Safety on Board
Functional safety in automation technology
Safety on Board – integrated, certified and seamless

Safety on Board stands for intelligent safety solutions developed by Rexroth to protect man and machine. This innovative safety solution meets the most demanding safe motion, peripheral signal processing and communication standards. Safety on Board: functional safety from Rexroth, the specialist for all control and drive technologies.

Integrated
Maximum protection of human health, simplified commissioning and validation and less idle time are just a few of the advantages of Safety on Board technology. Optimal interaction between the automation and safety systems reduces the risk that protective mechanisms will be manipulated, and it makes a vital contribution to accident prevention.

Certified
Safety on Board delivers maximum reliability to machine manufacturers based on safety technology which is tested and certified for compliance with the latest standards. The time and effort involved in validation is reduced to a minimum, and manufactures enjoy the benefits of functional safety and legal certainty.

Seamless
SafeMotion and SafeLogic blend seamlessly into a holistic safety solution which extends from the drive to the control system. Rexroth delivers safe, tailored automation technology ranging from homogenous system solutions and heterogeneous automation topologies to stand-alone components.

Safety on Board
Rexroth’s standard-compliant products deliver functional safety across all automation levels and technologies. From the component level right up to system solutions, we provide the support machine manufacturers need to deploy cost-effective applications. Our portfolio also includes a range of professional services and hands-on training.
SafeMotion
Rexroth’s drive-based safety solution goes far beyond “Safe Stop” on machines and systems. SafeMotion provides the basis for safe machine design. It gives the operator access with minimized risk to the process and increases availability by reducing downtime. The result is higher productivity.

SafeLogic
The Rexroth safety control which enhances the functionality of the standard control and extends the logic processing portfolio at the high end. SafeLogic is a powerful, user-programmable safety control for machines and extensive, interlinked systems with a large number of safety peripherals.

SafeLogic compact
is Rexroth’s small safety control which features modular scalability, open architecture, user-friendly programming and intuitive parameterization. It is designed for deployment in safety applications on small and mid-size machines.

▼ Safety on Board simplifies the implementation of machine design strategies and helps reduce non-productive time. It provides a path to standard-compliant implementation of machine-specific C standards and safety standards such as ISO 13849 and IEC 62061 while at the same time enhancing overall system effectiveness.
Safe drive technology from Rexroth means more than just safe stopping. Above all, it is safe motion functions that give you the means of protecting your personnel effectively, increasing productivity and accomplishing new safety concepts.

Whenever operators have to work inside the machine, it is a requirement of the Machinery Directive that the machine manufacturer has made provision for special safety precautions, because any uncontrolled movement can be a danger. Rexroth prevents these malfunctions as a pioneer of drive-integrated safety technology, with many years of experience in the field. “Safety on Board” was introduced to the market by Rexroth as early as 1999 and has been continually expanded with the addition of further functions ever since.

**Expanded range of functions**

In addition to the traditional safe stop and motion functions, IndraDrive also supports more than 18 safety functions. Such as safety door locking, various safely limited positions and a safe braking and holding system.

**Convincing advantages:**

- Increased machine productivity as a result of shorter special mode times
- No unnecessary idle times because the line circuit breaker does not have to be opened
- No need for re-synchronization of coupled axes
- High reliability thanks to certified and integrated safety functions
- Savings on limit switches, measurement and analysis units and control cabinet size
- Reductions in time and money spent on certification
- Online-self-monitoring, no periodic machine shutdown needed for fault detection

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**Drive-integrated safety functions**

**Classification in groups**

<table>
<thead>
<tr>
<th>Power disconnection</th>
<th>STO, SS1</th>
</tr>
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<tbody>
<tr>
<td>Braking</td>
<td>SS1, SS2, SMD¹, SBS¹</td>
</tr>
<tr>
<td>Motion</td>
<td>SOS, SLS, SMS¹, SDI, SLI</td>
</tr>
<tr>
<td>Position</td>
<td>SMP¹, SLP Precondition for safely coordinated motion</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>SDL¹, SIO¹</td>
</tr>
</tbody>
</table>

¹ Not defined in EN 61800-5-2:2007

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**Safety parameters according to EN ISO 13849-1, EN 62061, EN 61800-5-2, IEC 61508:**

- Safe Torque Off (L2): Category 3 PL e, SIL 3
- Safe Motion (S2): Category 3 PL d, SIL 2 (SS1, SS2, SOS, SMD, SLS, SMS, SLI, SDI, SMP, SLP, SDL, SIO, SBS)

In addition to the certificate issued by TÜV Rheinland, an EC prototype certificate confirms that the IndraDrive safety functions are compliant with the Machine Directive 2006/42/EG.

