A1**	DZ1	=	Detection zone 1, enabled
b	=	Reference boundary of the detection zone	S	=	Safety distance
e	=	Height of frame with reference boundary; recommended value: e > 1,200mm	G	=	Danger zone

Fig. 5.5-1: Access protection by passage monitoring with system check of a reference boundary

The reference boundary must cover at least two sides of the detection zone. The detection zone itself must be defined in such a way that no gaps can arise through which a person could pass through the passage without being detected. The reference boundary is defined with reference to the non-moving parts of the passage. These will then be constantly monitored by the laser scanner, so that any individuals intruding or other manipulative intervention will be detected beyond the possibility of doubt. In defining the reference boundary, please also have regard to the indications given in the instruction manual (software operation) for the **SD3SOFT** configuration and diagnosis software.

5.6 Protecting danger points

Please have regard to the general safety notes in Chapter 3.

5.6.1 Object of protection

The object of protection is the safeguarding

- of individuals who work with a machine or spend time in the danger zone associated with it.

The **SD3-A1** will detect the body parts of individuals and the intrusion of these body parts into the scanning field of the laser scanner. In this operating mode, hand and arm protection is effectively realised.

5.6.2 Installation position

Safeguarding of danger points on the basis of hand and arm protection is a suitable method if the machine operator, in close proximity to the danger zone, needs to halt the hazardous movement of the machine or to coordinate the handling of workpieces or their removal from the machine. It is best if the laser scanner is firmly installed above the danger zone, in such a way that it cannot be manipulated. The health and safety officer must ensure that the installation position of the **SD3-A1** does not leave any areas free through which manual intrusion could be effected. If appropriate, additional protective facilities should be installed to exclude any possibility of the operator's reaching over or around or getting behind the barrier. To prevent the latter, the distance from the scanning field to the machine table must not be more than 75mm. This can be guaranteed if suitable screens are installed for the monitoring of the reference boundary (see the illustrations in this chapter).

5.6.3 Safety-related settings, and calculation of the safety distance

In order to safeguard the protective equipment against inadvertent misadjustment and manipulation, the detection zones of the **SD3-A1** must be defined on the basis of a reference boundary. To make it possible to recognise the hand or arm of a person, the laser scanner must have a resolution of 30 or 40mm. These safety-related values will be automatically set in the **SD3SOFT** configuration and diagnosis software when the presetting "Hand protection" or "Arm protection" has been selected. At the same time the detection zone limits will be limited to 1.60m or 2.20m, and cannot be extended beyond this.

To safeguard the danger point, a safety distance S must be observed between the detection zone of the laser scanner and the danger zone. The **SD3-A1** can fulfill its protective function only if it has been installed and positioned in such a way as to allow for an adequate safety distance. The safety distance ensures that no body part whatever can reach the danger point until the hazardous movement of the machine has come to a complete standstill.

The safety distance S when safeguarding a danger point may be calculated, based on EN 999, by means of the following formula:

S = K × T + C

S = Safety distance in mm

K = Approach velocity in mm/s

At a close distance of 500mm, a velocity of 2,000mm/s should be assumed. If the calculation involves a distance in excess of 500mm, K may be taken to be 1,600mm/s. But in this case the safety distance is subject to a minimum value of 500mm.

T = Overall time of delay in seconds, a total consisting of:

Response time of the laser scanner	Adjustable, max. 200ms
Overtravel time of the machine including the controls	Based on measurement of overtravel time

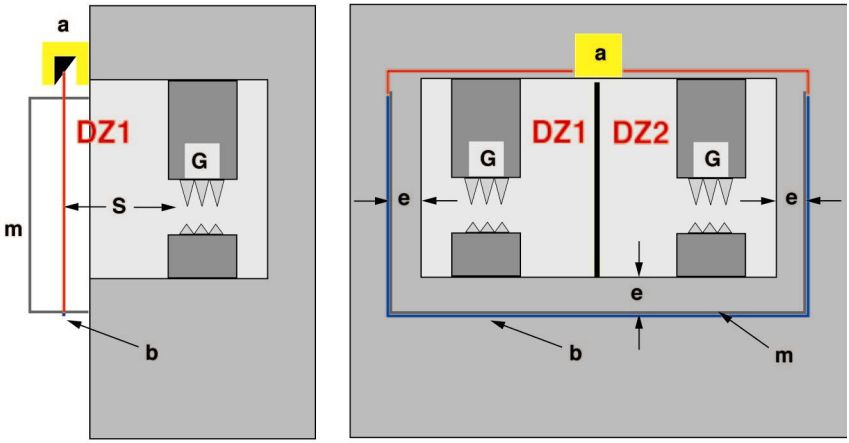
C = 8 × (d - 14) in mm

Added margin dependent on the depth of penetration of the detection zone, based on the resolution of the laser scanner: C (30mm) = 128mm, C (40mm) = 208mm

d = The resolution to which the laser scanner has been set — Here = 30mm or 40mm

In this connection please also have regard to the illustrations given in this chapter.

5.6.4 Defining the reference boundary



a = **SD3-A1**

b = Reference boundary of the detection zone

S = Safety distance

m = Screen

e = Distance from the screen to the intrusion zone of the danger point, e > 150mm (tolerance zone); the reference boundary must be defined with reference to the screen.

DZ1 = Detection zone 1, enabled

DZ2 = Detection zone 2, disabled

G = Danger point

Fig. 5.6-1: Safeguarding of danger point based on hand and arm protection with monitoring of a reference boundary

The reference boundary must cover at least two sides of the detection zone. The detection zone itself must be defined in such a way that no gaps can arise through which or over which a person could reach without being detected. The detection zone must also provide safeguards against a person getting behind the barrier. This can be very effectively managed by screening the sides of the danger zone. The reference boundary should be defined with reference to the non-moving parts of the screen arrangement.
The detection zone must be defined as large enough to ensure an overlapping greater than the tolerance zone of the reference boundary. The detection zone will then be constantly monitored so that any body parts intruding or other manipulative intervention will be detected beyond the possibility of doubt. In defining the reference boundary, please also have regard to the indications given in the instruction manual (software operation) for the **SD3SOFT** configuration and diagnosis software.

5.7 Safeguarding mobile machines

Please comply with the safety notes in Chapter 3.

5.7.1 The purpose of safeguarding

is for protection:

- to protect people when entering variable danger zones
- to protect objects located in the vehicle path
- to protect the automatic guided vehicle and its load

5.7.2 Installing adjacent laser scanners

The **SD3-A1** has been developed in a way that prevents several laser scanners from interfering with one other as much as possible.

An increase in the response time can, however, be caused by the installation of several adjacent laser scanners. If **none** of the constructive measures (section 5.2.1) described in the following sections or the specific adjustment (section 5.2.2) are implemented, **then the SD3-A1 response time set and shown in the configuration and diagnosis software (SD3SOFT) is extended by 40ms.** This extension in the response time must be taken into account when calculating the safety distance!

5.7.3 Mounting position

For the purpose of safeguarding the path of a vehicle, the **SD3-A1** is mounted on the front of a vehicle (in each direction of travel), preferably in the center.

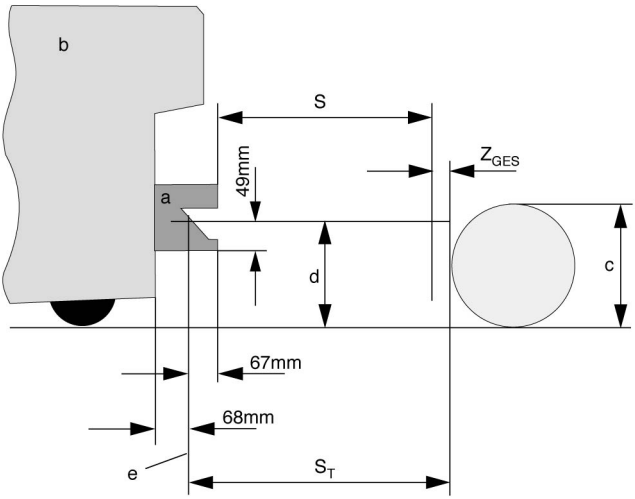
The scanner, and hence the beam axis, must be aligned horizontally in order to achieve a consistent scanning height.

Please comply with the safety notes in Chapter 3.7.

5.7.4 Mounting height

As a rule, the scanner should be mounted as low as possible in order to prevent people from crawling beneath the detection zone. This specification is limited due to such factors as uneven floors or the deflection of the springs in the AGV.

The maximum mounting height must be selected so that an object (cylinder with a diameter of 200mm in the prone position) is reliably detected (see DIN EN 1525). The detection must be tested at the position of maximum depth within the detection zone. For AGV applications, sufficient resolution of detection is achieved when an object (upright cylinder) with a diameter of 70mm can be detected throughout the detection zone.



a = **SD3-A1**
b = AGV
c = Height of the test piece, max. 200mm
d = Recommended maximum height of the scanning plane: 150mm
e = Axis of the rotating mirror
S = Safety distance
S_T = Depth of the detection zone
Z_{GES} = Detection zone additions in the direction of travel

Fig. 5.7-1: Mounting height on an AGV

Depending on the application, further additions may be necessary. Additional information is available in Chapter 5.7.6.

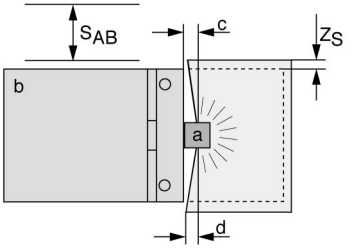
5.7.5 Recommendations for mounting to prevent unmonitored zones

The creation of unmonitored zones is dependent upon the following factors:

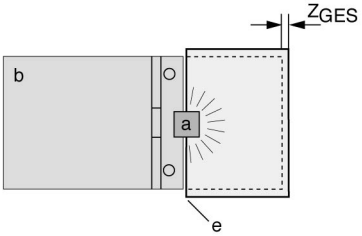
- the vehicle width
- the design of the vehicle (e.g. attachments, shape)
- the position of the scanner
- the installation depth
- the selected angle range.

If the detection zone of a **SD3-A1** mounted on an AGV does not cover the entire front of the vehicle, you can prevent the creation of unmonitored zones by changing the installation depth of the scanner or by adjusting the angle range (from 180° to 190°).

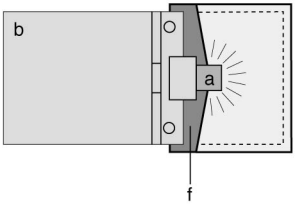
If this is not possible due to constructional limitations, additional safety measures such as mechanical cover panels, switch strips or bumpers must be implemented.
Please comply with the safety notes in Chapter 3.7.



SD3-A1 mounted on the front of a vehicle



SD3-A1 recessed into the front of a vehicle



SD3-A1 mounted on a protruding vehicle

a = **SD3-A1**
b = Automatic guided vehicle
c = The distance from the back wall of the scanner to the axis of the rotating mirror is 68mm.
d = The 190° detection zone enables an expanded monitored range.
e = The detection zone is limited by the scanner recess at the front of the vehicle (180°).
f = The protruding attachment results in the creation of unmonitored zones.
S_{AB} = Lateral safety distance (between the edge of the roadway and the boundary of the detection zone).
Z_{GES} = Sum of the system- and application-specific additions in the direction of travel
Z_S = Sum of the system- and application-specific additions to the side

Fig. 5.7-2: Three possibilities for mounting the **SD3-A1** onto an AGV

5.7.6 Additions

The axis of the rotating mirror (midpoint of the scanner) is of critical importance when configuring the detection zones. This axis is assigned a value of 64mm from the front edge of the scanner when calculating detection zones.

