# SAFETY IN FOCUS

Machinery Directive and ISO 13849 in Practice

SMC

NC314-B

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# On The
# Safe Side With SMC

## We think in optimal systems


Gain trust with safety. SMC is an innovative, reliable and capable partner for pneumatic and electric automation technology. We support our customers throughout the entire life cycle of their systems – we provide assistance in all safety-related issues with competent and professional solutions.
From the custom-designed machine to highly-complex systems, we fulfill all needs, and not only in terms of flexibility and productivity, but also in terms of trouble-free user and operational safety.

In order to guarantee this in your company as well, we offer innovative, customized safety solutions and safety components. The continuous focal point is achieving the highest possible risk minimization and protecting personnel at the machines.
The success lies in the detail. For all issues surrounding your safety engineering, we rely on personal commitment. We possess a large customer service team and a widespread network with more than 26 locations. Your benefit: our expert team is close by and is available to you as a personal point of contact.

> The focus is on safety
> between personnel and machine

# With SMC First Class State-of-the-art Safety

## Start setting standards during the design process

Stand up to the toughest requirements. At SMC, top priority is given to the development of the highest quality, innovative products that have excellent performance and provide optimal safety for operating personnel.

> Take advantage of our expertise and the appropriate components for complying with machine safety standards as per EN ISO 13849-1.

Due to the fast progress being made in production and mechanical engineering, the safety factor is becoming increasingly important in technology. With the introduction of the new Machinery Directive 2006/42/EC, which became effective on December 2009, machinery manufacturers across the world had to comply with new requirements and harmonized standards in the design and development of safe machines.

Simulate safety functions based on customer specifications. SMC provides their customers with the possibility of simulating circuits for functional safety as per EN ISO 13849-1 on a broad range of electric and pneumatic control panels at the United State Technical Center. Rely on the expertise of SMC engineering to ensure your company is strengthened for the future. We will assist you!

# Our Guide To Your Safety Engineering

## Safely assisted, right from the start

> On the following pages, find out more about the relationship between the key considerations and the requirements for the distributor in terms of the Machinery Directive and ISO 13849. SMC is happy to answer any questions as your competent partner!

Safety concepts driven by expertise. The professional distribution of machines and safety-related applications in the world demands well-founded knowledge of the legal basis and begins with the design and construction of your system.

In addition to hazard analysis and risk assessment, a concept for a safe control system is required. ISO 13849 deals with safety-related components and their design guidelines for control units. Together with the technicians from your company, we can answer the essential safety-related questions and find long-term solutions.

> Please also refer to our website on the topic of safety: www.smc-iac.com

# We Will Assist You On The Way

1

GUIDELINES & STANDARDS RESEARCH

>

2

DEFINITION OF SAFETY CHAIN

>

## Your key questions:

- > Which potential hazards can occur with my machine and how do I evaluate them?
- > Can this be considered a safety function? Can the failure of this function be hazardous to personnel?
- > Is my protective equipment dependent on a control unit?

- > Which safety functions are suitable for the respective hazard situation?
- > Which performance level does my risk assessment indicate?
- > Are design alterations enough to minimize the hazard?
- > What options do I have for achieving the required performance level?
- > Which components belong to the safety function?

## SMC provides solutions:

☑ We will assist you in the implementation of your safety function with the appropriate solution identification process and the corresponding components.

# For Optimal Safety

3 SAFETY-RELATED KEY FIGURES > 4 TECHNICAL IMPLEMENTATION > 5 VALIDATION

- > How often will the safety function presumably be actuated?
- > Does the lifetime correspond with the safety chain requirements defined by the standard?
- > To what extent must I be able to detect the failure of a safety function?

- > How do I design a standardized circuit?
- > Does a circuit have to be evaluated by an external expert?
- > What do I need for complete documentation in terms of EC conformity?
- > What form of documentation is required?
- > How long must the documentation remain available?

- > Was the required performance level actually achieved?
- > Did I carry out the task based on the latest technology?
- > Were all safety principles implemented accordingly?
- > Did I analyze all predictable types of misuse?
- > Which fault can I eliminate?
- > Does my quality assurance comply with the requirements in the standard?

☑ We would be happy to provide all the necessary specificationsfor SMC components. Furthermore, SMC offers professional support in determining the safety function as per ISO 13849-1.

☑ We provide comprehensive assistance with the selection of components for anything from simple circuits to integrable complete solutions with EC conformity.

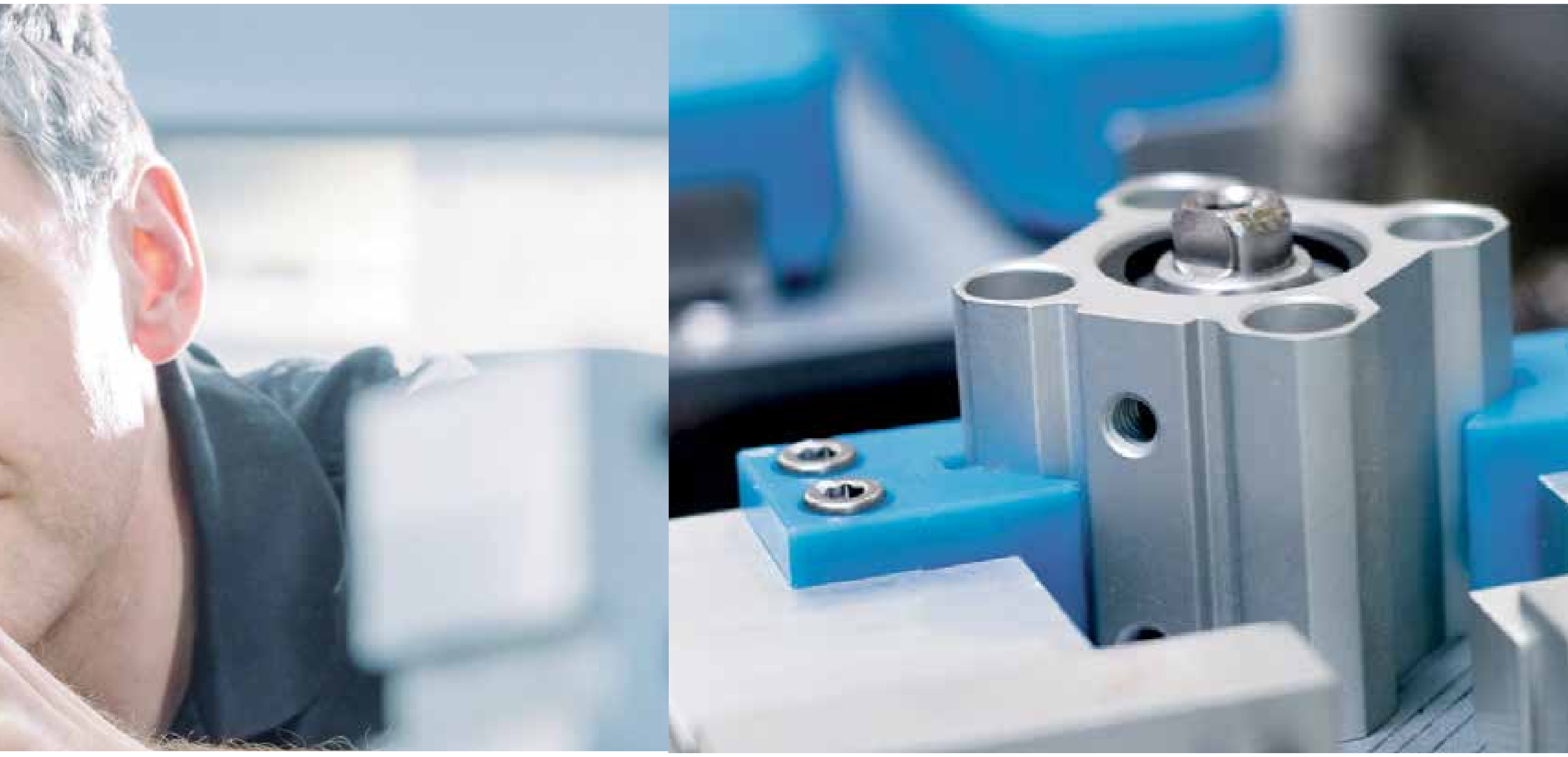
☑ We would be happy to assist you with the validation process using meaningful documentation (including the Sistema library).

# 5 Steps To Safety

## Worry-free from risk assessment to optimal safety function with SMC

> With the following 5 steps, we will take you through the entire process from risk assessment to safety function.

| 1 | 2 | 3 | 4 | 5 |
| --- | --- | --- | --- | --- |
| Risk assessment | Risk reduction | The control system as a component of risk reduction | Specification of the machine's safety functions | Ascertainment of the achieved performance level PL |

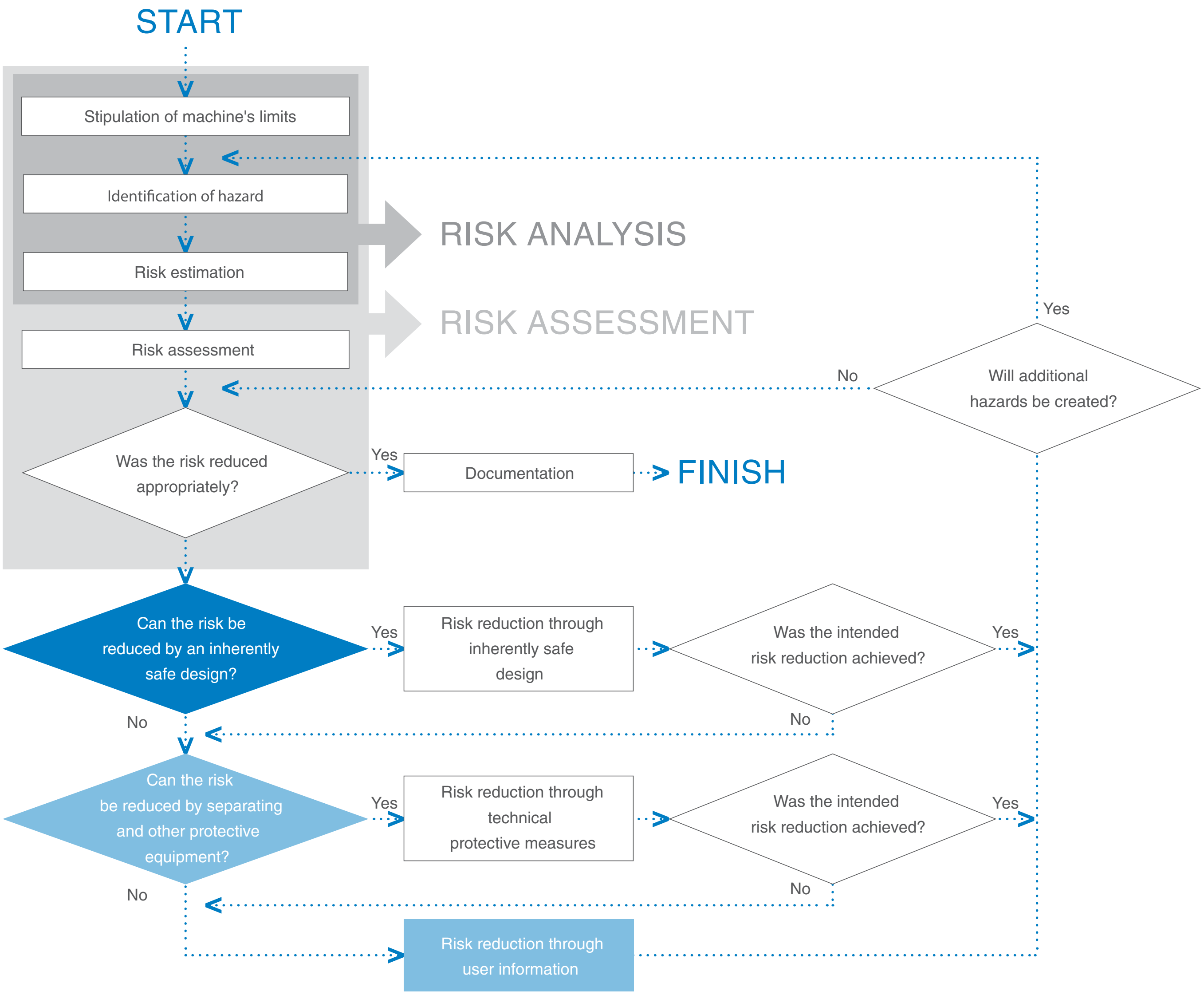


# Risk Assessment

Comprehensive safety engineering begins with the concept and design for the system. Potential risks and failure scenarios are analyzed as per ISO 12100, evaluated and eliminated on this basis. If elimination is not possible, the need for risk reduction is deduced.