NRTL listing in accordance with UL 508, NFPA 79, IEC 61508 and CAN/CSA C22.2 provides additional security for the US and Canadian market.
**Safe Torque Off (STO)**
Stop category 0 in accordance with IEC 60204-1: Safe drive torque cut off

**Safe Stop 1 (SS1)**
Stop category 1 in accordance with IEC 60204-1: Safely monitored stop, control or drive controlled with safe drive torque cut off

**Safe Stop 2, Safe Operating Stop (SS2, SOS)**
Safe Stop 2, Stop category 2 in accordance with IEC 60204-1: Safely monitored stop with safely monitored standstill at controlled torque

**Safe Direction (SDI)**
A direction (clockwise, counterclockwise) is also safely monitored in addition to safe motion

**Safely Monitored Position (SMP)**
A limited position range is also safely monitored in addition to safe motion

**Safely Limited Position (SLP)**
Monitoring of safe software limit switches

**Safe Braking and Holding System (SBS)**
The safe braking and holding system controls and monitors two independent brakes

**Safe Door Locking (SDL)**
When all the drives in one protection zone are in safe status, the safety door lock is released

**Safely Limited Increment (SLI)**
If enable signal is given a limited increment is safely monitored in special operating mode

**Safely Limited Speed (SLS)**
The maximum speed is safely monitored regardless of the mode of operation

**Safe Communication (SCO)**
Selection/deselection of safety functions and transfer of process data (e.g. actual position values) via safety bus
SafeMotion – fast, autonomous, reliable

Fast
The drive-integrated safety technology in IndraDrive monitors movements where they are generated. The results are very rapid response times of just 2 ms upon triggering of the internal monitors. This is particularly important for high-dynamic drives because otherwise there is a risk of impermissibly large residual distances. The drives remain in position control during any intervention work on the machine, which eliminates the need to disconnect from the main power supply and re-synchronize coupled axes. Reducing these special mode times leads to significant improvements in plant productivity.

Stand alone
IndraDrive with integrated safety technology can be used as a stand alone component, because two redundant and diverse monitoring channels are directly integrated in the drive. The safety peripherals such as mode selectors or enable switches, for example, can be connected directly to the drive so that the safety functions can be switched active. In contrast to conventional safety technology there is no need for additional external measurement and monitoring devices. This results in a space-saving, low-cost solutions.

Reliable
The safety functions in IndraDrive are tested by independent certification bodies and are compliant with the latest safety standards. You can rely on the certified safety of IndraDrive and therefore reduce the need to organize certification yourself. Since the complete monitoring system is integrated in the drive you can be sure of maximum safety without possibility of tampering.

Simple start-up
The safety parameters – such as a monitored, limited speed, for example – allow a simple menu-guided start-up. With removable memory cards, reproducing the safety parameters in series production machines is itself simple, as is re-importing whenever a drive controller is replaced.

Simple service handling
For servicing, the safety parameters are simply imported to a new device. All that has to be checked is the identification of the drive (manufacturer, machine type, axis). There is no need for the validation procedures to be repeated again on-site.
There are different ways in which the dual-channel selection of the required safety functions in the drive can be realized:

**Option L2 – Safe Torque Off (STO)**
Both channels via 24 V inputs

**Option S2 – Safe Stop and Safe Motion**
Both channels via 24 V inputs

**Option S2 – Safe Stop and Safe Motion**
Both channels via safety bus

**Option S2 – Safe Stop and Safe Motion**
One channel via 24 V input and one channel via standard control communication system

1) IndraDrive drives with Option S1 support all the safety functions shown on page 5.
SafeMotion – the safe braking and holding system

Rexroth is the first company in the world to integrate a safe braking and holding system in its drives for preventing vertical axes from crashing. This redundant concept provides maximum safety even after the power has been shut off.

Personnel frequently have to carry out work in the machining areas of plant and machinery – be it for commissioning, rectifying faults or for process optimization. Particular caution is required if any axes are under the load of gravitational force in the access area. Vertical or inclined axes can be a danger, in particular when disconnected from the power supply because of the risk of unintentional falling. Possible causes include holding brakes that are soiled, oily or damaged as a result of faults in the brake controls. The Rexroth safe braking and holding system provides protection against such dangers through three independent channels – sensing the motor torque and two redundant brakes.

Safety for man and machine
- Certified in accordance with EN ISO 13849-1 Kat. 3 PL d and EN 62061 SIL 2 for maximum safety
- Prevents axes under the load of gravitational force from falling
- Lightning response in the event of a malfunction thanks to drive-integrated monitoring
- Two independent brakes – separately controlled and monitored
- Redundant holding of the vertical axis even after the power supply has been switched off, e.g. in the event of an emergency switch-off or emergency stop
- Escalation strategy with graduated impact of the three braking forces minimizes the stress on the mechanicals
- Open for various different electrically released brakes – can also be installed on the load-side
Open for different brake systems
Different machines use a large variety of braking systems. The safe braking and stopping system is therefore open and flexible for connecting the many different products available on the market. It is even possible to use hydraulically or pneumatically actuated rods or guide rail brakes.