Add **83mm** or **100mm** for the maximum radial measurement error Z_{SM} as described in Chapter 5.3.5.

Add an addition Z_{REFL} as described in Chapter 5.3.5 if reflectors could be present in the area.

Without information from the AGV manufacturer, take into account the wear and tear on the brakes by adding an addition L_{STOP} of at least 10% of the braking distance, as long as this is not already included in the braking distance S_{STOP}.

If there is a very small distance between the bottom of the AGV and the floor, the detection difference between the leg and the toes must be considered in the calculation. For AGVs with a floor clearance of less than 120mm, an addition Z_{AFLR} must be added. This refers only to the travel of direction.

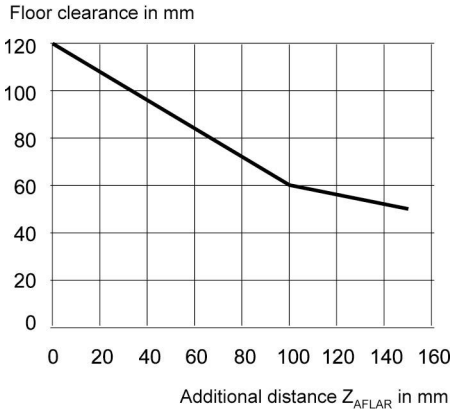


Fig. 5.7-3: Diagram for calculating the addition to compensate for inadequate AGV floor clearance

5.7.7 System availability

There must be a buffer distance of 83mm between the surrounding contour and the detection zone contour (including the additions). This distance increases the up-time of the AGV, since it prevents the surrounding contour from being detected as relevant for generating a switch-off signal due to a measurement error.

Furthermore, the dust algorithm of the **SD3-A1** can be implemented if floating particles may be present in the area. This algorithm can be activated in the user program "**SD3SOFT**" and prevents the AGV from being switched OFF unintentionally. Please note Chapter 5.3.5.

If the danger zone analysis allows a multiple evaluation, detection errors caused by floating particles can be decreased. The number of evaluations that is decisive for the response time of the scanner (T_{SCAN}), and thus also requires a larger detection zone, can be set in the user program "**SD3SOFT**".

In the event of an error event that lasts only briefly (for example the effect of extraneous light) the scanner performs a one-time reboot. If automatic startup / restart are activated, the scanner turns the OSSDs back ON after this brief error event, and after the detection zone has been free for about 25s. This one-time reboot results in an additional increase in availability. This function does not have any effect if detection zone activation is faulty. If startup test, startup interlock and / or manual restart are included, they will not be removed.

Safety notes:
Automatic startup / restart must only be used in cases where there is absolutely no possibility that the effective detection zone could be entered or bypassed in some other way. Depending on the hazard assessment, visual and / or acoustic startup warnings should be provided.

If parameters are set for the function "Manual restart", the required enable from the startup / restart button affects all detection zones and is independent of any detection zone changeover. If the current detection zone is manually enabled, this enable also applies even if the system switches to another detection zone and this detection zone becomes free! If startup / restart interlock is in effect in the current detection zone, it is also in effect for the other detection zone to which the system switches even if this detection zone is free.

5.7.8 Restart

At least 2s must elapse following the release of a violated detection zone before the AGV is allowed to startup again (in accordance with DIN EN 1525). The restart can be initiated either manually or automatically. In case of automatic restart, the delay time of up to 10s can be set in advance using the program "**SD3SOFT**". If a restart button is provided, it must be mounted outside the danger zone at a position from which the entire danger zone can be viewed. The areas that will be released must also be referred to in an easily understandable manner. The startup / restart interlock affects all detection zones and does not depend on any detection zone changeovers.
Please comply with the safety notes in Chapter 3 and Chapter 5.7.7.

5.7.9 Calculating the dimensions of the detection zone of an AGV application

Following are the specifications and calculation examples for the mobile safeguarding of automatic guided vehicles..

According to **IEC 61496-3**, the following formulas apply for calculating the safety distance:

$$S = (V_{MAXAGV} \times T) + S_{STOP}$$

V_{MAXAGV} = Maximum speed of the AGV, in mm/s
T = Response time of the scanner and the AGV, in s
S_{STOP} = Braking distance of the AGV until standstill, in mm

5.7.9.1 Direction-related minimum depth of the detection zone and additions

The depth of the detection zone in the direction of travel, with respect to the distance between the edge of the roadway and the boundary of the detection zone, is calculated according to the following formula:

$$S_T = V_{MAXAGV} \times (T_{SCAN} + T_{AGV}) + (S_{STOP} \times L_{STOP}) + Z_{TOT}$$

S_T = Depth of the detection zone in the direction of travel, in mm
V_{MAXAGV} = Maximum speed of the AGV, in mm/s
T_{SCAN} = Response time of the scanner, in s
T_{AGV} = Response time of the AGV, in s
L_{STOP} = Factor for wear and tear on the brakes
Z_{TOT} = Total of the system- and application-specific additions in the direction of travel in mm

$$Z_{TOT} = Z_{SM} + Z_{REFL} + Z_{AFLR} + Z_{AU}$$

Z_{SM} = Scanner measurement error, in mm
Z_{REFL} = Addition of the reflectors taken into account, in mm
Z_{AFLR} = Addition for inadequate floor clearance by the AGV, in mm
Z_{AU} = Application-specific addition, in mm

5.7.9.2 Maximum range of detection zone

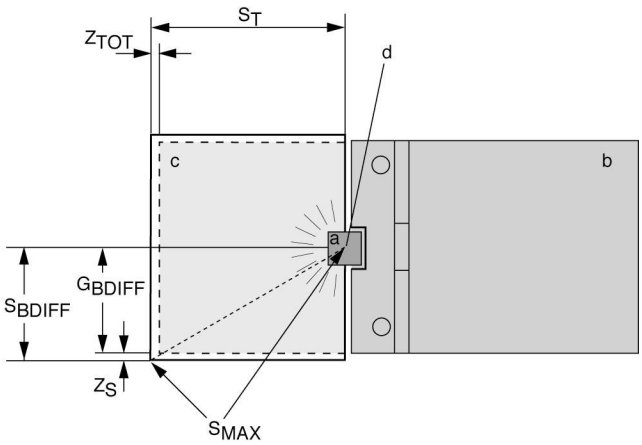
$$S_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}$$

$$S_{BDIFF} = G_{BDIFF} + Z_S$$

S_{MAX} = Maximum range of the detection zone, in mm
S_T = Depth of the detection zone in the direction of travel, in mm
S_{BDIFF} = Largest width of the detection zone, in mm
G_{BDIFF} = Largest width of the danger zone, in mm
Z_S = Sum of the system- and application-specific additions to the side, in mm

$$Z_S = Z_{SM} + Z_{REFL} + Z_{AU}$$

Z_{SM} = Scanner measurement error, in mm
Z_{REFL} = Addition of the reflectors taken into account, in mm (see Chapter 5.3.5)
Z_{AU} = Application-specific addition, in mm



a = **SD3-A1**
b = AGV
c = Detection zone
d = Axis of the rotating mirror
G_{BDIFF} = Largest width of the hazardous zone
S_{BDIFF} = Largest width of the detection zone
S_{MAX} = Geometrical maximum distances
S_T = Depth of the detection zone
Z_{TOT} = Total of the additions in the direction of travel
Z_S = Total of the additions to the side

Fig. 5.7-4: Considering the maximum measurement distance for safeguarding AGVs

In accordance with DIN EN 1525, a minimum safety distance of 0.5m width between the vehicle and its environment must be maintained.

5.7.9.3 Sample calculation of the depth of a detection zone

This example is based on the following typical application data (without access against the direction of travel and without retro-reflectors):

Largest width of the danger zone from the axis of the rotating mirror	= G_{BDIFF}	1,400mm
Maximum speed	= V_{MAXAGV}	1,800mm/s
Response time **SD3-A1** (selectable)	= T_{SCAN}	0.08s
Response time of AGV control	= T_{AGV}	0.1s
Braking distance	= S_{STOP}	1,900mm
Factor for wear and tear on the brakes	= L_{STOP}	1.1 (fixed addition to account for wear and tear on the brakes)
Measurement error	= Z_{SM}	83mm
Distance between AGV and floor	= Z_{AFLR}	90mm (results in an addition of 50mm according to Fig. 5.7-3 for calculating the addition for inadequate floor clearance)

The formula
$$\mathbf{S = V_{MAXAGV} \times (T_{SCAN} + T_{AGV}) + (S_{STOP} \times L_{STOP})}$$

results in a safety distance of:

$$\mathbf{S = 1{,}800mm/s \times (0.08s + 0.1s) + (1{,}900mm \times 1.1)}$$
$$\mathbf{= 2{,}414mm}$$

The formula
$$\mathbf{S_T = S + Z_{SM} + Z_{REFL} + Z_{AFLR} + Z_{AU}}$$

results in the following required depth of the detection zone in the direction of travel:

$$\mathbf{S_T = 2{,}414mm + 83mm + 0mm + 50mm + 0mm = 2{,}547mm}$$

5.7.9.4 Sample calculation of a maximum range of a detection zone

The formula

$$\mathbf{S_{MAX} = \sqrt{S_T^2 + S_{BDIFF}^2}}$$

$$\mathbf{S_{BDIFF} = G_{BDIFF} + Z_S}$$

yields, under consideration of the width of the danger zone results in the maximum distance to be monitored:

$$\mathbf{S_{MAX} = \sqrt{2{,}547mm^2 + 1{,}483mm^2}}$$

$$\mathbf{S_{BDIFF} = 1{,}400mm + 83mm = 1{,}483mm}$$

$$\mathbf{S_{MAX} = 2{,}947mm}$$

5.7.10 Side guarding configuration on AGVs

All previous considerations and the Chapter 5.7.9 (Calculating the dimensions of the detection zone of an AGV application) also apply for side guarding on AGVs. With AGVs that drive along conveyor segments it should always be ensured that big enough undercut is provided (see also, details in Chapter 5.4.4). If the structure of the conveyor segment does not allow an undercut, then it must be assumed that a person is in the space between the vehicle and the conveyor. This is especially the case with spaces of more than 100mm. This person in the space between vehicle and conveyor should be detected simultaneously with a person in the driveway, which must be taken into consideration with the dimensioning of the detection and warning zones.
The same safety distance calculations therefore apply.

A laser scanner resolution of 150mm is required to detect an entire person. This safety-relevant setting is automatically set in the **SD3SOFT** configuration and diagnostics software with selection of the "person detection" presetting. The definition of a reference contour as with access guarding is not necessary, as the approach of the person to be protected is made in the direction of the detection zone! If the conveyor segment height is over 500mm and the distance between vehicle and conveyor is more than 100mm, then the detection zone between vehicle and conveyor can be aligned. With conveyor segment heights below 500mm there is the increased danger of the conveyor segment being crossed over. In this case the alignment of the detection zone with the conveyor edge guarantees detection of a person at this point. If a laser scanner resolution finer than 150mm is additionally required for the safe position detection of the load, then this can also be selected in this application. The person in the in between space continues to be safely detected.

6 Details on Switching Over Detection and Warning Zones

During the course of an optimum machine utilization an alternate infeed or machining cycle often occurs, which brings the most diverse danger areas with it. Automated guided vehicle system applications by their very nature include various danger areas, depending on the operating status. If the approach or presence of people is now to be expected in these areas, the need exists of a precisely adjusting safety system. With its eight switchable and freely configurable detection and warning zones (zone pairs), the **SD3-A1** satisfies multifaceted requirements with regard to guarding the most diverse applications.

The definition of the necessary zone pair contours is possible with the convenient and easy to use configuration and diagnostics software, "**SD3SOFT**".