This involves evaluation all of the operating states of the system: the automatic mode, maintenance mode, cleaning, etc.

## Carrying Out The Risk Assessment Per ISO 12100 In A Simplified Version



# Risk Reduction

If not all potential risks could be completely eliminated in step 1, ISO 12100 requires three further measures for risk minimization. In this case, the sequence must be strictly observed.

## Measures For Risk Reduction

### 1 DESIGN-RELATED MEASURES

- Separating protective equipment
- Protective cover panels
- Housing, etc.

### 2 TECHNICAL PROTECTIVE EQUIPMENT

- Safety-related systems
- Access systems
- Facial recognition
- Safety-related components, etc.

### 3 USER INFORMATION AND TRAINING

- Signs
- Maintenance plan
- Hazard symbols
- Instruction

# The Control System As A Component Of Risk Reduction


If design-related solutions are insufficient for minimizing the risk appropriately, the ISO 12100 requires the development of protective equipment.
The design of the safety-related components of a control unit for this type of protective equipment is included in ISO 13849, which is applicable to pneumatic as well as mechanical, hydraulic and electronic control systems.

In steps 4 and 5, there is a description of how to ascertain the required performance level PLr which serves as a guideline for the achieved performance level, PL.

# Determining The Machine's Safety Functions

Now the details of the safety functions are specified. This includes the defining of the actual safety functions – such as secure positioning, safe venting, protection against unexpected start-up or similar – and creating block wiring diagrams for the safety-related components, as well as specifying the required reactions in the event of an error.

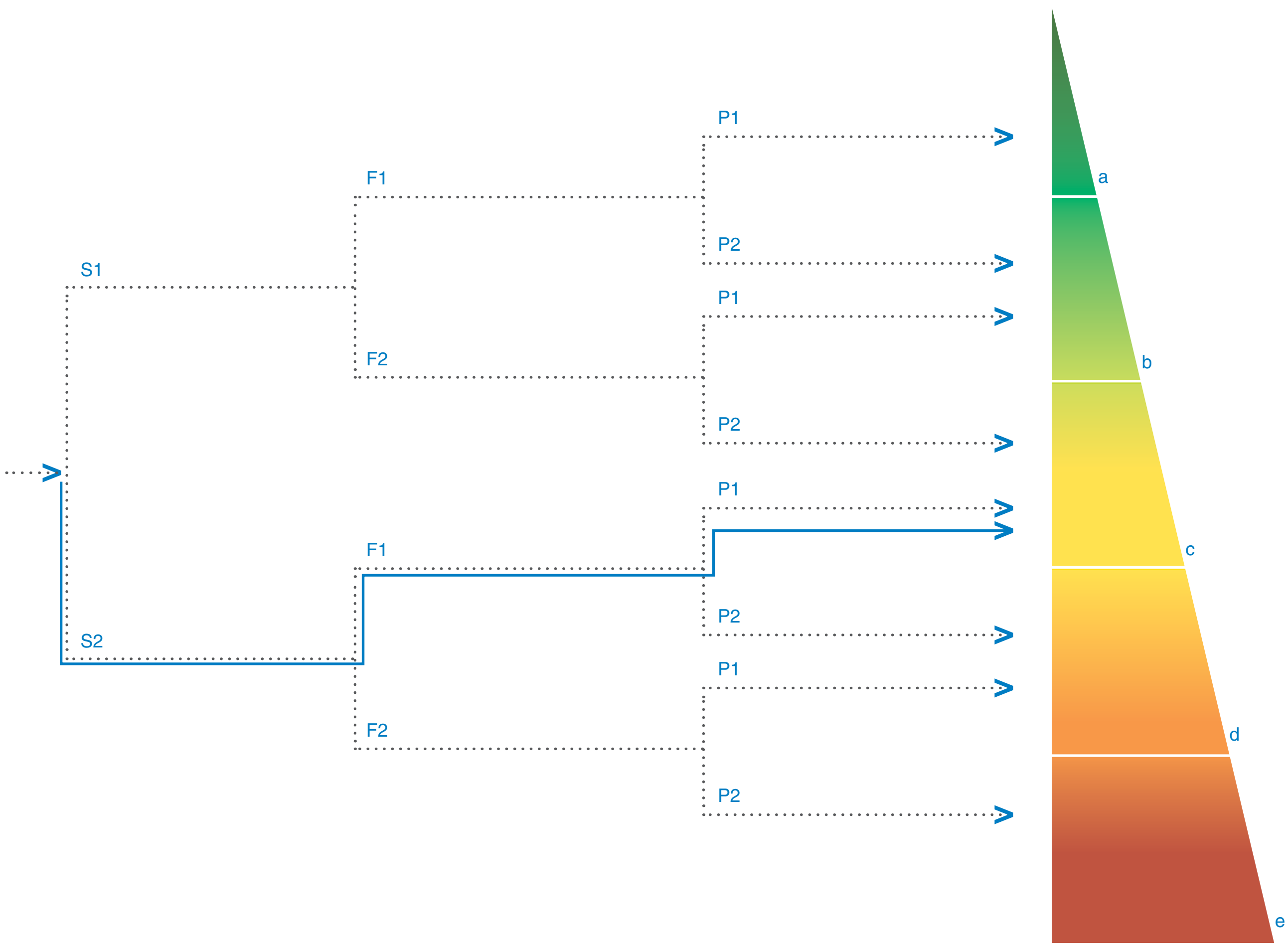
A performance level requirement PL is to be determined for each safety function using the risk-graphs.

## REMARK

Per ISO 13849, any irreversible injury (including bone fractures) are a serious incident as defined by the standard. In a non-normative note, the standard prompts the selection of F2 for interventions that are carried out more frequently than once per hour, and otherwise F1 (see image, pg. 13).

## ISO 13849-1 – Risk graph

| S: Severity of injury | F: Frequency and duration of stay | P: Method for avoiding hazards | Level of risk |
|---|---|---|---|




**S1:** Minor injury
(commonly a reversible injury)

**S2:** Death or severe injury
(commonly an irreversible injury)

**F1:** Seldom to occasionally

**F2:** Frequently to continuously

**P1:** Possible under certain circumstances

**P2:** Nearly impossible

**PL**

5

# Ascertainment Of The Achieved Performance Level PL

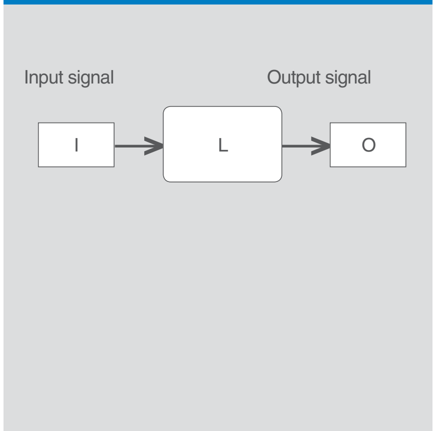
For the evaluation of the selected safety chain, the performance level, PL, is determined based on the following values:

- Structure (category)
- $MTTF_d$ (Mean Time to Failure dangerous): Mean time to dangerous failure
- DC (Diagnostic coverage): Diagnosis coverage level
- CCF (Common cause failure): Failure mutual cause
- Response of safety functions under fault conditions
- Safety-related software
- Systematic failures
- The capability to execute safety functions under foreseeable surrounding conditions

> NOTE
>
> The subsequent documentation, as prescribed in the applicable guideline, plays a key role in the compliance with the obligation to provide verifying documents for all 5 steps.

The process marked with blue arrows on the double pages will assist you with the ascertainment of the performance level. Based on the four basic parameters (category, MTTFd, DC and CCF) it should be ensured that the actual performance level, PL, corresponds to no less than the required performance level PL from the risk graphs (see risk graph, page 13).

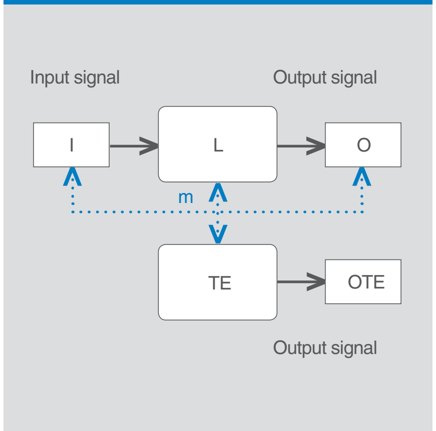
## Applicable for category B and category 1




I: Input (e. g. sensor)
L: Logic unit (e.g., PLC)
O: Output (e.g., valve, relays)

MTTFd from cat. 1 is higher than from cat. B, therefore the probability of a safety function failure is lower. Nonetheless, errors can lead to a loss of a safety function.

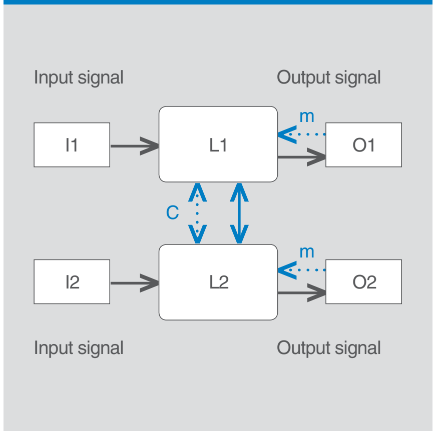
## Applicable for category 2




m: Monitoring
TE: Test equipment
OTE: Test equipment output

In cat. 2, a fault can lead to the loss of a safety function, if it occurs between two tests.

## Applicable for category 3 and category 4




m: Monitoring
C:Cross comparison
······ cat. 3: Periodic testing
—— cat. 4: Testing prior to every command for a safety function

In category 3, the accumulation of undetected errors can lead to a loss of the safety function. In category 4, the requirement of a safety function cannot be carried out until there is positive testing.

| Feature | Category | | | | |
|---|---|---|---|---|---|
| | B | 1 | 2 | 3 | 4 |
| Design per applicable standards stand up to anticipated influences | X | X | X | X | X |
| Fundamental safety principles | X | X | X | X | X |
| Proven safety principles | | X | X | X | X |
| Proven components | | X | | | |
| Mean Time to Dangerous Failure MTTFd | low to moderate | high | low to moderate | low to moderate | high |
| Fault recognition (tests) | | | X | X | X |
| Single fault safety | | | | X | X |
| Taking fault accumulation into account | | | | | X |
| Diagnosis coverage level - DCavg | none | none | low to moderate | low to moderate | high |
| Actions against CCF | | | X | X | X |
| Mainly characterized by | component selection | | Structure | | |

| | | | | | |
|---|---|---|---|---|---|
| 1 | Structure of hardware | Category | Structure of the safety function (configuration of I, L, O). The category is comprized of I (input), L (logic) and O (output). | 5 steps | B<br>1<br>2<br>3<br>4 |
| 2 | Lifetime of components | MTTFd<br>B10d<br>nop* | 1 single component<br>1. MTTFd-value provided by the manufacturer<br>2. MTTFd determination through Annex C<br>If the B10d-value is known, the following formula is applied:<br>$MTTF_d = \frac{B_{10d}}{0.1 \text{x} n_{op}}$<br>*The machine manufacturer must determine the nop value (How often will the component presumably be actuated per year?)<br><br>2 Complete system<br>$MTTF_d = \frac{1}{\sum_{i=1}^{n} \frac{1}{MTTF_{di}}}$ | 3 Steps | low: 3 years or more, less than 10 years<br>medium: 10 years or more, less than 30 years<br>high: 30 years or more, no more than 100 years |
| 3 | Monitoring the system | DCavg<br>DC<br>MTTFd | 1 single component<br>Determination of DC with Annex E<br>Determination of DC via FMEA<br><br>2 Complete system<br>$DC_{avg} = \frac{\sum_{i=1}^{n} \frac{DC_i}{MTTF_{di}}}{\sum_{i=1}^{n} \frac{1}{MTTF_{di}}}$ | 4 Steps | none: less than 60 %<br>low: 60 % or more, less than 90 %<br>medium: 90 % or more, less than 99 %<br>high: 99 % or more |
| 4 | System stability | CCF | The aim is to achieve no less than 65 points as per Annex F (starting with category 2) | 2 Steps | no: less than 65 points<br>yes: 65 points or more |

Category

| PL | B | 1 | 2 | | 3 | | 4 |
|---|---|---|---|---|---|---|---|
| a | MTTFd<br>low | | MTTFd | | MTTFd | | |
| b | medium | MTTFd | low | MTTFd | low | MTTFd | |
| c | | high | medium | low | medium | low | |
| d | | | high | medium<br>high | high | medium | MTTFd |
| e | | | | | | high | high |
| DCavg= | without | without | low | medium | low | medium | high |
| CCF= | irrelevant | | 65 points or more | | | | |

SMC will provide you with the necessary safety-related data for calculations.

