Always on the Safe Side –
Safe Solutions from Rexroth

The Drive & Control Company
Productivity Needs Safety

Anti-lock braking system, electronic chassis control or automatic distance warning system: comprehensive safety features are one of the most important sales arguments of car manufacturers. Safety engineering is also becoming much more important for stationary and mobile machines: changing standards reflect technological advances and take account of an increased awareness of responsibility.

As a pioneer in safety technology in the field of automation, Rexroth has been improving the state of the art since decades. Rexroth engineers were the first to develop certified and integrated safety functions in electric drives and safety circuits for hydraulics. Only Rexroth can offer entirely functional safety consistent on all automation levels and for all technologies and products: from components up to system solutions including software. In addition, close attention always ensures the interoperability between different components during the manufacturing process for drive and control technologies. As a reliable partner for safe hydraulic, electrical and pneumatic automation solutions, The Drive & Control Company provides machine manufacturers and end customers with best-in-class solutions based on the newest safety engineering. To this end, specialists purposefully combine individual technologies to achieve optimal performance and to fulfill all safety requirements.

Rexroth has many years of experience in controlling large forces, masses and accelerations. Using modern testing methods and the newest calculation and simulation...
techniques, the developers analyze vibrations and possible deformations in the components. Careful development and optimized production processes set quality standards throughout the industry. The products are suitable for numerous applications attending to national and international standards.

Rexroth supports machinery and production system builders with safety solutions from the design to the implementation of safety functions, with concepts, service and the transformation of application know-how in product requirements.

This opens up decisive perspectives for implementing safety engineering requirements economically: based on products fulfilling high safety standards. Specialists design complete system solutions which combine interoperable components with integrated functional safety.

Rexroth supports machine manufacturers and system/application developers to evaluate safety risks and provides solutions regarding new machines and machines with retrofit that have already been installed.
The European Machinery Directive 2006/42/EC and the Machinery Safety Standards ISO 13849 and IEC 62061 provide the framework: in a extensive evaluation with statistical parameters, machine manufacturers must proof protection of personnel under consideration of all components and systems installed into the machine or production system.

Rexroth offers more than certified components and tested circuits: using our technical know-how and the required parameters, we support machine manufacturers to evaluate their products considering the machinery directive and safety engineering standards. This leads to a considerable reduction in development effort for the machine manufacturer.

The new design criteria and probabilistic calculations cover safety engineering classifications of components and systems for nearly all stationary and mobile machines. For this purpose, suppliers must provide information about the reliability of all involved electrical, hydraulic, mechanical and pneumatic components.

Most important parameters:
- **PL** (Performance Level), discrete level to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions.
- **B_{10d}**, the expected value of the average number of cycles until 10% of the components fail dangerously.
- **PFH_d**, the probability of a dangerous failure per operating hour.
- **MTTF_d**, mean time to dangerous failure, the expected value of the expectation of the mean time to dangerous failure.
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Rexroth provides these data with all other necessary information. The designer can use the SISTEMA calculation program from BGIA to directly access these values without tediously searching in catalogues. This means that he or she is always up to date.

Machinery Directive 2006/42/EC stipulates that a risk assessment with the necessary technical documentation and declaration of incorporation must be carried out under all machine components and that selected technical documents must be provided as evidence of this risk evaluation. Intrinsically safe designs have therefore always higher priority over protective safeguards and information for users (e.g. warning signs). The machine manufacturer must assess the system's risk, design corresponding safety functions and specify the required performance level (PL) of the control system: this depends on the average probability of a dangerous failure per hour. "e", the highest performance level, statistically permits maximally one dangerous failure in 10 million operating hours. If the machine manufacturer personally develops his control systems, our specialists will provide advices and corresponding data for the components.

In the case of complete hydraulic controls, Rexroth ensures that the product meets the required safety level. Press controls attain, for example, the highest PL, i.e. “e”.

Rexroth has developed a guideline which systematizes the evaluation, conception and implementation of the safety functions. In 10 steps, designers can, according to standards, specify the required performance level, select and model the circuit, choose suitable components from all control technologies, evaluate the monitoring and robustness of the control system, verify compliance with safety principles, check the suitability of the software and finally verify and validate the attained safety level. Especially by complete electrohydraulic, electromechanical and electropneumatic systems, we reduce by this way the effort involved in implementing the new standards: automation products with certified safety functions and structured, standard-based evaluations of safety engineering questions come from a single source. In short: you are on the safe side with Rexroth!

10 Steps to the Performance Level: ISO 13849 – Functional Safety

1. Risk Assessment based on ISO 14121
2. Identification of the Safety Functions
3. Specification of the required Performance Level (PL)
4. Choice of the System Architecture (Category)
5. Modeling the System (Circuit) with Block Diagram
6. Selection of Appropriated Components: (MTTFd, B10, PL, PFHd)
7. Evaluation of the System Monitoring (DC)
8. Evaluation of the System Robustness (CCF)
9. Check the Safety Principles and Software Requirements
10. Verification and Validation of the Reached Performance Level PL ≥ PLr
Guaranteed Safe Movements

Safe movements in all drive technologies and the fast reaction of monitoring functions provide the basis for effective protection of personnel.