The zone pairs are activated via the connection of 24V DC to the corresponding control inputs, FP 1 to FP 4, which are provided on the X1 plug of the scanner. Please find detailed information on the scanner connection in Chapter 7.2 and Chapter 9.

If the **SD3-A1** is to be restarted or switching is to be made between different zone pairs, the following points must be observed:

- The zone pair planned for the start must be defined with special consideration of the danger areas valid for this moment.
- The sequence of the monitoring zones to be activated must ensure that the lower threshold of the application-related detection zone minimum values is never crossed.
- With selection of zone pair 8 the monitoring function of the scanner is deactivated, i.e. no detection zones are monitored and the safety outputs (OSSDs) remain constantly active! With zone pair 8 the laser scanner may not be started. Zone pair 8 is planned for application-related situations in which it has been absolutely ensured that there is no danger for any people present. These are, for example, vehicles with crawler mode or in completely partitioned OFF and secured areas, vehicles in approach mode in the area of loading or parking positions, as well as machines in the "setup" operating mode.

Please observe the connection and interface assignment in Chapter 9.5 and the safety notes in Chapter 3.

6.1 Sequence of zone pair switchovers

The **SD3-A1** safety laser scanner has eight detection / warning zones. Switchover between these zone pairs is possible at all times, provided the operating situation allows this. During the switchover process the **SD3-A1** monitors the zone pair activated before the switchover until a new one has been clearly activated. The rules for the switchover depend on the amount of the selected zone pairs and their numbers. The procedures described in the following tables apply.

Table 6.1-1 applies with activation (start or switchover) of zone pairs 1 to 8.

Zone pair	**Control input** **FP 1 – FP 2 – FP 3 – FP 4**	
1	1 - 0 - 0 - 0	Zone pair 1 is active
2	0 - 1 - 0 - 0	Zone pair 2 is active
3	0 - 0 - 1 - 0	Zone pair 3 is active
4	0 - 0 - 0 - 1	Zone pair 4 is active
5	1 - 1 - 1 - 0	Zone pair 5 is active
6	1 - 1 - 0 - 1	Zone pair 6 is active
7	1 - 0 - 1 - 1	Zone pair 7 is active
8	0 - 1 - 1 - 1	Zone pair 8 is active

Table 6.1-1: Connection of control inputs FP 1 to FP 4 with activation of zone pairs 1 to 8

The following points also apply for the switchover:

- The switchover must be made within 40ms, i.e. after 40ms one of the input connections shown in Table 6.1-1 must be valid and provided stable. During the switchover time the old zone pair is monitored; the new one after max. 80ms.
- The switchover process executed by the control unit must concur with the laser scanner's configuration, which was set beforehand with **SD3SOFT**.

If these points are not observed the laser scanner will fail within 40ms and will show this with the additional 2Hz flashing of the green LED 1.

6.2 Practical AGV application (example)

The following example shows the sequence of zone pair changeovers for an efficiently implemented AGV under consideration of the ambient conditions. Please observe the particular danger zone analysis for each detection zone in combination with the corresponding route segments. Also note the safe sequences of changeovers and starts. For information on programming the startup detection zones (detection zones enabled for starting up the scanner) and on determining the sequence in which the detection zones are to be activated, please see the instruction manual (software operation) for the **SD3SOFT**.

Activating an ZP	AGV position	Deactivating an ZP	AGV control of position
ZP 1	Straight section		High speed
ZP 2	2m before the curve	ZP 1	Low speed
ZP 3	Beginning of the curve	ZP 2	Steering lock - curve
ZP 1	Straight section	ZP 3	Steering lock - straight High speed

FP = 1 × detection zone + 1 × warning zone

Table 6.2-1: Practical AGV application

If the AGV is controlled by a PLC, for instance, which corresponds to Category 3 or higher according to DIN EN 954-1, the previous zone pair (ZP) can be deactivated immediately after the next zone pair has been activated, with no time delay.
This results in a faster switching sequence.

The applicable safety guidelines and standards as well as the operating instructions for the systems must be strictly complied with.

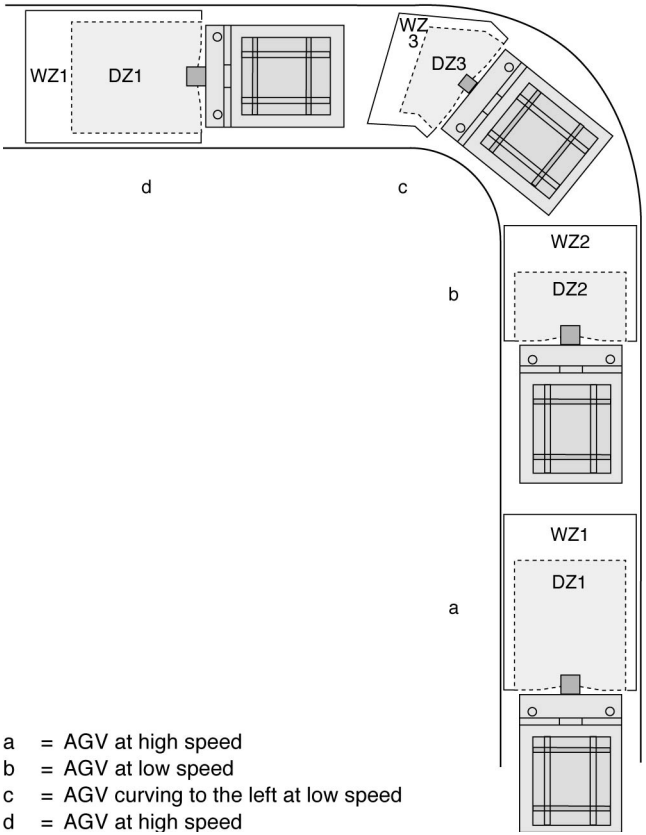


Fig. 6.2-1: Example of a zone pair changeover for an AGV on a curved route

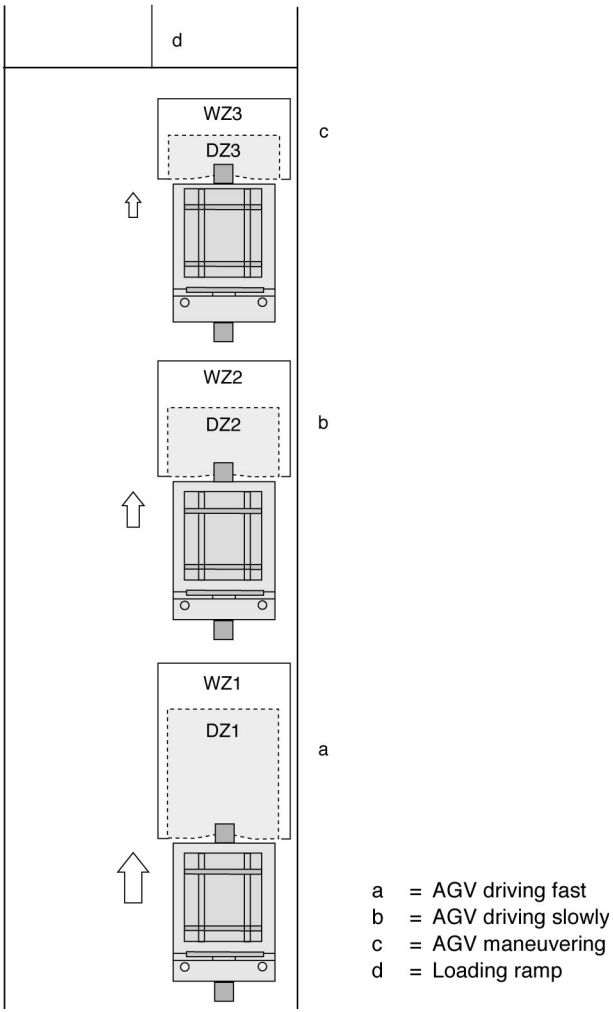


Fig. 6.2-2: Example of zone pair changeover with combined with reducing speed of the AGV

7 Functions of the SD3-A1

The **SD3-A1** is equipped with the X1 and X2 interfaces. The following functions are available through them:

7.1 Restart

Depending on the operating state, the restart input X1-2 has several functions:

- Enables the restart interlock following the interruption of a detection zone
- Enables the start interlock following a system start
- Restarts after a device error has been eliminated
- Recognizes a defined enable signal
  - after a device error
  - after a detection zone interruption for enabling the restart interlock

To activate the functions, apply 24V to input X1-2. In the meantime, the safety outputs OSSD 1 and OSSD 2 are switched OFF; the indicator at the scanner (LED 3) is lit up red. The duration of the signal must be between 0.12s and 5s.

The restart input X1-2 must be connected to an external, permanently installed button. X1-2 must not be connected with the remaining controls in order to prevent an unintended release with a restart pulse under some circumstances.

Force-guided, normally closed contacts can be monitored in the restart circuit (relay monitoring).

Please note the Chapter 5 (Information for Planning and Mounting) and 9.1 (Electrical power supply).

7.2 Channels for zone pair changeovers, FP 1 to FP 4

To activate the zone pairs, apply 24V (see Chapter 9.1) to the following inputs:

- X1-4 (FP 1)
- X1-6 (FP 2)
- X1-7 (FP 3)
- X1-8 (FP 4)

The following points also apply for the switchover:

- The switchover must be made within 40ms, i.e. after 40ms one of the input connections shown in Table 6.1-1 must be valid and provided stable. During the switchover time the old zone pair is monitored; the new one after max. 80ms.
- The switchover process executed by the control unit must concur with the laser scanner's configuration, which was set beforehand with **SD3SOFT**.

If these points are not observed the laser scanner will fail within 40ms and will show this with the additional 2Hz flashing of the green LED 1.

7.3 Alarm 1 (X1-5)

As long as the output X1-5 is switched ON, the system signals trouble-free operation.
If it is switched OFF, the following states are reported:

- Interruption of the warning zone is shown by the continuously lit LED 2 in the indicator field of the scanner.
- Warning state:
  For instance, the system may detect a slight dirt buildup on the optical window. To signal this state, LED 5 on the scanner flashes (2Hz). The user should clean the optical window before it gets dirtier; waiting too long will cause a device error to be reported and the outputs OSSD 1 and OSSD 2 to be switched OFF.
- Device error:
  Such as an erroneous reference measurement or extreme dirt buildup on the optical window. This state is signaled by LED 5 flashing quickly (4Hz).

Both the reporting of a warning zone interruption and the signaling of the warning and error state can be selected either separately or in combination. This procedure is described in the instruction manual (software operation) for the program "**SD3SOFT**".

Output X1-5 is equipped with an internal electronic current limit to protect it against damage from overload.

7.4 Alarm 2 (X1-15)

As long as the output X1-15 is switched ON, the system signals trouble-free operation.
If it is switched OFF, the following states are reported:

- Warning state:
  For instance, the system may detect a slight dirt buildup on the optical window. To signal this state, LED 5 on the scanner flashes (2Hz). The user should clean the optical window before it gets dirtier; waiting too long will cause a device error to be reported and the outputs OSSD 1 and OSSD 2 to be switched OFF.
- Device error:
  Such as an erroneous reference measurement or extreme dirt buildup on the optical window. This state is signaled by LED 5 flashing quickly (4Hz).

Output X1-15 is equipped with an internal electronic current limit to protect it against damage from overload.

7.5 OSSD 1 (X1-12) and OSSD 2 (X1-11)

When the detection zone is interrupted, the two semiconductor outputs switch OFF and, by way of elements such as positively guided relays, cause the monitored machine(s) to shut down.
It is not admissible to control different safety circuits with a single OSSD. Connected loads must exhibit a low-pass behavior in accordance with the plausibility control conducted by the scanner ($f_g \leq 1kHz$, $C_L \leq 100nF$). The OSSDs are equipped with an internal electronic current limit to protect them against damage from overload.