# FAQ In Safety Engineering

## Frequently asked questions – competent answers

1

### Is the issue an operational function, or a safety function?

> If the failure or improper response of a function can result in an injury, this is considered a safety-related function. Operational functions in pneumatics often meet safety aspects. For this reason, the components needed for safety functions as per ISO 13849-2 must be validated.

2

### Do pneumatic components require a safety-related assessment?

> Yes, since pneumatic actuators such as cylinders can also cause serious injuries, they are also to be evaluated as per ISO 12100, and, if needed, safe-guarded by design or control-related measures. Pneumatic or electro-pneumatic controls must be evaluated and realized per ISO 13849-1 and -2.

3

What does "protection against unexpected start-up" mean?
Must I give this aspect consideration?

> Principally, protection against unexpected start-up should be taken into consideration for every safety function. This is seen as one of the fundamental safety principles in ISO 13849-2. Protection against unexpected start-up in pneumatics involves, for example: After an energy outage (compressed air supply, compressor failure or a hose rupture) and a new start-up, the machine may not start automatically without receiving a separate start command. Often, the detection of a primary loss in pressure, which must result in a system block (please see the example on page 39) is sufficient.

4

Can bi-stable valves be used in safety functions?

> The list of proven safety-principles contained in ISO 13849-2 contains the following point: "Safe Position", which must be met by safety-related products and systems. This term means that the moving element of a component (flap of a valve) is held mechanically in one of the possible positions. Friction alone is not sufficient. Normally, soft-sealed, bi-stable valves are held in position solely by friction, and therefore do not fulfill this proven principle. Compliance with these principles is required as of category 1.

Bi-stable valves are permitted if they have a detent (mechanical lock) in the final position. Metal-sealed valves and special rubber-sealed valves (see page 45) made by SMC have this type of detent (see image below) and therefore can be used in safety-related control mechanisms. In this regard, compliance with the basic and well-tried safety principles in ISO 13849-2 is required, particularly the application of the energy isolation principle (closed-circuit principle). A safe state is achieved by releasing energy. This means that the last switch position before the release is the safe state. In addition, it should be ascertained on an application basis whether unexpected and/or dangerous movements can occur as the result of a power outage.

5

Is a valve, for which both the supply voltage and separately the pilot air is interrupted, considered to be a two-channel solution?

> A two-channel solution must at least be "fail-safe", which means that a single failure in the safety chain (such as failure to activate a valve) cannot result in the loss of the safety functions. This does not apply to a cylinder service valve, because a failure in the spool of the main valve (i.e. a shaving that blocks the spool) can lead to the failure of the entire system.

6

Is there a correlation between SIL (safety integrity level) and PL (performance level)?

> Yes, both systems are tied to the failure probability and can be converted accordingly. Generally, SIL /PL can only be calculated for complete systems. A single product cannot have a SIL /PL.

## 7

## A safety-related PLC is very expensive. Can I also carry out my safety functions purely pneumatically?

> Principally, it must be said that the safety functions which have electro-pneumatic actuation can also be carried out purely pneumatically. The cost-effectiveness of the acquisition of your own safety PLC depends on the complexity of the desired safety-functions and the related operating functions. Special attention is given to the sensor technology required in ISO 13849 for fulfilling the diagnosis coverage level as of category 2. To realize this solely with pneumatics would be much more expensive in terms of costs related to the circuit design, the quality of the components. Often, the acquisition of a safety PLC compared to safety functions of a purely pneumatic design is therefore the less costly alternative.


## 8

## Where can I find the safety-related data of SMC components?

> SMC will gladly provide you with all safety-related data, such as B10 and MTTF. In addition, SMC has an accessible Sistema library. Sistema is a program for the calculation of your safety-functions, which is provided free of charge. Contact your SMC office for more information about the Sistema library.

## 9

## What does a pneumatic LOTO (Lockout-Tagout)look like?

> LOTO's ( Lockout-Tagouts)are technical devices which lock the control elements of a technical system – such as switches, stopcocks, ball valves, etc. – into a specific position. They are used as protection against unauthorized access or unexpected start-up, for example during a maintenance procedure. If configuration or maintenance procedures are carried out in a depressurized state, it is possible to lock an SMC manual shut-off valve (VHS line) in the vented position.

# Expectations For Pneumatics

## Pneumatic systems and electric sensors

With the optimal interaction of pneumatic components and electronic sensors, we reinforce the safety of control systems. The sensors are essential for the diagnosis coverage level as of category 2.

Based on plausibility testing, it is determined if a digital or analog sensor signal changes as expected within a specific time period.
For example, the final position switch of the respective cylinder must transmit a change signal within a per-defined time period after a valve has been actuated.

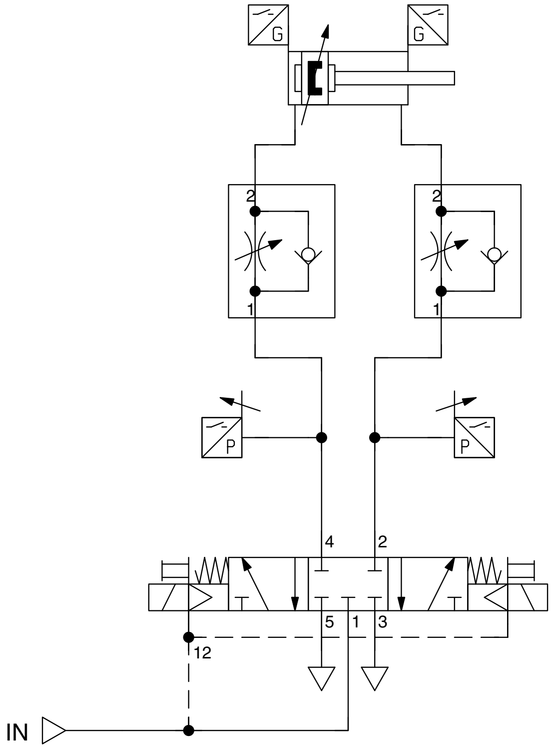
## Expectation in pneumatics

### Sensors:

- Position switch
- Pressure switch
- Spool detection of valves

### Detectable error from the list in ISO 13849-2:

- Change of switching times
- Non-switching or incomplete switch
- Spontaneous change of the initial switching position (without input signal)
- Bursting of the valve housing

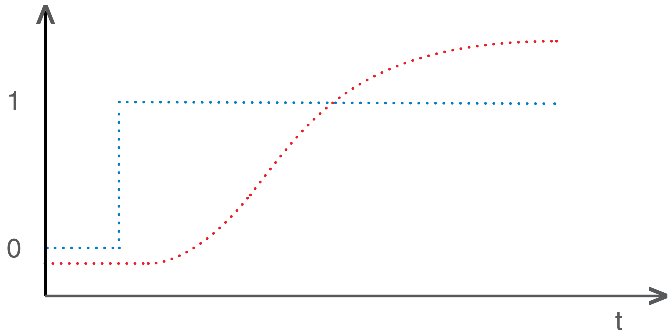



Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

## Diagram 1

### Sensors:

- Blue Line: Valve switching output
- Red Line: Pressure accumulation at a pressure switch
- Δ t: If the pressure does not rise to the pre-defined level after the valve has been actuated, an error has occurred.



# Components For Machine Safety

## Definitions and characteristics

As per the Machinery Directive 2006/42/EC, article 2c, a safety-related component is a component

- which serves to fulfill a safety function,
- which is independently placed to the market,
- the failure and/or malfunction of which endangers the safety of persons, and
- which is not necessary in order for the machinery to function, or for which normal components may be substituted in order for the machinery to function.

### NOTE

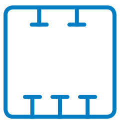
The safety component is evaluated by the component manufacturer in terms of safety. This eliminates the need for an additional validation process to be carried out by the mechanical engineer as per ISO 13849-2.

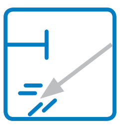
For safety-related control, standard components as well as validated safety components can be installed. However, this must be evaluated during the course of the system analysis.

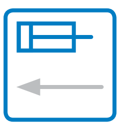
# Symbols

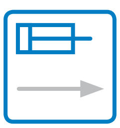
## Safety functions and emergency stop

### Pneumatic safety functions

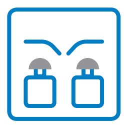

Safe stop


Safe venting

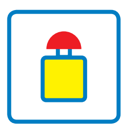

Safe retraction


Safe extension


Reduce pressure


Two-hand control


Protection against unexpected start-up


Emergency stop (extender safety function)

### REMARK ON THE EMERGENCY STOP FUNCTION

Every machine must be equipped with an emergency shutdown-safety feature. However, this does not replace a primary, self-actuating safety feature. It merely provides the opportunity to place the machine in a safe position - in a hazardous situation.

# Practical Examples

## Working safely with SMC

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### EXAMPLE 1

Safe venting (PL e, cat. 4)
and protection against unexpected
start-up (PL e, cat. 4)