Both brakes have to be released electrically and comply with the specification for the control signals. For motors with housings, the holding brake integrated in the motor is normally used as the first brake. The second brake takes the form of a brake fitted either directly to the motor flange, the transmission exit end or on the load-side. This offers the advantage of ensuring that any failures in mechanical transmission elements are also reliably controlled as well. For direct drive motors, underlying principles mean that only load-side brakes can be used. The second channel brake control is provided by an external control unit monitored by the drive. There are no safety-specific requirements for the individual brakes.

Detecting dormant faults
To detect dormant faults (e.g. oily holding brakes) the brakes have to be tested at regular intervals. First the current load torque caused by the gravitational force has to be determined.

The brakes are then applied in sequence and subjected to a load from the drive in both directions, the load in each case being 1.3 times the maximum weight load of the application. At the same time the positional information is monitored by two channels on the basis of a parameterizable tolerance range. An “overrunning” axis, caused for example by an oily brake, would be reliably detected and intercepted by this solution.

Once both holding systems have successfully passed the brake test, the internal brake status for an adjustable time is set to “Ok”. Within this time it will be permissible to enter and remain in the area beneath the vertical axis without the need for a new brake test.
SafeLogic – safe logic processing simply programmed

As an integral component of standard control systems, Rexroth’s SafeLogic allows the user to program both standard and safety applications together on a control system with the same IndraWorks engineering tool.

**Functional principle**
This involves upgrading standard control systems with an optional function module. This function module provides all the resources required for safe logic processing. The applications are completely decoupled from each other so that any changes to the standard application have no influence on the safety application.

The information exchanged between the participants in a data connection, i.e. between the producer and the consumer, is exchanged in the form of safe data telegrams. If the consumer determines that the received data is incorrect or if there is an error in transmission, it switches to a predefined, safe error status.

The transmission path therefore becomes a “Black channel” and has no impact on safety – irrespective of the medium or transmission path selected.

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1) in preparation
Communication
For the communication interface it is possible to use either the sercos and/or PROFIBUS interface on the standard controller. Both networks are run simultaneously and serve both the standard and the safety components in a mix. To this end, not only sercos safety is supported but the PROFIsave V2 protocol for connecting intelligent third-party safety components as well.

Certified function modules take the place of the relay and graphic connections (programming) between the function modules replacing the discrete wiring.

At an organizational level a distinction is made between two user groups:
- The basic level user only connects up the function blocks along the same lines as the discrete wiring. The resulting program reduces the cost and effort in the validation process to a minimum.
- For the extended level user the more extensive functionality allows user-defined function blocks to be created. However, the effort involved in the validation of these function blocks is considerably higher. On the other hand, once they have been verified they are suitable for use in the basic level, with the aforementioned advantages. Therefore this provides a simple means of implementing organizational measures associated with functional safety management.
SafeLogic – safe peripherals without limits

Safe peripherals are incorporated into the automation using the standard sercos III\(^1\), PROFIBUS and PROFINET IO\(^1\) bus systems. Both standard and safety I/Os are run on a communication medium and are fully and cost-effectively integrated into the plant automation.

**Safe drive technology**

The drive-integrated safety technology of Rexroth IndraDrive can be reliably incorporated into the network with sercos III. Drives in positioning block mode can also be added through PROFIBUS and PROFINET IO.

**Safe inputs and outputs**

A variety of safety I/O modules are available for reading in the signals from safety sensors and for activating safety actuators. They perform safety functions up to SIL 3 and PL e cat. 4. The safety I/O modules are incorporated into the automation through sercos III\(^1\), PROFIBUS or PROFINET IO\(^1\) and can function alongside standard I/O components without any problem.
sercos safety –
for safe communication worldwide

Safe data transmission up to SIL 3 in accordance with IEC 61508 – sercos safety combines the advantages of the sercos III Ethernet-based communication system and the internationally established safety protocol CIP Safety\(^1\).

This permits real time, safety and standard IP data to be exchanged via the same medium and beyond the boundaries of individual networks. CIP Safety offers worldwide market acceptance and allows interoperability between CIP Safety-based networks and components.