For some sample connections, see Chapter 8.

7.6 Data communication

The interface X2 allows the **SD3-A1** to support two types of connections to the PC.

Communication via the X2 connector in RS-232 mode does not require any further bridging. To enable data transfer in RS-422 mode, connect pin 5 with pin 6. The scanner automatically adjusts itself to the appropriate transfer type and baud rate.

The interface (X2) is used for

- configuring and setting parameters for the **SD3-A1**
- transferring measurement data while the scanner is in operation
- evaluating the coordinates during parameter setting (e.g. for AGV applications)
- advanced status and control diagnostics.

Guard operation is only permitted with the PC cable (X2) or dummy connected screwed ON. This also applies for transport and storage.

Please note the pin assignments specified in Chapter 9.5. For additional information on using the X2 interface, refer to the instruction manual (software operation) for the program "**SD3SOFT**".

8 Integrating the SD3-A1 into Machine Controls

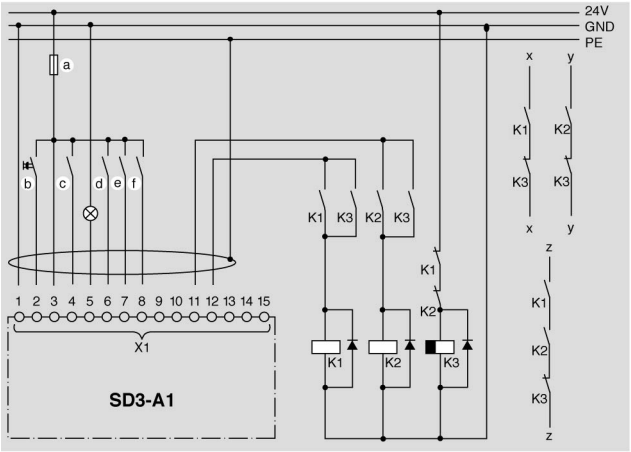
The following examples illustrate possibilities for integrating the **SD3-A1** into machine controls.

Once the operating voltage pin X1-3 ($+U_B$) has been connected to pin X1-1 (GND) and a detection zone has been activated (X1-4, X1-6, X1-7 or X1-8), the unit is ready for operation.

Please see the point "Define Detection / Warning Zones" in the instruction manual (software operation) for the program "**SD3SOFT**".

8.1 Integrating the SD3-A1 with external wiring with relays and eightfold zone pair changeover

In this connection example, the restart interlock function is provided by the connected command unit “start interlock”, which applies the voltage of 24V to the input RESTART X1-2. The **SD3-A1** itself must be configured using the “**SD3SOFT**” user software so that the operating mode “with restart interlock” is active.



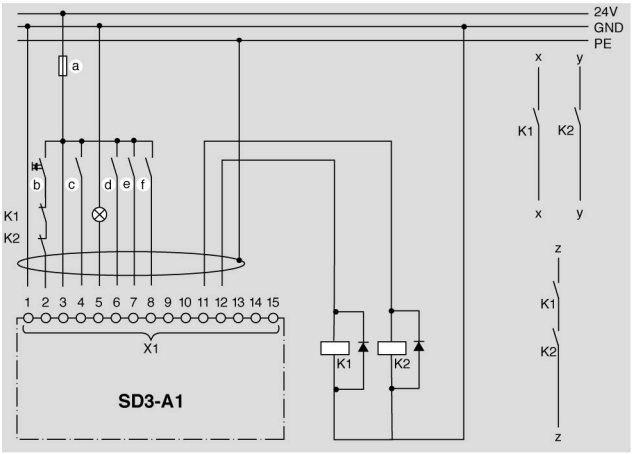
a = Fuse 1.25A, semi time-lag
b = RESTART button
c = DZ 1 / WZ 1
d = DZ 2 / WZ 2
e = DZ 3 / WZ 3
f = DZ 4 / WZ 4

Fig. 8.1-1: Wiring the **SD3-A1** with evaluation of the OSSDs, zone pair changeover and restart interlock (example)

Relays K1 and K2 must have forced contacts. They are operated directly at the two failsafe semiconductor outputs OSSD 1 (X1-12) and OSSD 2 (X1-11).
Relay K3 has a deenergizing delay. A suitable mechanism must be provided for extinguishing sparks. Please note that doing this will cause the switching time to be extended.

Channels “x” and “y” must be integrated for Category 3 in accordance with DIN EN 954-1. Integrating one channel based on “z” is only permitted with a one-channel control system and taking into consideration the results of a risk analysis.

Serial machine controls are admissible only insofar the valid regulations allow.



a = Fuse 1.25A, semi time-lag
b = RESTART button
c = DZ 1 / WZ 1
d = DZ 2 / WZ 2
e = DZ 3 / WZ 3
f = DZ 4 / WZ 4

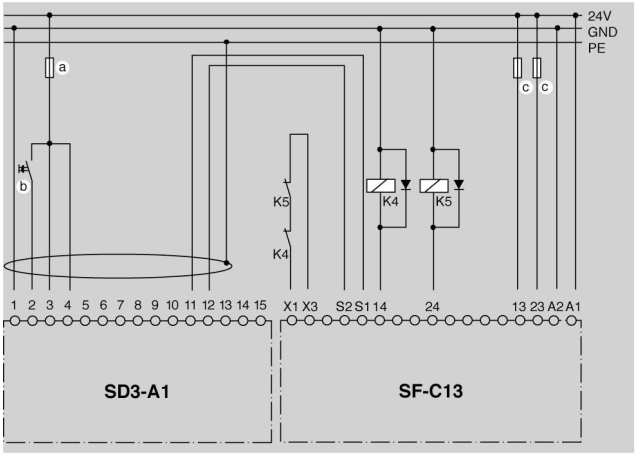
Fig. 8.1-2: Wiring the **SD3-A1** with evaluation of the OSSDs, zone pair changeover, restart interlock and static relay monitoring

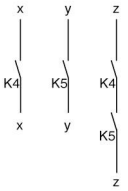
Relays K1 and K2 must have forced contacts. They are operated directly at the two failsafe semiconductor outputs OSSD 1 (X1-12) and OSSD 2 (X1-11).
A suitable mechanism must be provided for extinguishing sparks. Please note that doing this will cause the switching time to be extended.

Channels “x” and “y” must be integrated for Category 3 in accordance with DIN EN 954-1. Integrating one channel based on “z” is only permitted with a one-channel control system and taking into consideration the results of a risk analysis.

Serial machine controls are admissible only insofar the valid regulations allow.

8.2 Connecting the SD3-A1 to a safety sequence circuit with manual restart interlock, relay monitoring, without zone pair changeover





a = Fuse 1.25A, semi time-lag
b = RESTART button
c = Fuse 4A, delay-action

Fig. 8.2-1: Wiring the **SD3-A1** with manual restart interlock and relay monitoring, and without zone pair changeover

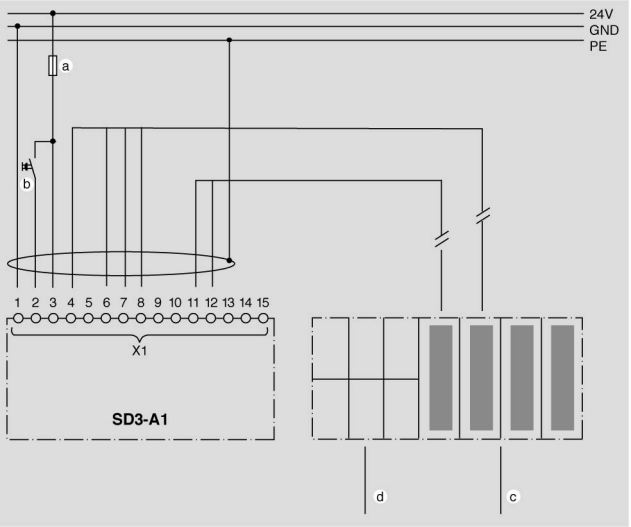
In this example, the relay monitoring is performed by an external safety module (e.g. **SRB 324ST**). Relays K4 and K5 must be equipped with positively guided contacts. A suitable mechanism must be provided for extinguishing sparks. Please note that doing this will cause the switching time to be extended.

Please refer to the operating instructions for the components.

Channels “x” and “y” must be integrated for Category 3 in accordance with DIN EN 954-1. Integrating one channel based on “z” is only permitted with a one-channel control system and taking into consideration the results of a risk analysis.

Serial machine controls are admissible only insofar the valid regulations allow.

8.3 Connecting the SD3-A1 to a PLC with corresponding safety level (Category 3 or higher, EN 954) and zone pair changeover



a = Fuse 1.25A
b = RESTART button
c = Decentralized peripherals
d = Further processing by a failsafe PLC

Fig. 8.3-1: Connecting the **SD3-A1** to a failsafe PLC with a safety level (at least Category 3, EN 954) and zone pair changeover (example)

All switching functions in this sample connection are controlled directly by the PLC.

The changeover of 4 zone pairs is achieved by way of the inputs X1-4 (FP 1), X1-6 (FP 2) X1-7 (FP 3) and X1-8 (FP 4).

For applications in which the scanner must be separately enabled for its detection zone, the signal can be given either by the machine controls or by connecting a command unit for restart interlock. The **SD3-A1** itself must be configured using the "**SD3SOFT**" user program so that the operating mode "with restart interlock" is active.

9 Electrical Connection

9.1 Electrical power supply

The **SD3-A1** requires a direct voltage of 24V and 8W of power plus the load at the outputs (max. 25W).

The power must be supplied by way of an external 1.25A, semi time-lag fuse (e.g. in an electronics cabinet). In addition, a permanent current of 2.5A must be ensured before safeguarding begins in order to guarantee that the fuse will be triggered in case of a fault.

In keeping with electrical safety requirements, the power to the **SD3-A1** all connected input and output circuits must be provided by a power supply unit with protective isolation from a safety transformer according to IEC 742 or comparable (this also applies for the use of battery chargers for AGV applications).

9.2 Connecting the PC and control cables to the scanner

Two connector adapters with cable screw coupling are supplied with the **SD3-A1**. Two of these are needed to accommodate the 9-pin Sub-D connector and the 15-pin Sub-D jack (PC cable and control cable). A housing is used as protection of the X2 interface when data communication with the PC is not desired.

The cable screw couplings can accommodate cable diameters from 6.5mm to 10.5mm.

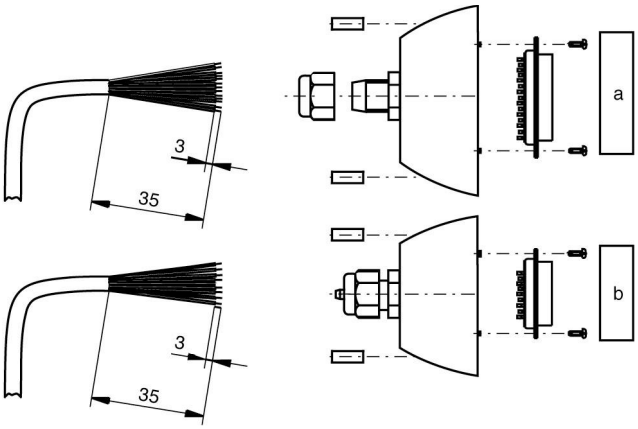


Fig. 9.2-1: Preparing the connectors

The connector adapter of control cable X1 must be connected with interface X1 and screwed tightly to the **SD3-A1**. The connector adapter of cable X2, or else the X2 dummy cap (without a cable), must also be screwed tightly to the **SD3-A1**. Screw thread bolts are located on the top of the scanner housing for this purpose. If one of the two connection housings is missing, the **SD3-A1** no longer meets the requirements of protection type 65. For information on the assignment of the connector, please refer to Chapter 2.2 and 9.5.