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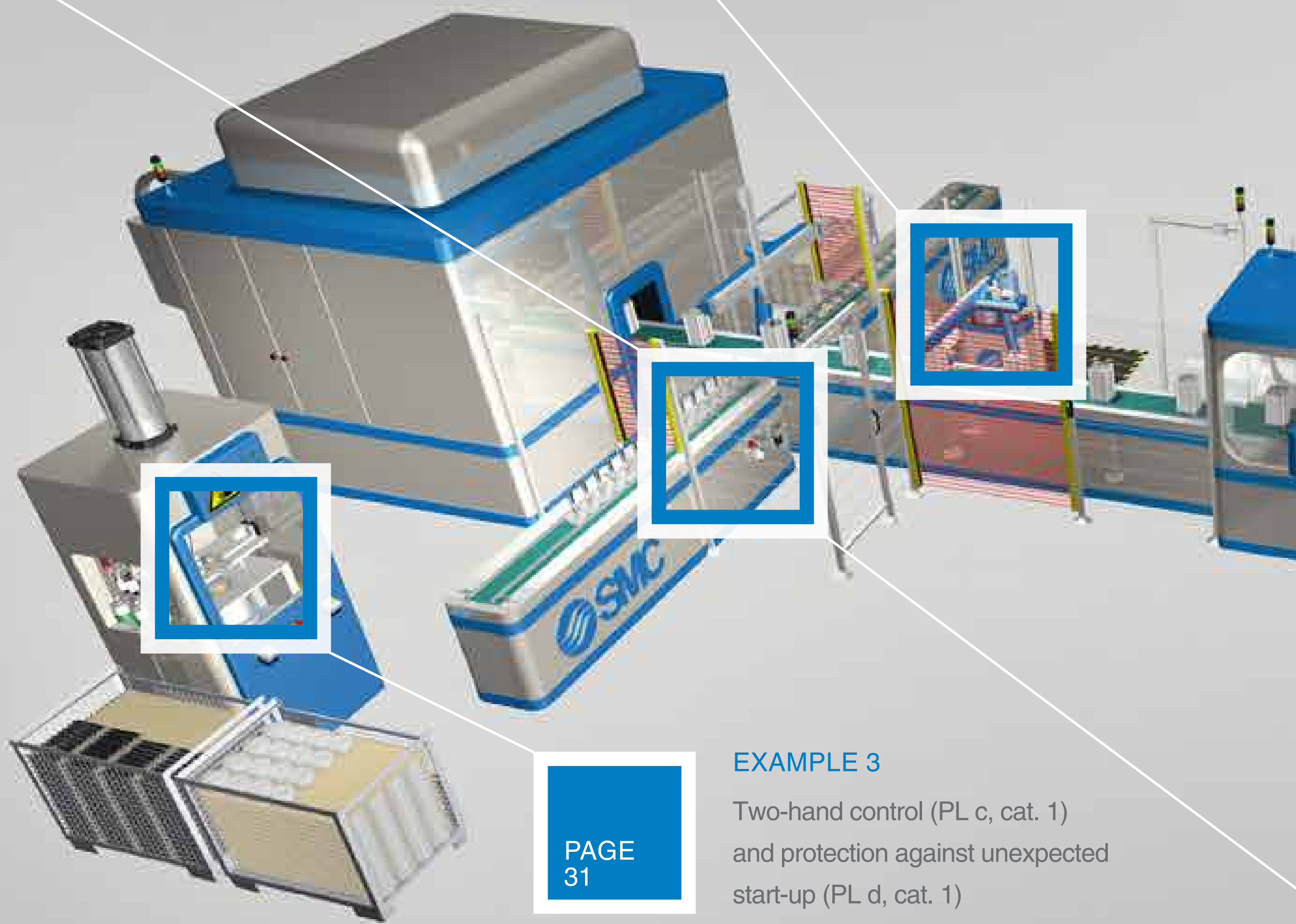
### EXAMPLE 2

Safe stop (PL d, cat. 3)
and protection against unexpected
start-up (PL d, cat. 3)



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### EXAMPLE 3

Two-hand control (PL c, cat. 1)
and protection against unexpected
start-up (PL d, cat. 1)

Based on our sample system, there are seven practical examples described, which show not only the basic considerations regarding the initial situation, but also tips on implementation. If your machine has a similar application, an additional clarification of the individual aspects with our safety experts is recommended.
Please note that the listed standard references are not intended to be complete, and serve solely as an orientation aid. The listed performance level is only applicable to the shown structure. Lifetime parameters, diagnosis coverage level and supplementary sub-systems (input and logic units) must still be evaluated by a mechanical engineer.

> For assistance with the design of your safety functions, you will find common practical examples on the following pages.

PAGE 33

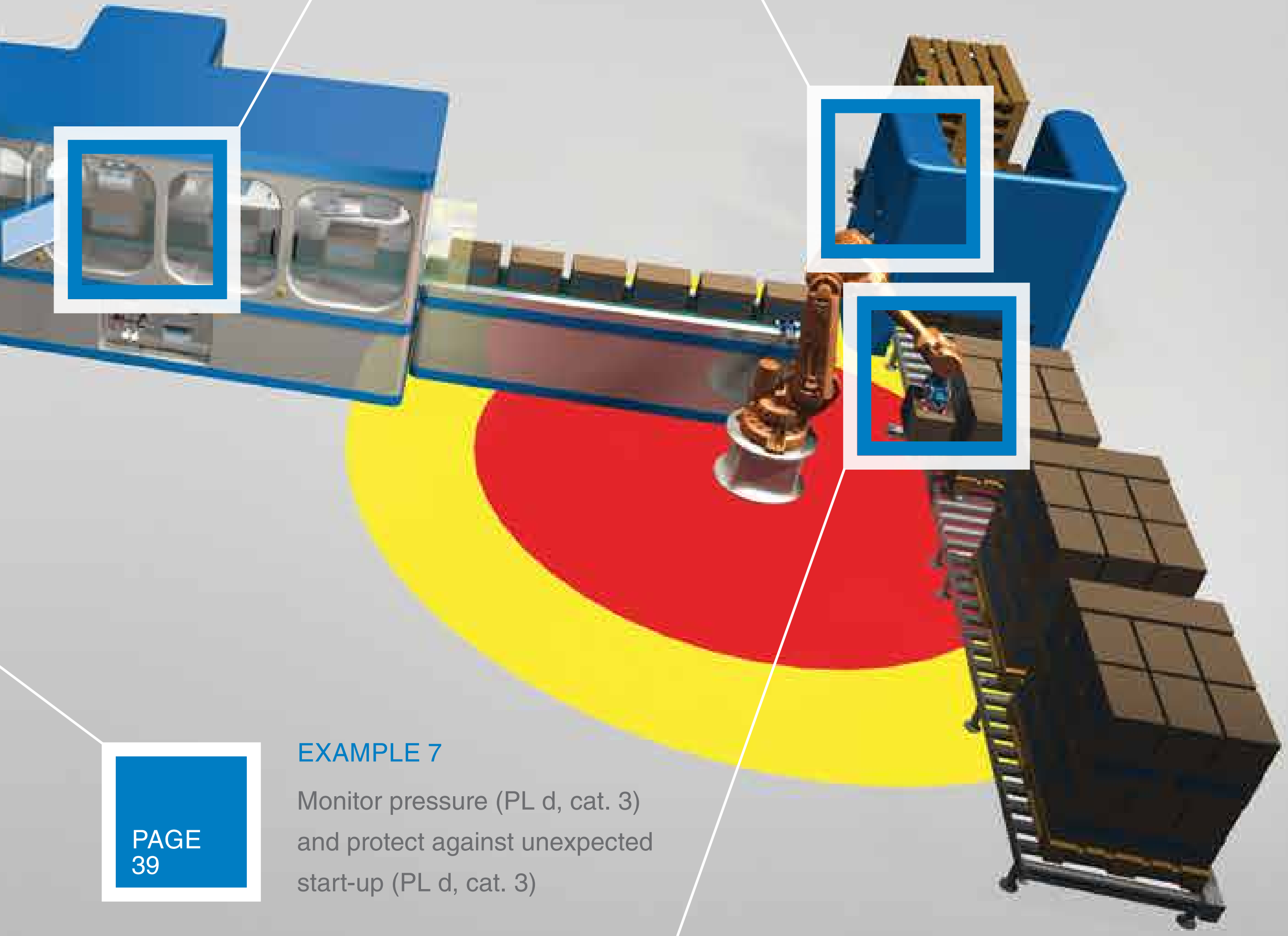
EXAMPLE 4

Protection against unexpected start-up (PL d, cat. 3)

PAGE 37

EXAMPLE 6

Reduce pressure (PL c, cat. 1) and protection against unexpected start-up (PL d, cat. 1)



PAGE 39

EXAMPLE 7

Monitor pressure (PL d, cat. 3) and protect against unexpected start-up (PL d, cat. 3)

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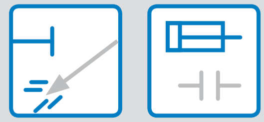
EXAMPLE 5

Safe venting (PL c, cat. 1) and protection against unexpected start-up (PL d, cat. 1)



SAFETY-FUNCTIONS IN PRACTICE – EXAMPLE 1

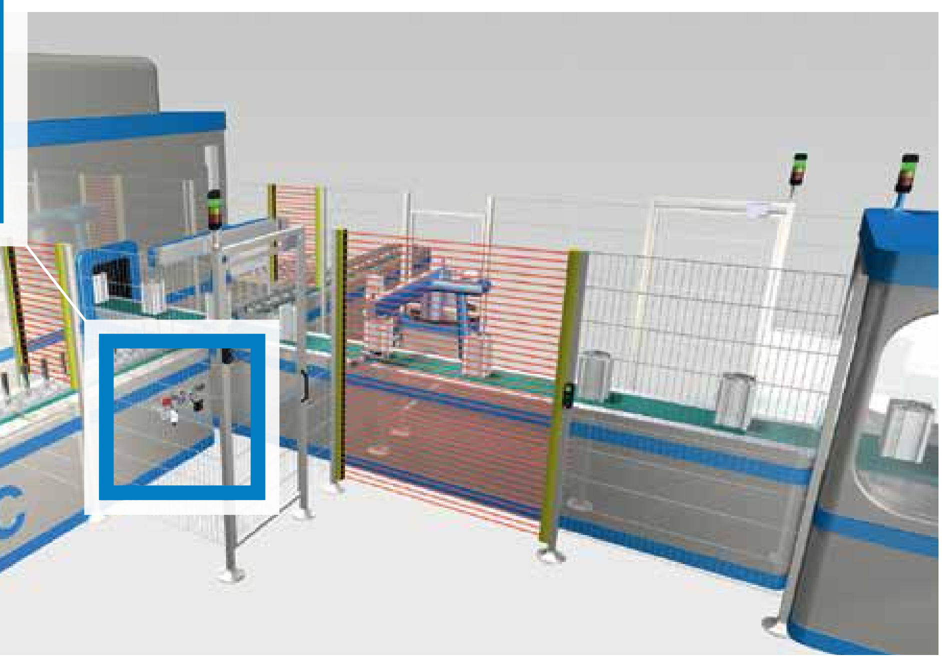
# Safe venting (PL e, cat. 4) and protection against unexpected start-up (PL e, cat. 4)

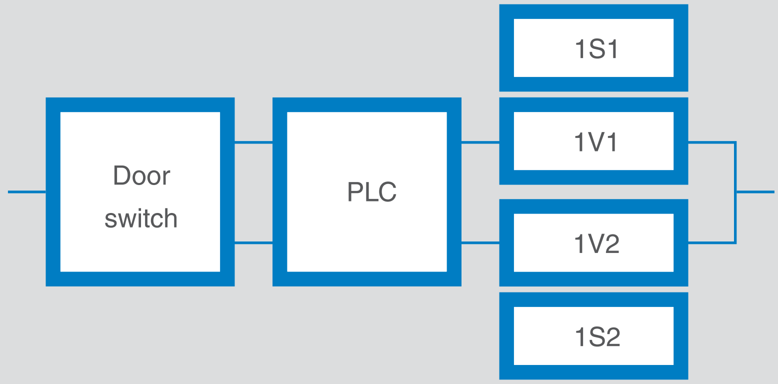
## Initial situation

The opening of the protective grid door must cause the pneumatic system to be vented. In so doing, no unexpected machine start-up may occur within the hazardous area during maintenance procedures.

## Information regarding implementation

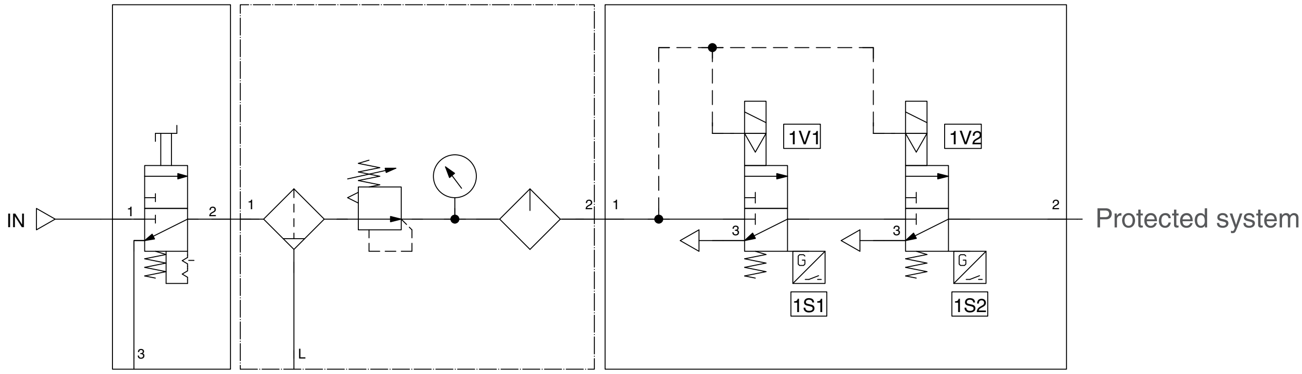
- The valve's venting capacity must be designed so that immediately upon entering into the hazardous area, no further dangerous movement can occur within the area.
- Downstream to the venting valve, no assemblies may inhibit or delay safe venting (e.g., by defective downstream components).
- Regular checks to the noise suppressors guarantee timely venting. The safety component does not require validation as per ISO 13849-2, because it has already been validated by the component manufacturer during the course of the EC conformity process.