Especially in the case of mechatronic systems with components from different technologies, Rexroth simplifies the design of safe machines: as a supplier of all drive and control technologies from a single source, we are aware of all safety-related parameters and can evaluate their interdependency from the aspect of safety engineering, with comprehensive physical understanding of all technologies.

For example, purely mechanical safety components also safeguard the load in the event of external damage to functional components, especially with vertical axes or ceiling installations. If there is a loss of pressure in a pneumatic system, a pneumatic locking element automatically prevents movement of the piston rod. It is also possible, for example, to report the function failure to the control system unit through torque monitoring.

Securely holding loads is one of the basic preconditions for safe work with hydraulic presses. Rexroth offers a large number of safety functions as standard modules with press control systems. They redundantly monitor the starting and stopping events of movements. Safety valves prevent pressure from building up before the axis is released. On the ring side, position-monitored valves act as counters, ensuring that there is no loss of pressure. Redundant measures ensure that the control maintains...
the required position of the axis even under load.

The hydraulic feed axis for machine tools with mechanical clamping shows how quickly and precisely a safety function can operate. Even in the case of a power shortage, the clamp axis achieves a maximum positional tolerance of 20 µm – less than the width of a hair. Even when the machine is restarted,

paths. Online-testing in Rexroth’s solutions runs automatically in the background during machining and without intervention by the operator. This creates the conditions for continuously safe round-the-clock operation.

Even if intrinsically safe designs are not possible, Rexroth can provide a solution: a protective barrier system separates personnel from dangerous areas. The control-unit-connected door immediately switches the machine to safe mode if a person enters these monitored areas.

Rexroth therefore ensures maximum safety through extensive diagnostic coverage in all drive technologies. A large number of sensors and measured parameters for “condition monitoring” concepts monitor the state of hydraulic systems and fluid media – on request also with corresponding online database links and reporting options.

Online testing of the periphery by the servo drives with “Safety on Board” detects “hidden faults” during operation. Whereas with other concepts production has to be interrupted at the latest after eight hours to check the safety paths.
Logical Safety in the System

Rexroth combines the safety functions at the drive level with safe logic integrated in general control hardware. This ensures maximum interaction between all components and therefore maximum safety of personnel and availability of the overall machine.

Rexroth’s systems offer integrated safety. Industry-specific automation solutions provide maximum performance and the highest possible availability coupled with the lowest topology costs. The automation kit contains electrical, hydraulic and pneumatic drive systems, hydraulic safety circuits, drive-, controller- and PC-based controls, E/A systems and corresponding operating and visualization devices.

Rexroth therefore combines programmable functional safety with easy implementation: the general development environment makes it easier to program safe automation solutions. In this case Rexroth also uses standards such as the PLCopen safety specification for simple standard-based programming.

Systematic implementation of this specification ensures compliance with normative requirements during safety-related programming with the engineering tool IndraWorks and saves the user from having to perform additional tasks. Non-reactive processing of standard and safety signals decouples the functional applications from the safety functions. Total safety is therefore maintained even if the standard application functions change. This substantially reduces the costs of customer-specific adaptation of machines and changes.

Rexroth also provides a high degree of freedom in safe communication and supports both PROFIsafe and SERCOS safety participants.

IndraWorks – standard framework for all engineering tasks from project planning and programming through to commissioning and diagnosis.

Scalable Safety on Board solutions.
Machine manufacturers and users can therefore simply access data both in homogeneous and heterogeneous topologies.

Properly planned safety is actually able to increase productivity. If functional safety is correctly designed, people can stay in a dangerous work area close to the machine while the machine keeps running. This increases cost-effectiveness and also reduces the risk of manipulations – the most frequent cause of accidents. Because if the measures do not hinder the operator, but help him in his work, he no longer has a reason to manipulate safety devices.
Share Knowledge for Quick Results

Safety always involves challenging technical teamwork which depends on intensive cooperation between the automation partner and the machine manufacturer: as an all-round automation partner, Rexroth provides access to unique know-how relating to all drive and control technologies.

The challenge is obvious: designers must intensively familiarize themselves with the new Machinery Directive and the new standards. Designers have gotten additional tasks in the form of new evaluation methods for implementing the safety function. They can rely on the support of Rexroth all over the world. Specialists from Rexroth impart the implementation knowledge in numerous training courses.

Rexroth has also trained a large number of employees in safety engineering aspects within the company and provides a systematic procedure for standard-based solutions in its guideline entitled “10 Steps to Performance Level”.

The specialists use this knowledge for safety evaluation of Rexroth’s system solutions. They also share this knowledge as an independent
service for production system builders as well as for end users. This opens up access to the worldwide unique safety know-how in all drive and control technologies.

It’s up to machine manufacturers to decide how far they want to profit from this knowledge: whether at a component level with all necessary parameters, with systems through to complete inter-
technology automation solutions featuring integrated safety systems and standard-based evaluation, or as an independent service – you will always be on the safe side with Rexroth.
This Brochure is a helpful accessory for the design of a control system based on the standard ISO 13849-1 and ISO 13849-2. It has no claim of completeness. The statements in this document have been done carefully, but without guarantee. Only the original text from the relevant standards and directives are obligatory.