9.3 Connector assembly

Every connector adapter consists of the following individual parts:

- Housing with sealing ring and fastening nuts
- Cable screw coupling (M16) with dummy plugs
- Sub-D9 connector and / or Sub-D15 jack, each with a solder connection

9.4 Points to consider when preparing and laying the cables

- The cross-section of cable X1 must be at least 0.5mm^2.
- The outer diameter of the cable must be between 6.5mm and 10mm.
- The maximum cable length for X1 is 50m.
- The maximum cable length for X2 is 10m (for RS-232).
- The maximum cable length for X2 is 50m (for RS-422, twisted pair).
- Use shielded cables.
- Connect the cable shielding with PE to the electronics cabinet only.
- The cables must not be laid loose.

Scanner control cables may not be laid in a stand parallel to power supply cables for machines. This minimizes the effects of inductive interference factors from motors carrying high current. In addition, the cables should be laid so that they cannot be damaged (e.g. by being crushed or pinched).

Cabling prepared for connection to the scanner is available as an optional accessory in various lengths and for both interfaces. For further information, see Chapter 13.

9.5 Interface pin assignments

Pin assignments for connector X1

PIN	Signal	Description
1	GND	Power supply ground
2	Restart	Input, scanner reset, and connecting of the restart button
3	UB	24V DC power supply; protected by a 1.25A delayed-action fuse
4	FP 1	Zone pair control input
5	Alarm 1	Semiconductor output that switches OFF when the warning zone is violated as well as for warning messages such as “optical window slightly dirty”, error messages such as “optical window very dirty”, and for internal errors (the functions can also be selected in combination).
6	FP 2	Zone pair control input
7	FP 3	Zone pair control input
8	FP 4	Zone pair control input
9	Reserved	Internally connected
10	Reserved	Internally connected
11	OSSD 1	Semiconductor output, switches OFF when the detection zone is violated, Channel 1
12	OSSD 2	Semiconductor output, switches OFF when the detection zone is violated, Channel 2
13	Reserved	Internally connected
14	Reserved	Internally connected
15	Alarm 2	Semiconductor output with shut-off when warning and malfunction message

Table 9.5-1: Pin assignments for connector X1

Pin assignments for connector X2 used as an RS-232 port

PIN	Signal	Description
1	Reserved	Internally connected
2	TxD	Data communication, transmit
3	RxD	Data communication, receive
4	Reserved	Internally connected
5	GND / shield	Ground / shield
6	RS-232	Internally connected
7	N.C.	Do not assign
8	N.C.	Do not assign
9	Reserved	Reserved for testing purposes

Table 9.5-2: Pin assignments for connector X2 used as an RS-232 port

Pin assignments for connector X2 used as an RS-422 port

PIN	Signal	Description
1	Tx +	Data communication, receive
2	Tx -	Data communication, receive
3	Rx -	Data communication, transmit
4	Rx +	Data communication, transmit
5	GND / shield	Ground / shield
6	RS-422	Select RS-422 interface by connecting a bridge to pin 5
7	NC	Do not assign
8	NC	Do not assign
9	Reserved	Reserved for testing purposes

Table 9.5-3: Pin assignments for connector X2 used as an RS-422 port

For the pin arrangement, please refer to Chapter 2.2 and 9.5 in the instruction manual (connection and operation) of the **SD3-A1**.

10 Commissioning

Communication with the PC needs to be established so that the **SD3-A1** can be configured and the detection zones and warning zones can be programmed. This is also necessary for displaying the measurement contours and for the system check.

The program "**SD3SOFT**", which is included with delivery, makes this easy and convenient to do. Refer to the instruction manual (software operation) to find additional important information and helpful explanations.

10.1 Hardware and software requirements

The following components are required for the initial startup:

- **SD3-A1**
- RS-232 interface cable (1:1, without cross-connection)
- Shielded control cable for the power supply and for activating a zone pair
- Power supply that meets the requirements specified in Chapter 9.1
- PC, color monitor
- "**SD3SOFT**" program

The PC should fulfill the following requirements:

- Intel® processor, Pentium® class or higher (or compatible models such as AMD® or Cyrix®)
- At least 64MB RAM
- CD drive
- Hard drive with at least 50MB of free memory (more if detection zone data and / or configuration data are going to be stored)
- Mouse
- Interface RS-232 (serial)
- Microsoft® Windows 95 / 98 / NT® / 2000 / XP®

10.2 Installing "SD3SOFT" and starting up the SD3-A1

- First, run the installation program "start.exe" in order to install the program on the PC.
- Start the software by calling up the program.
- Connect the control cable and the PC cable.
- Then apply the supply voltage to the **SD3-A1**. The scanner will now attempt to communicate with the PC; this process is displayed on the screen.

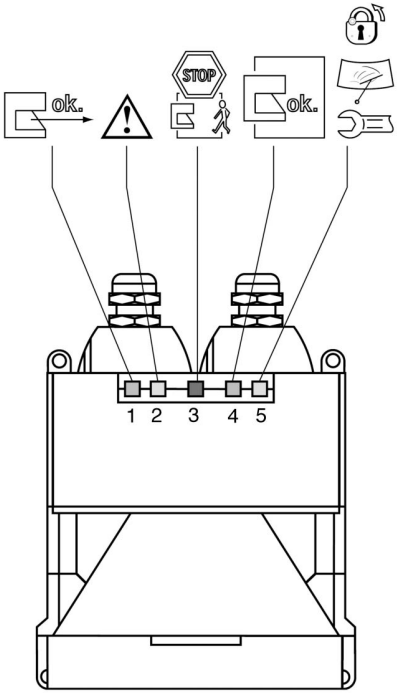
- When the connection between the **SD3-A1** and the PC was successful, you can enter the appropriate password and then change the parameters and zone pairs of the **SD3-A1** to meet the needs of the particular application.
  The standard password to be entered in the access level "Authorized User" of the SD3-A1 is: "SD3SUNX". Please note that the password must be changed following the initial configuration of the scanner, and that the data carrier must be kept locked up in a secure location.
- The **SD3-A1** is ready for operation once the scanner settings and detection zone configurations have been transferred.

Every **SD3-A1** is factory-equipped with the maximum safety parameters. For this reason, first the device settings and then the detection zones must be adapted to the requirements of the application before the scanner is put into operation. After configuring the scanner, remove the PC interface cable from position X2, put on the dummy cap provided with delivery, and screw it tight.

For a list of parameters, please see the instruction manual (software operation) for the **SD3SOFT**.
Please observe Chapter 11, Maintenance and Testing.

10.3 SD3-A1 status indicator

There are five LEDs located on the front of the scanner behind the cover with the matte finish. These LEDs indicate the status of the **SD3-A1**.



Association to function:

Easy-to-interpret pictographs on **SD3-A1** provide information on the meaning of the LEDs

1 = Green
2 = Yellow
3 = Red
4 = Green
5 = Yellow

Fig. 10.3-1: The **SD3-A1** status indicator

Meaning of the individual LEDs

LED	Color	Function / Meaning	Pictograph
1	Green	• Sensor function is active, active detection zone is free • Fault input zone pairs, Light flashing at 2Hz	
2	Yellow	• Configuration conflict, Light flashing at 4Hz • Warning zone is assigned	
3	Red	OSSD outputs are switched OFF	
4	Green	OSSD outputs are switched ON	
5	Yellow	• Constantly lit: Start interlock Restart interlock • Flashing slowly (1): Warning message (approx. 2Hz) Optical window dirty • Flashing quickly (((1))): device message (approx. 4Hz)	

Table 10.3-1: Meaning of the **SD3-A1** LED displays

10.4 Status information of the SD3-A1

Scanner display LED numbers 1	2	3	4	5	Indicator	Status
–	–	1	0	–	LED 3	The OSSD outputs are switched OFF (e.g. during booting).
1	0	0	1	0	LED 1 LED 4	The sensor function is active (measurement operation without an interruption of the activated zone pair). The OSSDs are switched “active high”.
1	1	0	1	0	LED 1 LED 2 LED 4	The sensor function is active (measurement operation without a violation of the activated detection zone). Violation of the activated warning zone. The OSSDs are switched “active high”.
0	1	1	0	–	LED 2 LED 3	Violation of the warning zone. Violation of the detection zone. The OSSDs are switched OFF.
1	0	0	1	(1)	LED 1 LED 4 LED 5	The sensor function is active (measurement operation without a violation of the activated detection zone). The OSSDs are switched “active high”. Warning message signaled by slow flashing at approx. 2Hz (e.g. with optical window dirty)
0	0	1	0	(((1)))	LED 3 LED 5	The OSSDs are switched OFF. Fault message indicated by fast flashing at about 4Hz (e.g. with defect or safety-related fault)
1	0	1	0	1	LED 1 LED 3 LED 5	The sensor function is active (measurement operation without an interruption of the activated zone pair). The OSSDs are switched OFF. Restart interlock is active.
0	1	1	0	1	LED 3 LED 5	Interruption of the zone pair. The OSSDs are switched OFF. Restart interlock is active.

1 = LED is lit up
0 = LED is dark
– = Undefined

Table 10.4-1: Status information of the **SD3-A1**

Upon delivery, the **SD3-A1** is programmed with the largest possible detection zone and with activated startup interlock and manual restart. For this reason, LED 5 is constantly lit up when the scanner is switched ON. When starting up your **SD3-A1**, please modify the parameters to meet the specific needs of your application.

10.5 Restart and device swap-out

The **SD3-A1** can be connected via the X1 standard plug or the ConfigPlug with integrated configuration memory. With a restart the laser scanner starts in every case with the configuration that was set when it went out of operation. Thereafter a technical expert does not have to look at it, but the test in accordance with the specifications for daily testing must be performed.
With a device exchange, however, the procedure is different!

When the X1 standard plug is used the configuration must be transferred with the PC to the replacement device. All procedures and specifications of the first startup apply here. A technical expert should look at the device!

If the ConfigPlug is used with integrated configuration memory, the **SD3-A1** reads the saved configuration automatically from the ConfigPlug when it is switched ON. The ConfigPlug must be clearly identified with a nameplate and the switch in the plug must be at the "1" (left) default position. During the startup with the automatic configuration read-back, the laser scanner signals the successful transfer with a brief flashing of the two yellow LEDs 2 and 5. In this case it does not have to be looked at by a technical expert, but the test in accordance with the specifications for daily testing must also be performed.

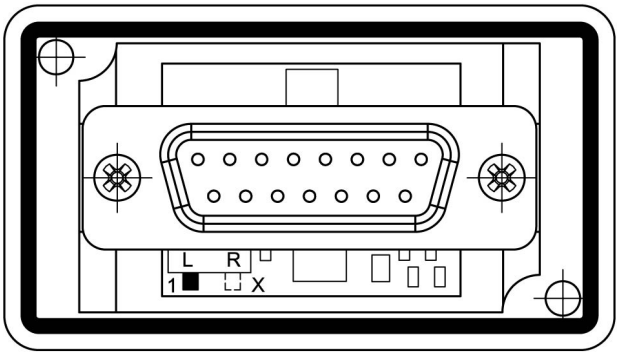


Fig. 10.5-1: **SD3-A1** ConfigPlug with switch setting "1"

11 Maintenance and Testing

When placing the system in service for the first time, when it has been out of service for some time, after conversions and repair work, make certain the scanner and any other safety parts are checked specifically for the application and operation by the responsible trained specialist. This must be done taking into consideration applicable local requirements, especially for guidelines on machines and using work material and work safety guidelines. If the correct functionality is not clearly confirmed or if safety-related parameters have been changed, turn OFF the machine or vehicle immediately. Provisional measures are not permitted.
Please comply with the safety notes in Chapter 3!