## Circuit description

The desired "safe venting" safety function as well as the protection against unexpected start-up are implemented by the safety component in this example. The required coverage level is also fulfilled (by 1S1 and 1S2). It must be ensured that the secondary valves can be vented even in the event of a power outage or improper response. For example, a 3-position valve with a closed center position may not be used.




Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

## SMC products (also see page 43)

Venting valve
with direct monitoring
Item: VP-X538

Venting valve with
direct monitoring
Item: VG342-X87

Venting valve with direct monitoring and
soft-start function
Item: VP-X555

Manual shut-off valve
Item: VHS

SAFETY-FUNCTIONS IN PRACTICE – EXAMPLE 2

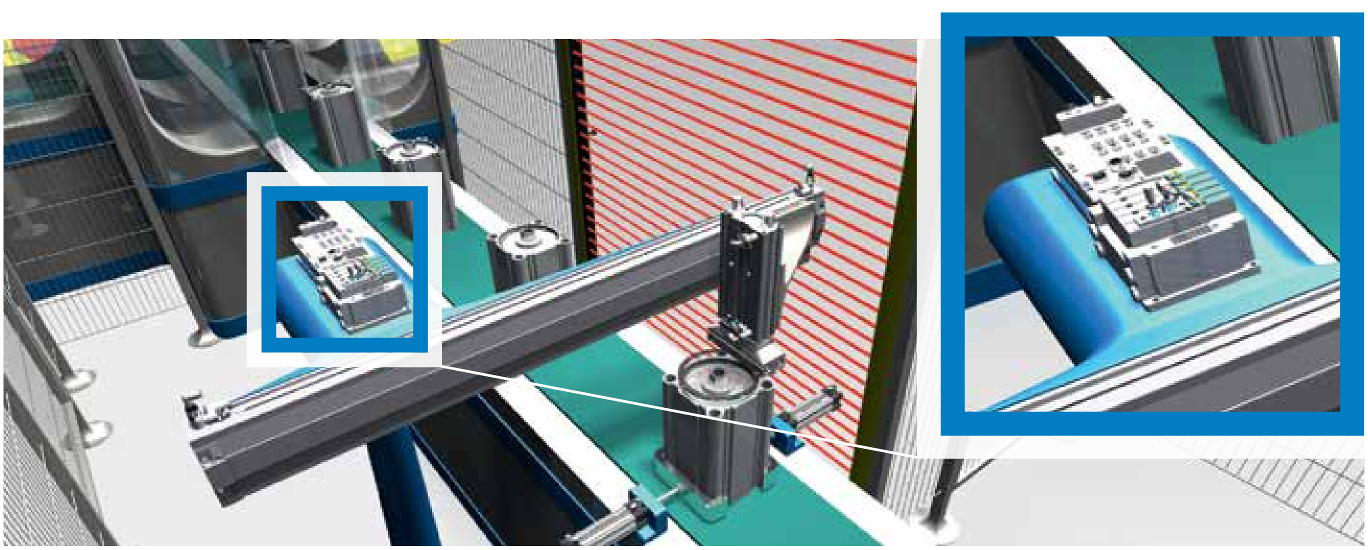
# Safe stop (PL d, cat. 3) and protection against unexpected start-up (PL d, cat. 3)

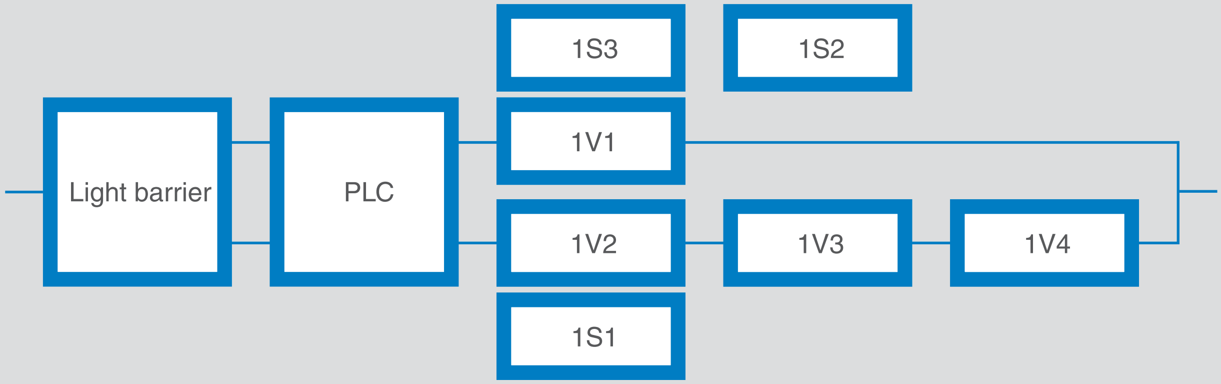
## Initial situation

For the removal of rejected components from the conveyor belt, the downstream drives should stop safely due to the interruption of the electric eyes. When carrying out work in the hazardous area within the electric eye zone, it must be impossible to unexpectedly start-up the machines. The pneumatic valves and the diagnosis by means of a pressure switch should be installed in a valve manifold.

## Information regarding implementation

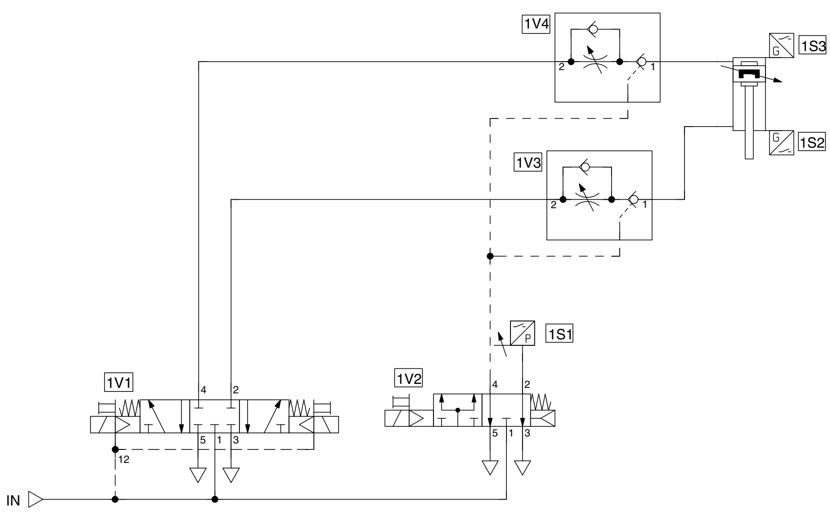
- The Sensors must be installed so that manipulation is impossible, and that a special tool is required to make any adjustments. The distance between the light barrier and the hazardous area must be great enough that the safety chain can stop the dangerous actuator in a timely manner, before the operating personnel enters into the hazardous area.
- The closing of the safety-related valves is not carried out via the standard bus - this would be unsafe – but instead, via an independently-controlled module within the valve manifold (for details, see "Frequently asked questions", page 17).
- Particularly with the vertical installation of actuators, which are subject to heavy loads, pilot operated check valves should be screwed directly into the cylinder.
- Monitoring the pilot operated check valve's function on a regular basis can be a part of a test routin–e, or be carried out by directly monitoring the pilot operated check valve.
- For the pneumatic safety function "safe stop", the cylinder overrun must always be observed based on the air compression.






## Circuit description

The first channel of the safety function consists of a 3-position valve (1V1). As shown in the block diagram, the 3-position valve 1V1 needs the sensors 1S3 and 1S2, in order to achieve the required diagnosis coverage level. The second channel consists of a 2-position valve (1V2) and pilot operated throttle check valves (1V3 and 1V4). In this example, the installed pressure sensor (1S1) monitors the functions of the second circuit with components 1V2, 1V3 and 1V4. Protection against unexpected start-up, cat. 3, is realized by the 3-position valve with a closed center position and the pilot operated throttle check valve.




Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 47 is mandatory.

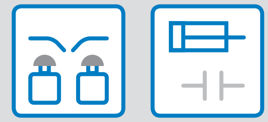
## SMC products (also see page 43.)

Solenoid valve
Item: SY 3000 / 5000 / 7000

Pilot operated
throttle check valve
Item: ASP

Pilot operated check valve
with direct monitoring
Item: XT34

Digital pressure sensor
Item: PS1000



SAFETY-FUNCTIONS IN PRACTICE – EXAMPLE 3

# Two-hand control (PL c, cat. 1) and protection against unexpected start-up (PL c, cat. 1)

## Initial situation

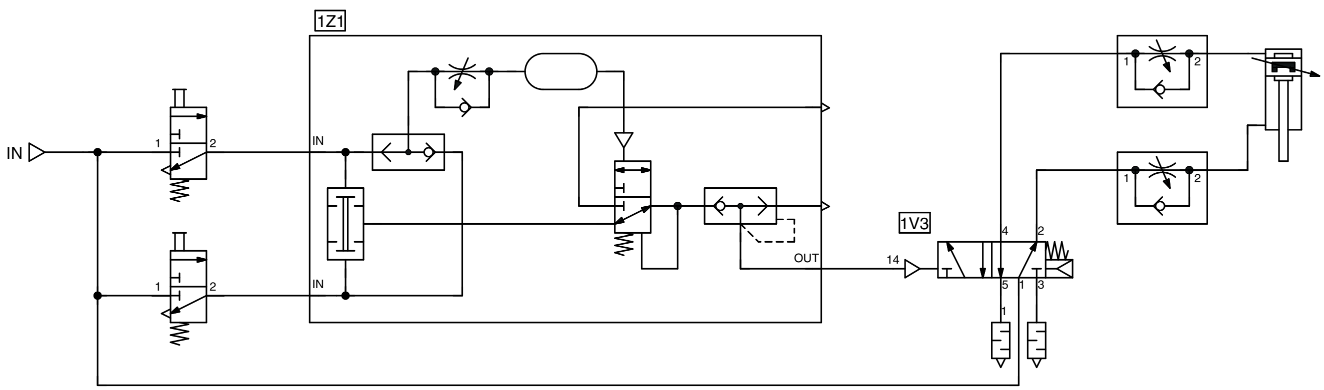
Crimping between the cylinder piston and the piston rod is realized by means of a purely pneumatic press with two-hand control. When the button is released, the press cylinder will move to the upper final position.

## Information regarding implementation

- When reversing the press tool, the crushing hazard must be evaluated. Actuating a safety function may not result in the generation of a new hazard. The appropriate response in the event of a failure should be included in the risk analysis.
- Regarding the distance between both actuation buttons and their design, EN 574 must be observed.
- The safety component (1Z1) does not require validation as per ISO 13849-2, because it has already been validated by the component manufacturer during the course of the EC conformity process.


## Circuit description

By pushing both buttons in close succession, a pneumatic output signal on the two-hand control valve (1Z1) is generated. Automatic reverse is realized by means of a pneumatically-controlled 2-position valve (1V3), which returns to home position after the signal stops.




Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

## SMC products (also see page 43.)

| | | |
|---|---|---|
|  Two-hand control valve<br>Item: VR51 |  Pneumatic valve<br>Item: VSA7-6 |  Visual display<br>Item: VR31 |

SAFETY-
FUNCTIONS
IN PRACTICE –
EXAMPLE 4

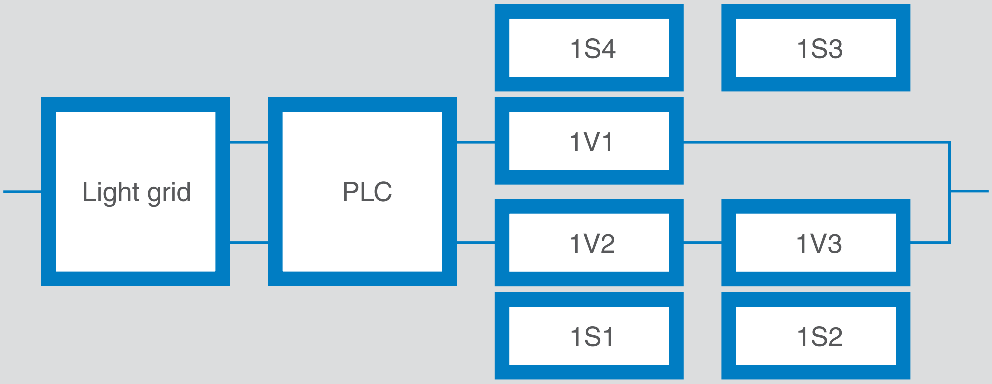
# Protection against unexpected start-up (PL d, cat. 3)

## Initial situation

It must not be possible to open the packaging machine's protective casing, until all pneumatic drives are at a standstill.

## Information regarding implementation

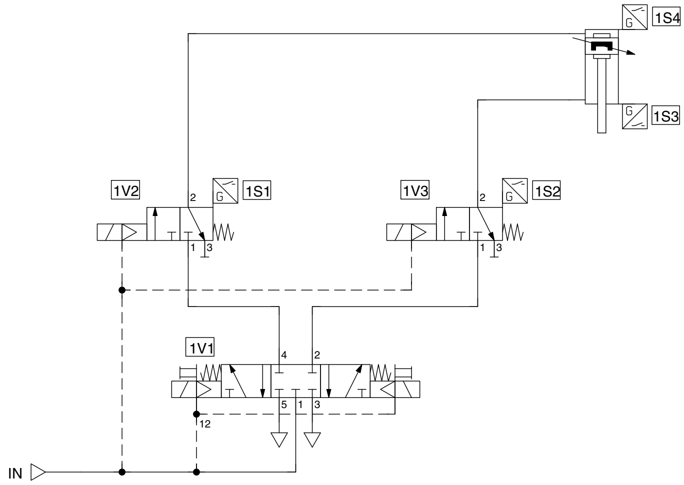
- The protective casing remains closed by means of a dual-channel lock until the drive has come to a standstill.
- For the vertical installation of actuators, appropriate measures against hose breakage must be taken, e. g. using metal tubing.




## Circuit description

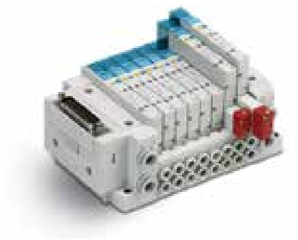
As shown in the block diagram, the first channel, which is realized by means of the 3-position valve (1V1), needs the respective sensors (1S4 and 1S3) to achieve the required diagnosis coverage level.

The second channel, consisting of two valves (1V2 and 1V3), which are directly linked to the cylinder. In contrast to example 2, by using valves that can be queried, regular functional testing of the pilot operated throttle check valves can be omitted. In this example, the spool detection integrated in the valves (1S1 and 1S2) monitors the functions of the second circuit. Protection against unexpected start-up in category 3 is realized by the 3-position valve with a closed center position and both valves.

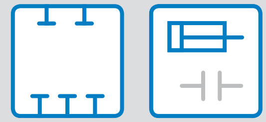



Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

## SMC products (also see page 43.)

| | | |
|---|---|---|
|  Valve with direct monitoring<br>VP-X536 |  Solenoid valve<br>Item: SY |  Residual pressure venting valve<br>Item: KE |

SAFETY-FUNCTIONS IN PRACTICE – EXAMPLE 5



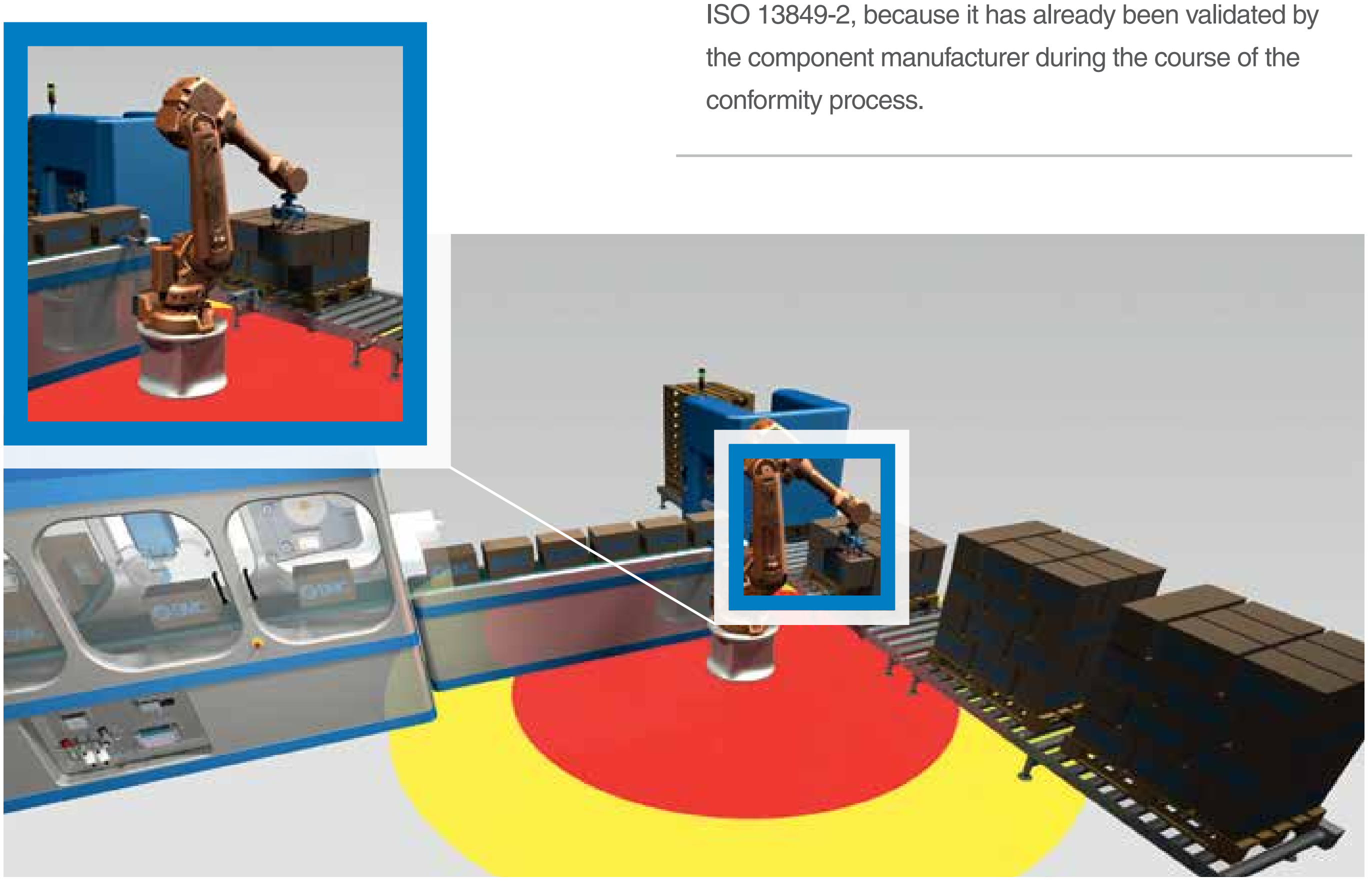
# Safe venting (PL c, cat. 1) and protection against unexpected start-up (PL c, cat. 1)

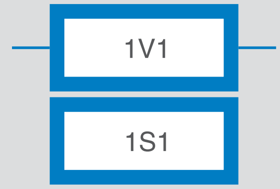
## Initial situation

If the operator enters into the hazardous area marked in red, the robots should stop and the pneumatic system should vent safely. The hazardous area is monitored using laser scanner. In this example, the robot is not a part of the safety-related evaluation.

## Information regarding implementation

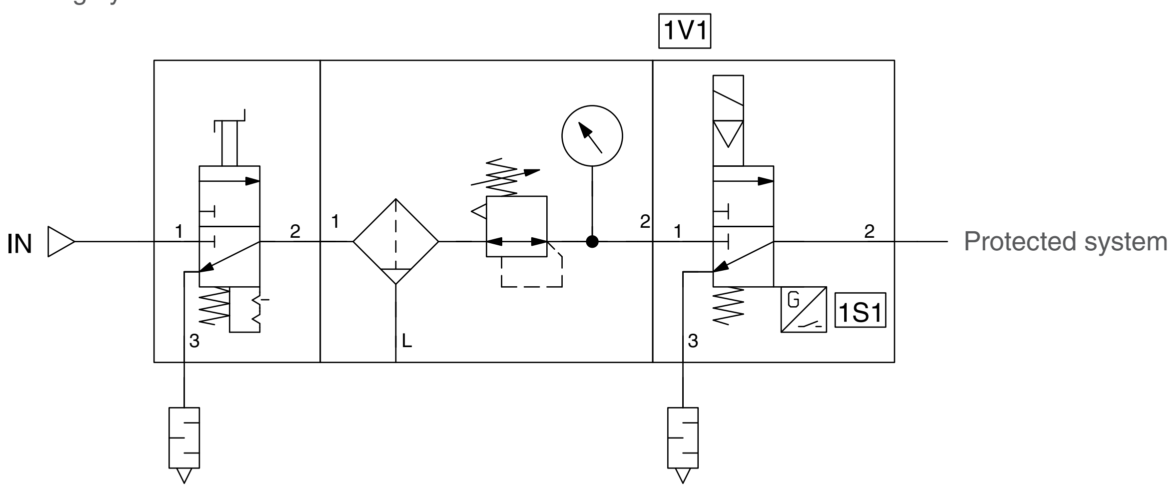
- The valve's venting capacity must be designed so that immediately upon entering into the hazardous area, no further dangerous movement can occur within the area.
- Downstream to the venting valve, no assemblies may inhibit safe venting.
- Regular checks to the noise suppressors guarantee timely venting.
- The safety component does not require validation as per ISO 13849-2, because it has already been validated by the component manufacturer during the course of the conformity process.






## Circuit description

The safety component, valve (1V1), vents the single channel system. A diagnosis coverage level is not required for category 1.




Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

## SMC products (also see page 43.)

Venting valve with direct monitoring
Item: VP-X536

Switch-on valve with soft-start function
Item: AV(A)/AVL

Magnetic valve
Item: VT

SAFETY-FUNCTIONS IN PRACTICE – EXAMPLE 6

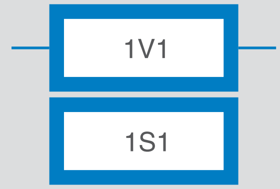
# Reduce pressure (PL c, cat. 1) and protect against unexpected start-up (PL c, cat. 1)

## Initial situation

If the operator enters into the hazardous area marked in yellow, the robot's speed should be reduced and the pneumatic system should reduce the pressure. The hazardous area is monitored by a laser scanner. In this example, the robot is not a part of the safety-related evaluation.