**sercos safety means:**
- The use of the CIP Safety mechanisms for protocol security
- Adaptation of sercos on CIP Safety
- Sercos-specific Safety profile

**sercos safety offers the following:**
- Simple accomplishment of safety applications up to SIL 3 in accordance with IEC 61508, even for short cycle times
- Drastic reduction in topology costs compared to current solutions
- Drive-integrated safety functions incorporated in the machine control system to optimum effect, increasing plant productivity in the process
- Realization of homogeneous safety solutions in which the control system, drive, data transmission and I/O peripherals all merge to optimum effect
- Implementation of central and distributed architectures to meet the highest requirements in terms of performance and deterministics

**sercos III**
Direct cross-communication permits data exchange between two safety slaves without the safety master having to route the data. sercos III can therefore be used to create structures which work without any central safety control system whatsoever and which allow ultra-short response times.

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\(^1\) CIP Safety is a registered Trademark of the ODVA (Open DeviceNet Vendor Association)
Machine tools

Whether setting up tools and probes, performing control measurements or resolving faults, the control- and drive-integrated SafeLogic and SafeMotion safety functions allow applications to be designed simply and safely, e.g. in accordance with ISO 23125, EN 12417 and EN 14070 requirements. For as long as the safety doors are closed, the machine produces at full speed. In special mode the doors can be opened and various safety functions are active, depending on the protection area, e.g. to monitor the safe operating stop or permit operation at reduced speed. In automatic mode processes can be observed at higher, safely monitored speeds.

Forming machines

SafeLogic and SafeMotion, the safety functions from Rexroth, simplify the achievement of safe machine concepts, e.g. to ensure compliance with EN 692, EN 693 or EN 12622, and minimize unproductive downtimes. When changing tools, loading and unloading manually or resolving faults, operators need safe access to the press chamber. When safety doors are open, functions such as „safe operating stop“ and „safely limited speed“ help protect personnel against uncontrolled axis movements. The safe monitoring of motion travel (absolute position) allows the danger caused by non-permitted axis positions, e.g. of press springs, to be avoided. The speed can also be safely monitored in automatic mode as well, enabling processes to be optimized.
Packaging machines
Whether filling, sealing, group packaging or palletizing, if a product or package gets stuck, the operator needs safe access into the machine if he is to be able to rectify the process fault quickly. SafeLogic and SafeMotion enable a machine to be brought to a safe torque off state or a safe operating stop without an electromechanical power down and the time-consuming restart that this would entail. This allows the overall equipment effectiveness (OEE) to be significantly improved. SafeLogic and SafeMotion permit realization in compliance with standards, e.g. the requirements of EN 415 for packaging machines.

Print and processing machines
Whether changing plates or blankets, washing cylinders or changing rollers, SafeLogic and SafeMotion contain everything that is required for safe printing and paper processing, e.g. in accordance with EN 1010 requirements. The safety functions such as the monitoring of protection areas, reduced speeds or safe direction of rotation are available as certified functions in the control system and in the drive. The safety functions are integrated into the application through the corresponding function modules, allowing safety and standard applications to merge optimally with each other.
Assembly and handling applications

Modern manufacturing cells with several access areas are now expected to meet the following requirements:

- The work area of interlinked robots is to be reliably enabled
- The feeding of materials and rectification of process faults are to be enabled
- The robots are to be set up for new production orders by the operator

SafeLogic and SafeMotion meet the requirements such as those of ISO 10218 safely and simply. When new positions and travels are being taught in, SafeMotion protects against uncontrolled axis movements. The robots operate at full load. Peripherals are integrated with SIL 3:Safety IO modules through sercos safety or PROFIsafe.
Always on the safe side –
safe solutions from Rexroth

To ensure a cost-effective unit life cycle, Rexroth supports you with all the services associated with Safety on Board – from the concept and design through engineering and commissioning to modernization.

**Expertise from the safety technology experts**
Rexroth has played a pioneering role in automation safety technology, and it has been setting the standard for many years. Our engineering teams developed the first certified on-board safety functions in electric drives, to cite just one example. We are your professional partner for safe electric, hydraulic and pneumatic automation solutions. We deliver top-quality, leading-edge safety technology solutions which offer incremental value-add combined with maximum safety. Our machine safety service portfolio allows you to select specific modules or enjoy the benefits of full-service packages. Our support coverage extends from the risk assessment phase to installation, commissioning and conformity assessment.

**Handbook for realizing functional safety in accordance with ISO 13849**
The handbook is a practical guide for the design of safe machines. It helps to significantly reduce the expense of configuring safe machine controls. Risk assessment, safety functions, Performance Levels, diagnosis and reliability values for all electric, hydraulic, mechanical and pneumatic components are key stations along the way to configuring safety-related control systems compliant with ISO 13849. When producing the handbook, our experts were keen not only to reproduce standards and guidelines, but also to translate these into practical know-how using real-life examples. The 264-page handbook can be obtained for €49.90 from the bookstore (ISBN 978-3-9814879-1-6) or the Rexroth eShop under number R961006998.

www.boschrexroth.com/eshop
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