11.1 Test before first startup by person qualified and authorized to perform the task

- Check in accordance with the guidelines cited above, using the checklists provided following if necessary to verify that the protective equipment has been properly attached is connected to the control system electrically and that its effect works in all operating modes of the machine or vehicle.
- The result of the test must be documented, along with the scanner setting, in an understandable form. Printouts of scanner parameters and all defined detection zone contours must be included with the materials. Keep these where they are inaccessible for unauthorized personnel.
- During initial startup, you should anticipate unexpected behavior in the machine or vehicle. Because of this, people must be kept out of the danger area.
- Operating personnel must be instructed by trained specialists before starting work. Instruction is part of the area of responsibility of the machine operator.
- Ensure that a daily test is performed. Please take note in this regard of the “Daily test with the test piece performed by responsible operating personnel”.

11.2 Extended shutdown of the SD3-A1

If a system is taken out of operation and the **SD3-A1** is placed in storage for later use with other machines / vehicles, the factory settings should be restored. Please see the chapter entitled “Set default configuration values” in the instruction manual (software operation) for the **SD3SOFT**.

11.3 Regular tests by a person qualified and authorized to perform the task

Regular tests must be performed taking into consideration applicable local requirements, especially for guidelines on machines and using work material and work safety guidelines. The purpose of these tests is to discover changes (for example lag times) or manipulations on a machine, vehicle or piece of safety equipment.
To do this, see the checklists under Chapter 11.5 or 11.6

- Have the effectiveness of the safety equipment checked within the required periods, but at least once a year by a trained and knowledgeable person.
- The checklists mentioned above are ideal for regular tests, especially checks for safety-related changes to the machine, the vehicle or the piece of safety equipment.

11.4 Daily test by with test piece performed by responsible operating personnel

The **SD3-A1** is a safety-oriented laser scanner of Category 3. It is extremely important, however, to check the effectiveness of the detection zone with the test piece daily or after a shift change. This ensures that if the parameters or operating mode is changed, the protective function is ensured at every point in the detection zone.

11.4.1 Checklist for daily test of stationary applications by responsible operating personnel

1)	Are there any problems in the external state of the protective equipment, the cable, cable connections and any command devices?	Yes	No
2)	Are the fastening screws in the mounting system firmly tightened?	Yes	No
3)	Are the fastening screws in the **SD3-A1** firmly tightened?	Yes	No
4)	Are both protective caps (X1 and X2) screwed on and are the firmly in place?	Yes	No
5)	Do the safety equipment and command devices show any safety-relevant changes or gaps in safety (e.g. changes in access possibilities or changes in the surrounding area)?	Yes	No
6)	If the protective function of the **SD3-A1** is present for all required monitoring cases (e.g. testing the switch-off function with a test piece along the detection zone contour), the LED 3 for **SD3-A1** must light up with each attempt and the movement that poses a danger must be stopped immediately. Possibility of danger to the person running the test must be excluded?	Yes	No
7)	Is the startup test / restart interlock (if there is one) working?	Yes	No
8)	Does the base marking match the detection zone contour?	Yes	No
9)	Do the necessary detection zones match the configuration protocol?	Yes	No
10)	If correct functionality is not certain or id the **SD3-A1** LED 5 is flashing, take the machine out of operation immediately. Are any doubts resolved?	Yes	No

If the answer to any of the questions above is No, the machine should be checked by a trained specialist.

11.4.2 Checklist for daily test of mobile applications by responsible operating personnel

1)	Are there any problems in the external state of the protective equipment, the cable, cable connections and any command devices?	Yes	No
2)	Are the fastening screws in the mounting system firmly tightened?	Yes	No
3)	Are the fastening screws in the **SD3-A1** firmly tightened?	Yes	No
4)	Are both protective caps (X1 and X2) screwed on and are the firmly in place?	Yes	No
5)	Do the safety equipment and command devices show any safety-relevant changes or gaps in safety (e.g. by widening the vehicle)?	Yes	No
6)	If the protective function of the **SD3-A1** is present for all required monitoring cases (e.g. testing the switch-off function with a test piece along the detection zone contour, the LED 3 for **SD3-A1** must light up with each attempt and the movement that poses a danger must be stopped immediately. Possibility of danger to the person running the test must be excluded)?	Yes	No
7)	Does the vehicle actually stop within the limits defined by the responsible specialist (test of switch-off function using a test piece. Is the possibility of danger to the person running the test excluded)?	Yes	No
8)	Is the startup test / restart interlock (if there is one) working?	Yes	No
9)	Do the necessary detection zones match the configuration protocol?	Yes	No
10)	If correct functionality is not certain or id the **SD3-A1** LED 5 is flashing, take the vehicle out of operation immediately. Are any doubts resolved?	Yes	No

If the answer to any of the questions above is No, the vehicle should be checked by a trained specialist.

11.5 Checklist for testing stationary applications

The following checklist represents an aid. It helps in, but does not replace the test before the initial startup as well as the regular tests performed by a trained specialist.

1)	Is the mounting position and adjustment of the **SD3-A1** correct and is the possibility of misusing the **SD3-A1** (for example to climb on excluded)?	Yes	No
2)	Is the external condition of the additional safety equipment and control devices free of problems?	Yes	No
3)	Are all connection pieces and connection cables in flawless condition?	Yes	No
4)	Are the two safety outputs (OSSDs) connected to the following machine control system in accordance with the corresponding safety category?	Yes	No
5)	Are the following switch elements that are controlled by the **SD3-A1**, for example contactors with forced contacts or safety valves monitored by the feedback loop (EDM)?	Yes	No
6)	Does the actual connection of the **SD3-A1** to the machine control system match the circuit diagrams?	Yes	No
7)	Was the safety distance calculated according to the applicable formulas for safeguarding danger areas and is this minimum distance observed between the detection zone contour and the danger areas?	Yes	No
8)	Is the effect of any potentially reflective surfaces taken into consideration with an addition in the calculation of the safety-related distance? As an alternate solution, have the surfaces been changed (e.g. matted)?	Yes	No
9)	Does the risk assessment take into account the fact that detection zone heights above 300mm are considered high enough to crawl under in the Standard (EN 999)?	Yes	No
10)	Is access to the danger area only possible through the activated detection zone of the **SD3-A1** in question, or are other entrance or access possibilities safeguarded with suitable safety parts, for example guard fences?	Yes	No
11)	Is the possibility of being between the activated detection zone and the danger area reliably ruled out?	Yes	No
12)	Is an installed protection to prevent walking behind (e.g. undercut) in effect?	Yes	No
13)	Is the **SD3-A1** able to cover the entire danger area? Are dead zones excluded?	Yes	No

14) Has the effectiveness of the activated detection zone been tested with the black test piece (70mm diameter)?	Yes	No
15) Does the base mark match the correctly identified detection zone?	Yes	No
16) Is the start / restart button for resetting the **SD3-A1** positioned according to requirements and does it work properly?	Yes	No
17) Does the **SD3-A1** work in all necessary operating modes and during the entire motion of the machine that is causing a hazard?	Yes	No
18) Is the motion causing the hazard stopped when electrical power to the **SD3-A1** is disconnected and is a confirmation of the start / restart button necessary to reset the machine after the power is restored?	Yes	No
19) Are all test and parameter inaccessible to unauthorized personnel?	Yes	No
20) Is an identifying sign placed on the machine for the daily test of the **SD3-A1** where it is clearly visible for operating personnel?	Yes	No

11.6 Checklist for testing mobile applications

The following checklist represents an aid. It helps in, but does not replace the test before the initial startup as well as the regular tests performed by a trained specialist.

1)	Is the mounting position and adjustment of the **SD3-A1** correct and is the possibility of misusing the **SD3-A1** (for example to climb on excluded)?	Yes	No
2)	Is the external condition of the additional safety equipment and control devices free of problems?	Yes	No
3)	Are all connection pieces and connection cables in flawless condition?	Yes	No
4)	Are the two safety outputs (OSSDs) connected to the following vehicle control system in accordance with the corresponding safety category?	Yes	No
5)	Are the following switch elements that are controlled by the **SD3-A1**, for example contactors with forced contacts or safety valves monitored by the feedback loop (EDM)?	Yes	No
6)	Does the actual connection of the **SD3-A1** to the vehicle control system match the circuit diagrams?	Yes	No
7)	Has the safety distance for safeguarding automatic guided vehicles (AGV) been calculated and observed according to applicable formulas?	Yes	No
8)	Is the effect of any potentially reflective surfaces taken into consideration with an addition in the calculation of the safety-related distance? As an alternate solution, have the surfaces been changed (e.g. matted)?	Yes	No
9)	Does the risk assessment take into consideration the fact that the height of the detection zone must be as low as possible (DIN EN 1525)?	Yes	No
10)	Is an installed protection to prevent walking behind (recessing the **SD3-A1**) in effect?	Yes	No
11)	Has the effectiveness of the activated detection zone been tested with the black test pieces (70mm diameter standing and 200mm diameter on their sides)?	Yes	No
12)	Is the start / restart button for resetting the **SD3-A1** positioned according to requirements and does it work properly?	Yes	No
13)	Does the **SD3-A1** work in all necessary operating modes and during the entire motion of the vehicle that is causing a hazard?	Yes	No

14) Is the motion causing the hazard stopped when electrical power to the **SD3-A1** is disconnected and is a confirmation of the start / restart button necessary to reset the vehicle after the power is restored? Yes No

15) Are all test and parameter inaccessible to unauthorized personnel? Yes No

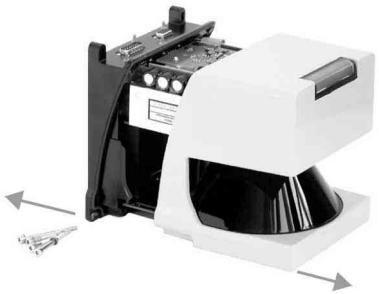
16) Is an identifying sign placed on the machine for the daily test of the **SD3-A1** where it is clearly visible for operating personnel? Yes No

11.7 Replacing the optical window

11.7.1 General information:

- Only professionally trained personnel are permitted to replace optical windows.
- Be careful everything stays clean during all jobs (If possible, work in a dust-free environment. An adverse environment is not good for working on the device).

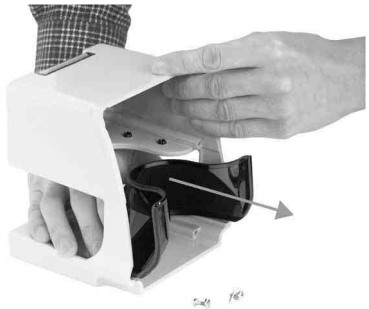
1) Loosening the housing parts



Loosen the four Allen screws on the rear housing wall.
Take the two housing parts carefully apart from each other and place them on a level surface.

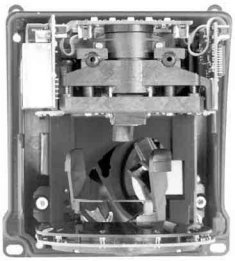
2) Dismounting the optical window

Loosen the screws on the fastening straps.
Remove the fastening straps



Press the old optical window out through the rear (through the housing)

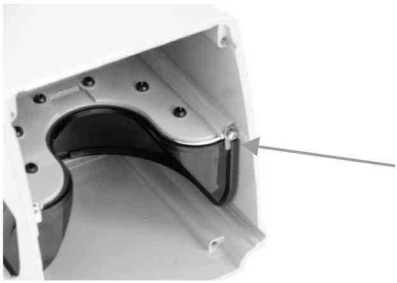
3) Checking the condition of the scanner



Please do not fail to observe:
Check the mirror, optics and housing parts to make certain they are free of dust. Dry if necessary with a dry, oil-free, light jet of compressed air with appropriate components. Do not touch any parts in the device. Avoid leaving fingerprints (grease from fingers may cause the device to function improperly).