## Information regarding implementation

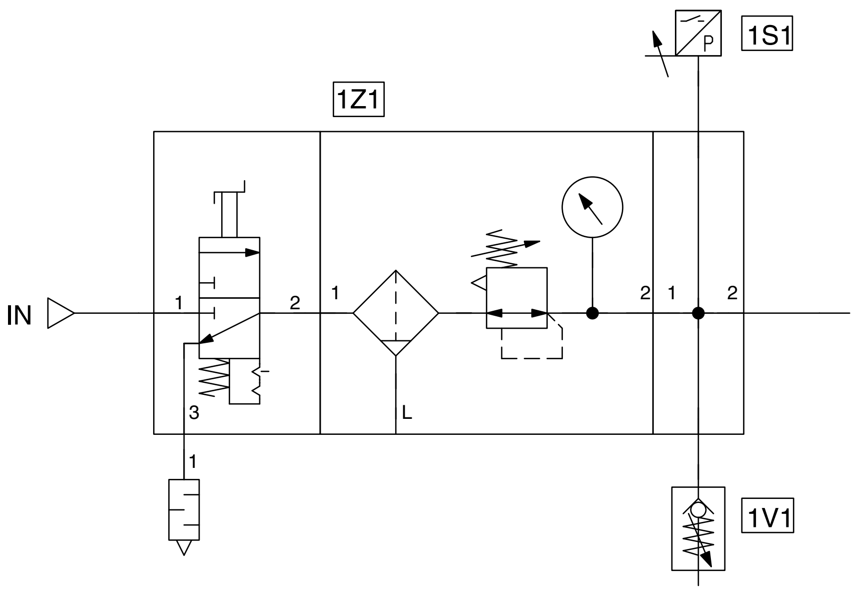
- The pressure in the maintenance unit should be reduced to a safe level, insofar as the application permits, so that the actuators are not subject to a crushing risk.
- Very frequently, applications in which lateral forces occur put the guiding properties of a cylinder in focus and result in the oversizing of the cylinder. This results in an increased safety risk, due to an excessive thrusting force.




## Circuit description

The pressure is reduced by the installed filter regulator (1Z1), in the event of a failure, the pressure limitation valve (1V1) will release the critical system overpressure.

The pressure switch (1S1) is optional, because it is not mandatory for category 1.




Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

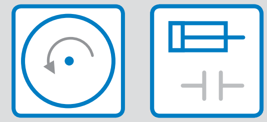
## SMC products (also see page 44.)

Digital pressure sensor
Item: PS1000

Mechanically adjustable pressure switch
Item: IS10

Manual shut-off valve
Item: VHS

Switch-on valve with soft-start function
Item: AV(A)



SAFETY-FUNCTIONS IN PRACTICE – EXAMPLE 7

# Monitor pressure (PL d, cat. 3) and protect against unexpected start- up (PL d, cat. 3)

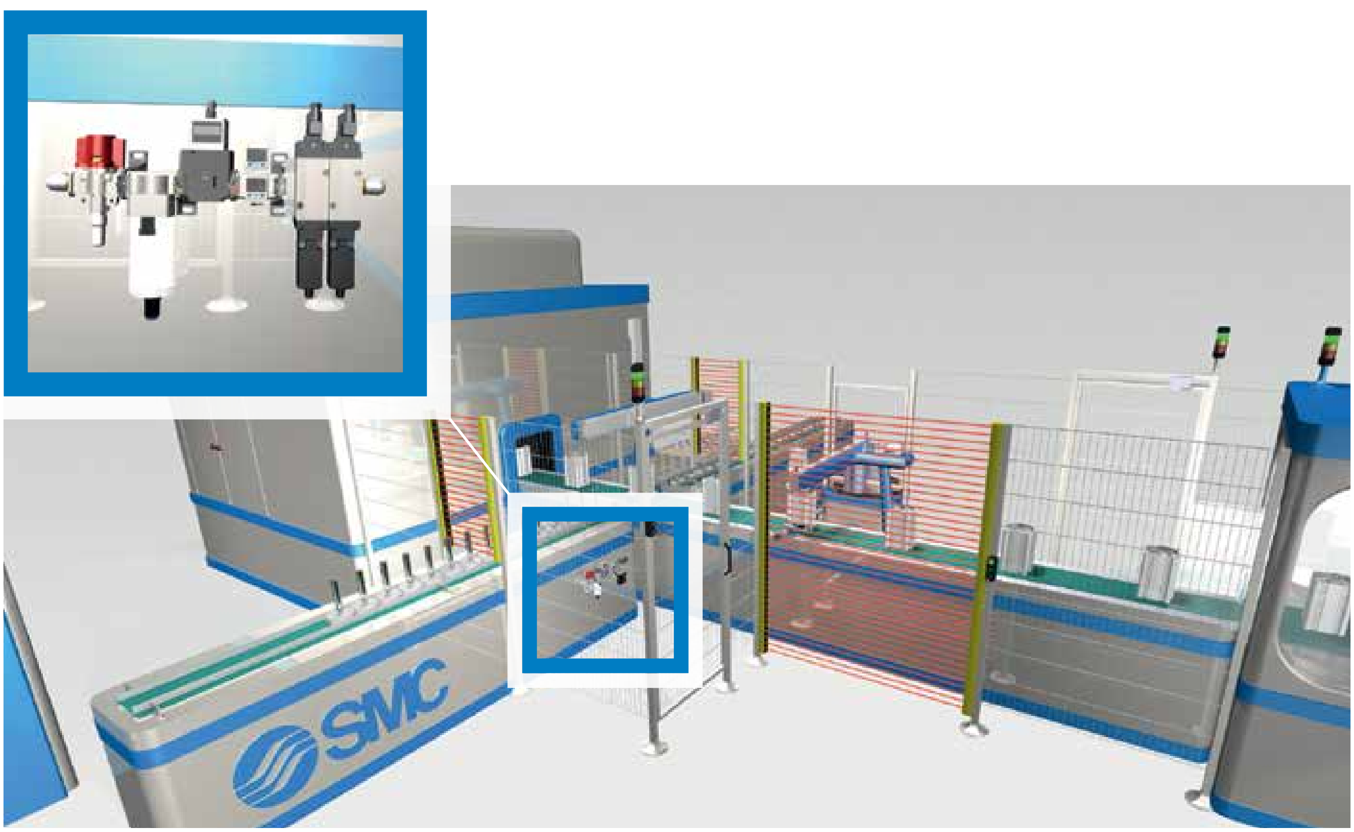
## Initial situation

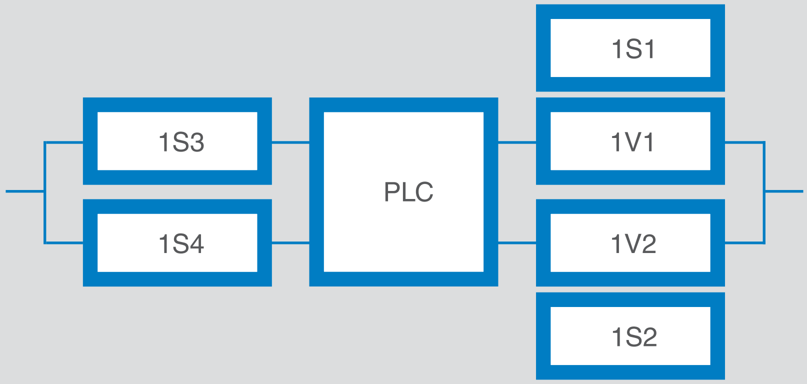
In addition to automatic mode, maintenance mode can also be selected via the operating mode switch. When the handling station is in maintenance mode, the actuators must be movable under pressure.

The pressure should be reduced in the maintenance unit to a defined-level and safely monitored, so that the actuators are not subject to a risk of crushing, while configuration and adjustment options can still be carried out. If the pressure reaches a critical level, the safety PLC receives an analog signal, and the system is vented.

## Information regarding implementation

- Maintenance mode may only be selected with the appropriate key at the operating mode selection panel.
- Trained personnel must be familiarized with the existing residual risk in maintenance mode.

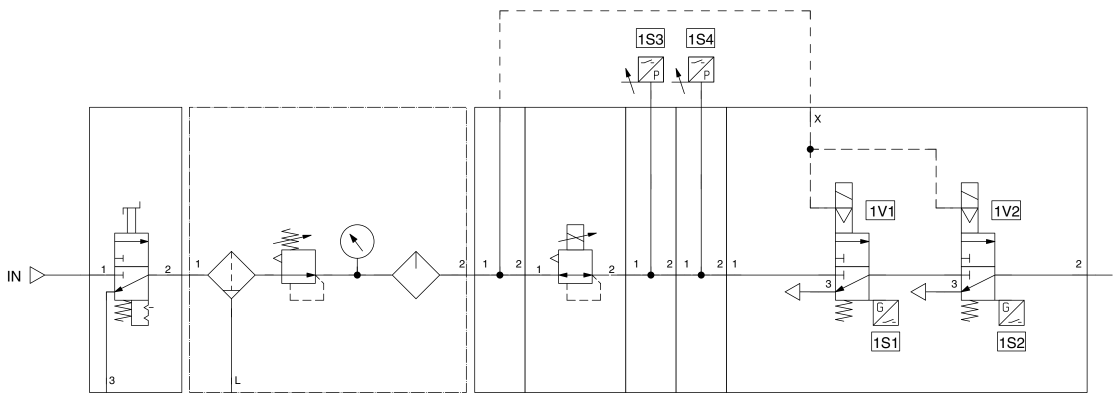





## Circuit description

The reduction in pressure is completed by means of an electro-pneumatic pressure regulator. Safe pressure monitoring is carried out by both of the pressure switches, which are equipped with analog signal output.

When the pressure on one of the pressure switches exceeds the defined threshold value, the entire system is vented via the safety valves 1V1 and 1V2.




Detailed product information can be found in the respective operating manuals. In addition to the listed information, the observance of legal references found on page 46 is mandatory.

## SMC products (also see page 43.)

Venting valve with direct monitoring
Item: VP-544-X538

Digital pressure sensor with analogue output
Item: ISE30A

E/P-Proportional converter
Item: ITV

# Standard references

| Standards | | EXAMPLE 1 (Page 27) | EXAMPLE 2 (Page 29) |
|---|---|---|---|
| ISO 12100 | Safety of machinery - General principles for design - Risk assessment and risk reduction | ☑ | ☑ |
| ISO 13849-1 | Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design | ☑ | ☑ |
| ISO 13849-2 | Safety of machinery - Safety-related parts of control systems - Part 2: Validation | ☑ | ☑ |
| ISO 13857 | Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs | | ☑ |
| EN 1037 | Safety of machinery - Prevention of unexpected start-up | ☑ | ☑ |
| ISO 4414 | Pneumatic fluid power - General rules and safety requirements and their components | ☑ | ☑ |
| EN 574 | Safety of machinery - Two-hand control devices - Functional aspects - Principles for design | | |
| ISO 13850 | Safety of machinery - Emergency stop - Principles for design | ☑ | ☑ |
| ISO 1219-1 | Fluidics - Graphical symbols and circuit diagrams - Part 1: Graphical symbols | ☑ | ☑ |

• The list of standards is not intended to be exhaustive. • The machine manufacturer determines the applicable standards during the process of risk assessment for the machine.

| EXAMPLE 3 (Page 31) | EXAMPLE 4 (Page 33) | EXAMPLE 5 (Page 35) | EXAMPLE 6 (Page 37) | EXAMPLE 7 (Page 39) |
|---|---|---|---|---|
| ☑ | ☑ | ☑ | ☑ | ☑ |
| ☑ | ☑ | ☑ | ☑ | ☑ |
| ☑ | ☑ | ☑ | ☑ | ☑ |
| ☑ | | ☑ | ☑ | |
| ☑ | ☑ | ☑ | ☑ | ☑ |
| ☑ | ☑ | ☑ | ☑ | ☑ |
| ☑ | | | | |
| ☑ | ☑ | ☑ | ☑ | ☑ |
| ☑ | ☑ | ☑ | ☑ | ☑ |

# SMC Products

## Suitable components for your application

### Safety components

#### Venting valve

- Safety valve as per MRL 2006/42/EC
- For max. cat. 2
- Venting capacity up to 131 cfm (3,700 L/min (ANR))

Item:
VP-X536

#### Venting valve

- Safety valve as per MRL 2006/42/EC
- For max. cat. 4
- Venting capacity up to 77 cfm (2,180 L/min (ANR))
- Mountable with SMC FRL units