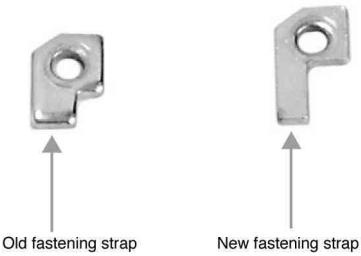
4) Inserting the new optical window

Hold the new optical window by the sides and carefully insert it in the correct position, pressing the optical window together slightly as you do so. Make certain the rubber seal is not damaged. Make certain it is in the groove in the housing designed for that purpose.



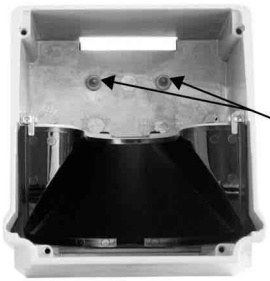
Check to make sure the optical window is seated correctly. There should be no gap between the optical window and the housing that lets light through.

Find the correct position to avoid a light gap

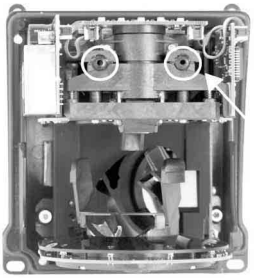


Then fasten the new optical window in place again with the fastening straps. As you screw in the screws, you can apply a little pressure on the outermost edge of the optical window with your thumbs. The new fastening strap (which has been available since 2002) is the one to use.

5) Assembling the housing



When assembling the housing, note that the two retaining bolts slide into the rubber sleeves provided for them. To do this, carefully join the two housing parts on a level surface.



After that, carefully screw in the screws on the rear wall of the housing, working back and forth around the circle from screw to screw.
Remove any finger prints on the optical window

11.7.2 Initial measurement of the new optical window

After the optical window has been properly mounted, it is essential to perform a calibration of the optical window. Correct functionality of the scanner cannot be guaranteed without calibrating the optical window!

Please note: The calibration should be performed with an ambient temperature of +20°C to +25°C!

Safety Notes: The optical window (dark red) must be clean and in new condition. Dirty and scratched panes must not be calibrated and used. They would represent a safety risk since the laser light would be weakened under some circumstances.

11.7.3 Procedure when using the SD3SOFT user software version 1.00 or later

1) Starting the PCs
2) Connection of X1 (electrical power supply with zone pair activated) and X2 (RS-232 cable 1:1)
3) Start **SD3SOFT** user software
4) Select the “Authorized user” access level
5) Confirm the echo data shown by the scanner
6) Click on the “Calibrate optical window monitoring” icon under “System data”
7) Start the optical window calibration with “Calibration” (lasts a few seconds, typically with values between 100 and 700).
8) Click on the “Close” button

11.8 Cleaning

11.8.1 Cleaning the optical window when dirty

Different methods will work better under different conditions depending on load and medium. What is the best approach?

Note:
SD3-A1 clean sets are available for cleaning the optical window. They contain a special cleaning agent and suitable cleaning cloths. Two sizes are available. For more information, see the chapter entitled “Accessories and spare parts”.

Please note:
Generally it is sufficient to remove particles relatively quickly moving the cleaning cloth horizontally. If cleaning takes longer (for example because of fingerprints), the scanner will report the fault in optical window monitoring (after cleaning, press “Restart”).

Description	Solution
Particles, loose, abrasive	• Remove with no contact using suction or blow off with oil-free air • Wipe clean with a cleaning cloth, wiping in one direction only
Particles, loose, not abrasive	• Suction off with no contact or blow off with oil-free air • Wipe clean with a cleaning cloth, wiping in one direction only
Particles, adhering	• Wet or moisten the cloth with cleaning agent • Wipe clean with a cleaning cloth, wiping in one direction only
Particles, statically charged	• Suction off with no contact • Wipe clean with cloth moistened in cleaning agent
Particles / drops, greasy	• Wet or moisten the cloth with cleaning agent • Wipe clean with a cleaning cloth, wiping in one direction only
Drops of water	• Wipe clean with a cleaning cloth, wiping in one direction only
Drops of oil	• Wet or moisten the cloth with cleaning agent • Wipe clean with a cleaning cloth, wiping in one direction only
Fingerprints	• Wet or moisten the cloth with cleaning agent • Wipe clean with a cleaning cloth, wiping in one direction only
Scratches	• Replace optical window

11.8.2 Cleaning the optical window; cleaning diffusing light panes

The front and light panes and diffusion screens must be washed depending on the load on the application in question. Generally this is a quick process.

Fig. 11.8-1: Cleaning the optical window

Sharp cleaning materials and / cloths that scratch must never be used!

Fig. 11.8-2: Cleaning diffusing light panes

Note:
Dirt can often be eliminated in a work step. If the optical window is cleaned within 4 seconds, the scanner is not turned OFF.

Note:
The order designations are available in Chapter 12.2.

12 Delivery Package

The **basic unit** consists of:

- **SD3-A1**
- **SD3-A1** connector, complete, 15-pin, interface X1
- **SD3-A1** connector, complete, 9-pin, interface X2
- Instruction manual (connection and operation) for **SD3-A1**, instruction manual (software operation) for **SD3SOFT**, Configuration and Diagnostic Software **SD3SOFT** on CD-ROM including the **SD3SOFT** instruction manual.
- Mounting screws, 4 pieces
- Instruction manual (safety instructions) for **SD3-A1**

12.1 Disposal

Laser scanners that are no longer in use must be disposed of in an appropriate manner.

12.2 Accessories and spare parts

Brief description	Description
MS-S3-1	**SD3-A1** mounting system for securing and adjusting the **SD3-A1**
SD3-DEMO-24V	**SD3-A1** configuration and test equipment, 24V DC
SD3-CP-C5	**SD3-A1** control cable with ConfigPlug, ready-made at scanner side, 5m, straight
SD3-CP-C10	**SD3-A1** control cable with ConfigPlug, ready-made at scanner side, 10m, straight
SD3-CP-C25	**SD3-A1** control cable with ConfigPlug, ready-made at scanner side, 25m, straight
SD3-CP-C50	**SD3-A1** control cable with ConfigPlug, ready-made at scanner side, 50m, straight
SD3-CP-C10-L	**SD3-A1** control cable with ConfigPlug, ready-made at scanner side, 10m, angled
SD3-RS232-C3	**SD3-A1** PC cable, RS-232, ready-made on both sides, 3m
SD3-RS232-C5	**SD3-A1** PC cable, RS-232, ready-made on both sides, 5m
SD3-RS232-C10	**SD3-A1** PC cable, RS-232, ready-made on both sides, 10m
SD3-CP	ConfigPlug for **SD3-A1**, straight, without cable, for automatic configuration at device exchange
SD3-RS232	**SD3-A1** plug, sock., 15 pins, for X1 interface
SD3-PS	**SD3-A1** plug, sock., 9 pins, for X2 interface
SD3-RS232-L	**SD3-A1** plug, sock., 15 pins, for X1 interface, cable routing to the rear
SD3-PS-L	**SD3-A1** plug, sock., 9 pins, for X2 interface, cable routing to the rear
SD3-CLEAN1	Cleaning fluid for synthetic materials, 150ml, 25 cleaning cloths, soft and lint-free
SD3-CLEAN2	Cleaning fluid for synthetic materials, 1,000ml, 100 cleaning cloths, soft and lint- free
SD3-WINDOW	**SD3-A1** scanner optical window with seal

Table 12.2-1: Accessories and spare parts for the **SD3-A1**

12.3 Coding of the control cable X1

The following table defines the pin assignments for the 15-pin connector cable

Pin No.	Color code	Meaning
1	Black	GND
2	Blue	Restart
3	Red	U_B
4	Orange	FP 1
5	Yellow	Alarm 1
6	Green	FP 2
7	Violet	FP 3
8	Gray	FP 4
9	N.C.	
10	N.C.	
11	White	OSSD 1
12	White / Black	OSSD 2
13	N.C.	
14	White / Brown	
15	Brown	Alarm 2

Table 12.3-1: Coding of the control cable X1

13 Technical Data

13.1 Test pieces

The following test pieces are defined for the purpose of controlling the effectiveness of the monitoring function by the detection zones:

- Cylinder, 500mm in length, reflectance factor 1.8% ±0.2%, for stationary applications, diameter: 30, 40, 50, 70, 150mm
- Cylinder, 1,000mm in length, 200mm in diameter, reflectance factor 1.8% ±0.2%, for mobile systems (e.g. AGV).

13.2 Detection zone

Detection range at a resolution of 30mm at a resolution of 40mm at a resolution of 50mm at a resolution of 70mm at a resolution of 150mm	**SD3-A1** 1.60m 2.20m 2.80m 4.00m 4.00m
Reflectance factor	Min. 1.8%
Min. adjustable range	200mm
Detection range of test piece from housing	Min. 0mm
Response time	Min. 80ms (2 scans) Adjust. up to 640ms (16 scans)
Number of detection zones	8 (changeover via switch inputs)
Output	2 failsafe PNP transistor outputs, 24V / 250mA
Safety category	Requirement class 4 as per DIN V 19250, fail-safe, Category 3 as per EN 954-1, Type 3 as per DIN EN 61496-1 and IEC 61496-3, SIL 2 acc. to IEC 61508
Startup	The startup test and start interlock can be adjusted separately.
Restart	Automatic or manual, adjustable from 160ms to10s

Table 13.2-1: Technical data – detection zone

13.3 Detection zone additions

Addition with deactivated dust suppression	83mm
Addition for activated dust suppression	83mm (for a detection zone size < 3.5m) 100mm (for a detection zone size ≥ 3.5m)
Addition if retro-reflectors or very shiny surfaces such as certain metals or ceramics are present in the scanning plane	0mm (more than 1.2m behind the detection zone line) 110mm (in the detection zone or up to 1.2m behind detection zone line)

Table 13.3-1: Detection zone additions

13.4 Warning zone

Detection range	0 to 15m
Reflectance factor	Min. 20%
Object size	150 × 150mm
Response time	Double evaluation: 80ms (corresponds to 2 scans), up to 16 scans can be selected (640ms)
Number of warning zones	8 (selectable via switch inputs)
Output	PNP transistor output, max. 100mA

Table 13.4-1: Technical data – warning zone

13.5 Contour measurement

Measurement range	0 to 50m
Reflectance factor	Min. 20%
Output	Serial interface RS-232 (10m), RS-422 (50m)
Radial resolution	5mm
Lateral resolution	0.36°

Table 13.5-1: Technical data – contour measurement

13.6 Electrical power supply

Power supply	24V DC +20% / -30%, supply according to IEC 742 with safety transformer or comparable for DC / DC converters
Overload protection	Provide by 1.25A semi-delay fuse in the electronics cabinet
Current consumption	Approx. 300mA (use a power supply with 2.5A)
Power consumption	8W at 24V, plus the output load
Excess voltage protection	Over-voltage protection with safe end cut-off
Voltage drops	In accordance with DIN EN 61496-1
Non-fused ground conductor	Connection not allowed

Table 13.6-1: Technical data – electrical power

13.7 Inputs

Restart / reset	For connecting a command device for operating mode “with restart interlock” and / or device reset, 24V DC, insulated by photocoupler
Zone pair changeover	For selecting among 8 zone pairs via 5 control cables with internal monitoring (zone pair = 1 detection zone and 1 warning zone), 24V DC, insulated by photocoupler
Signal definition High / logical 1 Low / logical 0	 16 to 30V < 3 V

Table 13.7-1: Technical data – inputs

13.8 Outputs

Detection zone	2 × failsafe semiconductor output, PNP, max. 250mA, short-circuit monitored, overload protected
Warning zone / Dirt / Fault	2 × PNP transistor output, max. 100mA
Load characteristics, maximum	Low pass behavior, limit frequency $f_g \leq 1$kHz, $C_{Load} \leq 100$nF
Level high (OSSD active) Level low (OSSD inactive) Level high (alarm active) Level low (alarm inactive)	U_B - 3.2V < 2.0V U_B - 4V < 2.0V

Table 13.8-1: Technical data – outputs

13.9 Software

User software	**SD3SOFT** under Windows® 95 / 98 / 2000 / NT® / XP® with safe protocol for programming

Table 13.9-1: Technical data – software

13.10 Interfaces

RS-232, RS-422	For device configuration and data exchange

Table 13.10-1: Technical data – interfaces

13.11 Optics

Angle range	Max. 190°
Angle resolution	0.36°
Lateral tolerance without mounting system with mounting system	 ±0.18° (with respect to the back wall of the housing) ±0.22° (with respect to the mounting surface)
Scanning rate	25 scans/s or 40ms/scan
Laser protection class	Class 1, as per EN 60825-1: 1994 + A1: 2002 + A2: 2001 Wavelength: 905nm Repeat frequency: 25kHz

Table 13.11-1: Technical data – optics

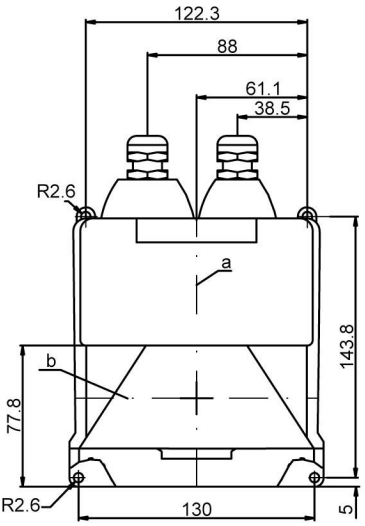
13.12 Environment and material

Protection type	IP65 in accordance with IEC 60529
Operating temperature	0 to +50°C
Storage temperature	-20 to +60°C
Humidity	DIN 40040 Table 10, Identifying letter E (moderately dry)
Dimensions	140 × 155 × 135 (W × H × D) in mm
Distance from the middle of the scanning plane to the bottom edge of the housing	48.75mm
Distance from front edge of the housing to the axis of the rotating mirror	64mm
Connection	2 connectors (plugged in from above)
Control cable length X1	Max. 50m at a cable cross-section of 0.5mm^2, shielded Connect shield with PE to the electronics cabinet only
Data cable length X2 RS-232	Max. 10m
Data cable length X2 RS-422	Max. 50m (twisted pair)
Housing	Die-cast aluminum, plastic
Weight	Approx. 2kg
Dynamic stress across 3 axles	In accordance with IEC 60068 Part 2 - 6, 10 to 150Hz, max. 5G
Continuous shock across 3 axes	In accordance with IEC 60068 Part 2 - 29, 10G, 16ms
Interference immunity	In accordance with DIN EN 61496-1 (corresponds to requirements for type 4); additionally in accordance with DIN 40839-1 / 3 test pulses 1, 2, 3a, 3b and 5 (not used for vehicles with internal combustion engines)
Rotating mirror drive	Brushless direct-current motor
Rotating mirror bearing	Maintenance-free ball bearing

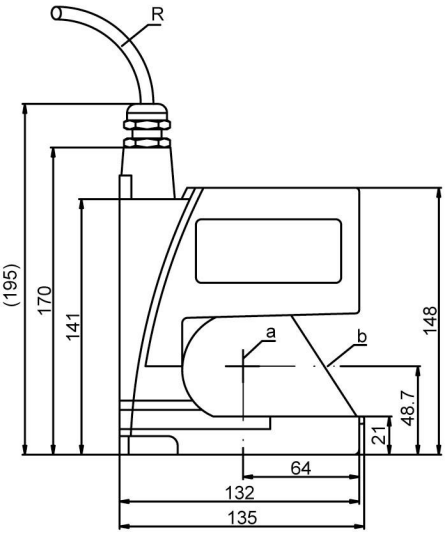
Table 13.12-1: Technical data on the environment and material

13.13 Dimensional drawings of the SD3-A1

Front view

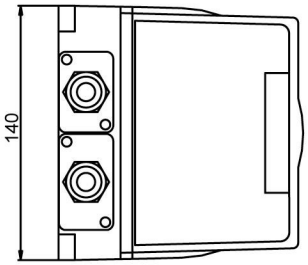


Side view



R = Smallest bending radius = 50mm (SUNX accessory)
a = Axis of the rotating mirror
b = Scanning plane

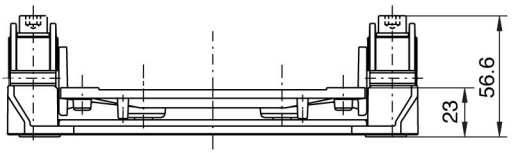
All dimensions given in mm



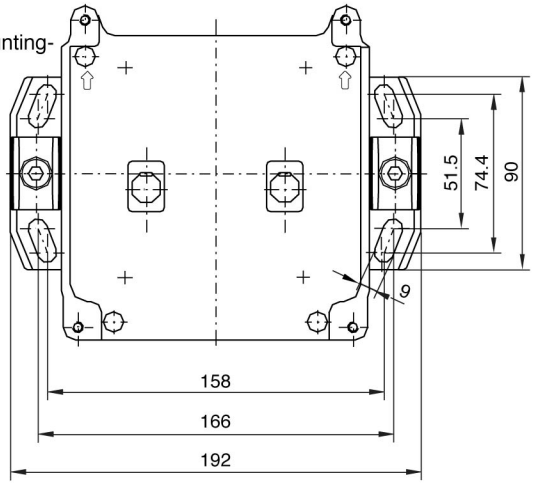
View from above

13.14 Dimensional drawings of the mounting system

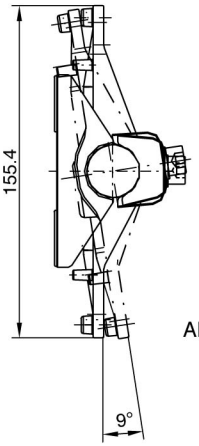
Side view



Scanner mounting-surface



Overview of parts



All dimensions given in mm

14 Diagnostic codes and causes

Location	Description	No.	Cause
102	Processing of commands, processing of messages	2	Data transmission error on the X2 interface
103	Control of command processing	2	Data transmission error on the X2 interface
104	Processing of commands, Processing of configuration	2	Data transmission error on the X2 interface
105	Processing of commands, generation of output messages	6	Function, access, command not permitted with currently selected access level
201	Processing of the receive protocol	4	Too much data sent over the X2 interface. Message will be overwritten by new message
302	Processing of the transmit protocol	2	The verification of displayed data remained unacknowledged for too long.
306	Output of measurement values	5	Previous message not yet completely output
801	Event processing	2	Event memory cannot be read, internal fault
805	Processing of the commands to the event memory	6	Event memory cannot be transferred. Data transmission error on interface X2
1002	Motor control during initialization	1	Motor does not reach rated speed after start. Internal fault.
1002	Motor control during initialization	2	Motor speed not constant after start. Internal fault.
1110	Test of the switch outputs.	4	Switch outputs (OSSD) have a state other than the one the scanner expected. Possible wiring or control error
1110	Test of the switch outputs.	5	Switch output (OSSD) cannot be switched OFF
1110	Test of the switch outputs.	6	Switch output (OSSD) cannot be switched ON
1111	Short circuit test of switch outputs	7	Short circuit of a switch output (OSSD) with ground
1111	Short circuit test of switch outputs	8	Short circuit of a switch output (OSSD) with Vcc
1606	Motor speed monitoring	4	Motor speed deviation, zero pulse not detected properly, internal fault
1607	Monitoring of duration of a scan	5	Motor speed deviation, motor not at rated speed

Location	Description	No.	Cause
1705	Processing of field monitoring light barrier data	1	Signal of a light barrier in optical window monitoring is under the lower limit. Dirty optical window
1705	Processing of field monitoring light barrier data	2	Signal of a light barrier of optical window monitoring is above the upper limit. Fluid media on the optical window
1906	Test of the external watchdog	1	Watchdog is not enabling the OSSDs. There may be a wiring or control error
1906	Test of the external watchdog	2	Watchdog not switching OFF the OSSDs. Internal fault
1906	Test of the external watchdog	5	Switch outputs (OSSD) have a state other than the one the scanner expected. Possible wiring or control error
1906	Test of the external watchdog	6	Watchdog not switching the cut-off path for the laser. Internal fault
1907	Test of the external watchdog	4	Event detected by watchdog, watchdog switched OFF (motor speed deviation), scanner housing may be rotating
1907	Test of the external watchdog	7	Event detected by watchdog, watchdog switched OFF (motor speed deviation), scanner housing may be rotating
2002	Processing of parameter commands	12	The verification of displayed data remained unacknowledged for too long.
2007	Verification of parameter data received	18	The date of the detection zone currently being transferred is older than the date of the detection zone in the scanner
2201	Area monitoring	5	Number of measurements in the scan too small due to motor speed error or switch-off of the watchdog. Internal fuse faulty
2302	Control of software sequence	1	Error occurred while starting the scanner. Sequential error
2401	Reference measurement on the dark reference element	10	No distance value can be calculated for reference measurement. Glare from another source of light (905nm) or deviation in motor rotation speed

Location	Description	No.	Cause
2401	Reference measurement on the dark reference element	13	No removal value can be calculated for reference measurement. Dust in device because connector housing or dummy connector not screwed on
2402	Reference measurement on the light reference element	10	No distance value can be calculated for reference measurement. Glare from another source of light (905nm) or deviation in motor rotation speed
2701	Processing of messages for system diagnostics	1	Invalid diagnostic command received. Software and firmware incompatible
2702	Processing of requests for diagnostics data	3	Invalid diagnostic value requested. Software and firmware incompatible
2800	Processing of inputs for detection zone changeover	2	2 detection zones active longer than 1s
2800	Processing of inputs for detection zone changeover	3	The detection zone changeover that occurred does not correspond to the requirement programmed in the scanner.
2800	Processing of inputs for detection zone changeover	4	More than 2 detection zones selected during operation
2800	Processing of inputs for detection zone changeover	6	Unevaluatable data or defective data quality for activation of detection zone
2800	Processing of inputs during scanner operation	8	No detection zone activated during scanner operation
2801	Test of inputs for detection zone changeover	1	Error during testing of inputs for detection zone changeover, internal fault
2802	Initialization of detection zone changeover	3	The detection zone deactivation that occurred does not correspond to the requirement programmed in the scanner.
2802	Initialization of detection zone changeover	4	More than 2 detection zones selected during power-ON
2802	Initialization of detection zone changeover	6	Unevaluatable data or defective data quality for deactivation of detection zone
2802	Initialization of inputs during power-ON	8	No detection zone activated during scanner starting
3016	Monitoring the access authorization with one-time password	11	Confirmed one-time password was entered incorrectly

Table 14.0-1: Diagnostic codes and causes

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