Item:
VP-X538

#### Venting valve

- Safety valve as per MRL 2006/42/EC
- For max. cat. 4
- Venting capacity up to 77 cfm (2,180 L/min (ANR))
- Mountable with SMC FRL units
- Gentle pressure increase

Item:
VP-X555

#### Venting valve

- Safety valve as per MRL 2006/42/EC
- For max. cat. 4
- Venting capacity up to 1,459 cfm (13,000 L/min (ANR))

Item:
VG342-X87

#### Two-hand control valve

- Safety valve as per MRL 2006/42/EC
- Cat. 1 type IIIA as per EN 574

Item:
VR51

## Directional valves

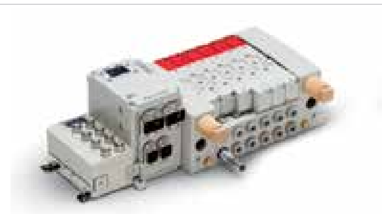
### Solenoid valve

- Numerous valve options, incl. residual pressure venting
- Steel detent for bi-stable valves
- Rubber-sealing for bi-stable valves with detent (as per ISO 13849-2)
- Available with optional spool detection for direct monitoring
- Available as a single valve

Item:
SY 3000 / 5000 / 7000

### Solenoid valve

- Numerous valve options
- Rubber-sealing for bi-stable valves with detent (as per ISO 13849-2)



Item:
VQC-X*

### Solenoid valve

- 3 port 2-position directly actuated poppet valve

Item:
VT

### Switch-on valve with soft-start function

- With manual override and adjustable venting throttle
- Switch-on valve with soft-start function and Lock-Out/Tag-Out
  Also available in purely pneumatic version


Item:
AV(A)/AVL

### Pneumatic valve

- Pneumatically actuated 2-position or 3-position valve in sizes ISO 1 and ISO 2

Item:
VSA7-6

### Pneumatic valve

- Pneumatically actuated 3 port 2-position poppet seat valve

Item:
VTA

### Manual shut-off valve

- 3 port 2-position manual shut-off valve, suitable for maintenance units and Lock-Out/Tag-Out systems

Item:
VHS

# Block and flow control valves

## Pilot operated check valve/ speed control

> Connection thread: 1/8" to 1/2"
> Installed directly in the cylinder

Item:
ASP

## Pilot operated check valve with residual pressure venting & speed control

> Connection thread: 1/8" to 1/2"
> Installed directly in the cylinder

Item:
ASP-X352

## Pilot operated check valve with state detection for direct monitoring

> Installed directly in the cylinder

Item:
XT34

## Residual pressure venting valve

> Plug connection Dm 6 – 12 mm or thread Rc 1/4 and Rc 3/8

Item:
KE

## Pneumatic logic valve

> Logic valve with AND/OR function

Item:
VR12

## Visual display

> Visual display for pressure monitoring

Item:
VR31

## Sensors for diagnostics

### Digital pressure sensor

- Adjustable pressure and vacuum sensor

Item:
PS1000

### Mechanically adjustable pressure switch

- Contact type (reed contact)
- Mountable with modular maintenance unit

Item:
IS10

### Signal generator

- Electronic
- Rounded groove

Item:
D-M9

### Signal generator

- Mechanical (reed)
- Rounded groove

Item:
D-A93

## LEGAL NOTICES

The circuit examples shown introduce application possibilities for our products and assemblies, with which various pneumatic sub-systems for safety functions can be realized.

The circuits are merely examples for the listed safety functions, and do not represent a binding solution or application recommendation for a specific application. Even if a similar type of safety function is being treated, it is not guaranteed that the existing risk can be adequately reduced by this example in a real application (see Chapter 5.5, DIN EN ISO 12100). The machine manufacturer or control-relevant personnel is instead solely responsible for testing independently for each individual application, and if required, to make additions or changes to the circuits. In so doing, the machine manufacturer or control-relevant personnel must independently examine and comply with all laws, guidelines and standards pertaining to the construction, manufacture and product information and to observe them during implementation. The machine manufacturer or the control-relevant personnel bear sole responsibility for the suitability of the circuits for the installed components. SMC assumes no warranty or liability for an implemented solution designed by the machine manufacturer or control-relevant personnel for their respective, specific application, or for the assumption of a sample circuit shown here for their specific application.

The circuits show only the pneumatic subsystem (control-component "actuator"). For the completeness of the safety functions, the machine manufacture or control-relevant personnel must generally add additional safety-related subsystems (usually  "sensor" and "logic" control components).

# Safety in the U.S. Technical Center (UTC)

## Practice-oriented and cooperative

Realistic simulation based on customer specifications. The United States Technical Center (UTC) at Noblesville, Indiana is a cross-sector innovation and competence center. Futuristic automation solutions based on customer specification are created here.

Collaboratively, we at UTC can realistically simulate various tasks and production options from the following sectors:

### EFFICIENCY

Intelligent solutions for resource efficiency and energy savings.

### FLEXIBILITY

Industry 4.0 as the decisive component for automation processes of the future.

### SAFETY

Safety aspects for human – machine interfac es, as well as the handling of diversified application testing.

# Circuit testing as per DIN EN ISO 13849-1 or customer specifications

Take advantage of our expertise and the right components for creating pneumatic circuits, which comply with functional machinery safety regulations as per DIN EN ISO 13849-1.

### Core competence:

SMC provides validated pneumatic components for the creation of circuits in various categories as per DIN EN ISO 13849-1. Sample circuits can be put together from pre-fabricated control panels for various safety functions. Your requirement can be simulated. If you wish to perform testing on one of your real machine components, we offer the use of appropriate workspace and workbenches.
If needed, or requested by the customer, it is also possible to obtain the assistance of our safety experts.

### Test unit equipment:

- There are many electric and pneumatic control panels available for the simulation of circuits for functional safety as per DIN EN ISO 13849-1.
- There are sample circuits with descriptions for various protective functions available.
- Open space and workbenches can be used for setting up your application.

# SMC North America

SMC...
Supporting automation through cutting edge pneumatic technology and a relentless pursuit of customer satisfaction.

## INTRODUCTION

### PRODUCTION AND SUPPLY

Currently, our product offering includes over 12,000 basic products with over 700,000 variations. This vast array of products satisfies nearly every application.
State-of-the-art global and local production facilities combined with local inventory ensure fast delivery of these quality products at competitive prices. Through maximization of local production capabilities, a stable supply of product is guaranteed.

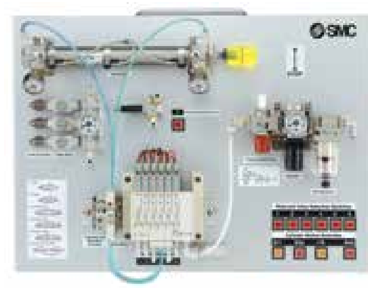
### TECHNICAL DEVELOPMENT

SMC's staff of over 1,400 engineers located at technical centers in Japan, the United States, China and Europe provide quick, clear and detailed responses to customer requests through our local sales group. They are constantly on the alert for new trends and technologies that lead to new and innovative world class products.

### SALES & COMMUNICATION NETWORK

Local subsidiaries have been established in 78 countries worldwide with over 360 sales offices and 5,700 sales people. By establishing a strong local presence in each country and region, SMC provides the best possible service in the industry. SMC maintains close communication with our customers, keeping our engineering teams and products at the leading edge of industry.

# Training




Focus on training customers
from basic pneumatics
to specific industry related products

# Energy Saving


Reduce consumption of electricity
Reduce consumption of compressed air
Reduce $Co_2$ emissions
Reduce operating costs

# E-Tech


Digital pneumatic products builder
The on-line application to select, size and build
Pneumatic automation products
• Download CAD files
• Configure part numbers
• Save and e-mail part lists
• Millions of product part number available

# Trade Show & Show room


Primary way to show new SMC products and
receive direct customer feedback.

Various products involving new products
are exhibited and demonstrated at various show rooms.

# Global Manufacturing, Distribution and Service Network

## Worldwide Subsidiaries

### EUROPE

**AUSTRIA**
SMC Pneumatik GmbH (Austria)
**BELGIUM**
SMC Pneumatics N.V./S.A.
**BULGARIA**
SMC Industrial Automation Bulgaria EOOD
**CROATIA**
SMC Industrijska Automatika d.o.o.
**CZECH**
SMC Industrial Automation CZ s.r.o.
**DENMARK**
SMC Pneumatik A/S
**ESTONIA**
SMC Pneumatics Estonia
**FINLAND**
SMC Pneumatics Finland OY
**FRANCE**
SMC Pneumatique S.A.
**GERMANY**
SMC Pneumatik GmbH
**GREECE**
SMC Hellas EPE
**HUNGARY**
SMC Hungary Ipari Automatizálási Kft.
**IRELAND**
SMC Pneumatics (Ireland) Ltd.
**ITALY**
SMC Italia S.p.A.
**LATVIA**
SMC Pneumatics Latvia SIA
**LITHUANIA**
SMC Pneumatics Lietuva, UAB
**NETHERLANDS**
SMC Pneumatics BV
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**POLAND**
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**ROMANIA**
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SMC Pneumatik LLC.
**SLOVAKIA**
SMC Priemyselná Automatizáciá, s.r.o.
**SLOVENIA**
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**SWEDEN**
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**INDIA**
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**JAPAN**
SMC Corporation
**MALAYSIA**
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**PHILIPPINES**
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**SINGAPORE**
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SMC Pneumatics Korea Co., Ltd.
**TAIWAN**
SMC Pneumatics (Taiwan) Co., Ltd.
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SMC Thailand Ltd.

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**USA**
SMC Corporation of America

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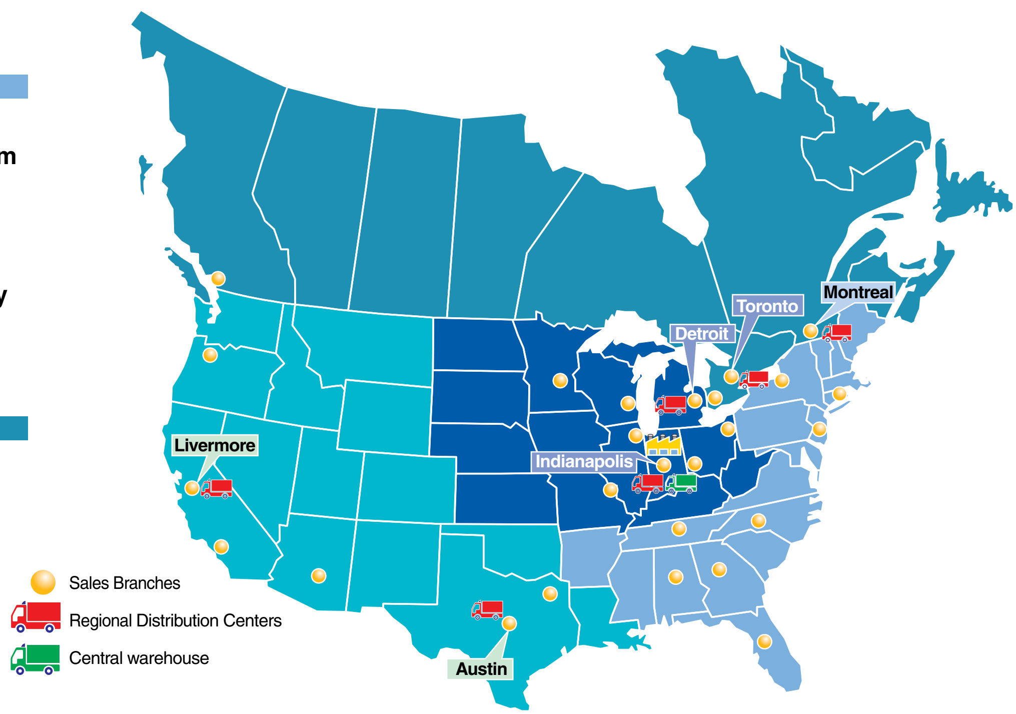



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