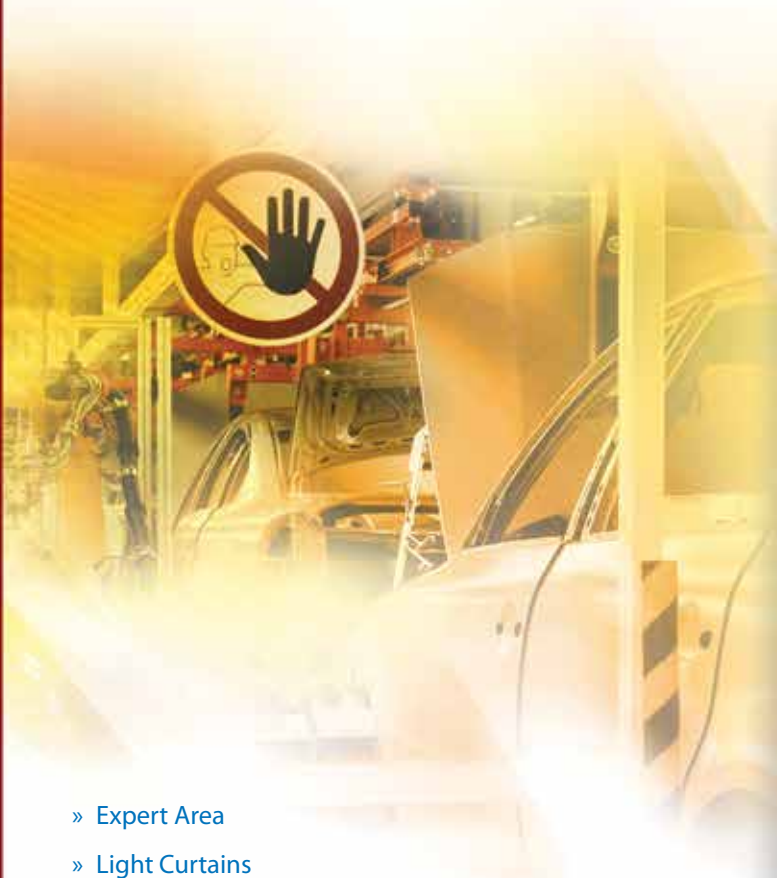


Machine & Process Safeguarding

Solution Selection Guide

2015-2016



- » Expert Area
- » Light Curtains
- » Laser Scanners
- » Programmable Safety Systems
- » Mats and Edges
- » Door Switches
- » Emergency Stop Devices
- » Switches and Operator Controls
- » Monitoring Relays
- » Safeguard Integration Services



Making Safety Simple— Omron's Concept for the Future

Today, forward-thinking manufacturers clearly realize the new role of increased safety on the factory floor.

- » Recently adopted international safety standards have shifted the way systems are evaluated.
- » Safety is a corporate responsibility, not an obstruction to productivity.
- » Safety is essential to increased productivity and profitability.



“The modern user of safety
products demands a new vision.”

Poised at the leading-edge of safety solutions worldwide, Omron's STI safety products focus on making safety work. We are aware of the many demands of automation safeguarding. Consequently, our automation safety products meet or exceed local and international safety standards.

Omron is committed to providing safeguarding solutions that meet your needs for safety and productivity. We design and engineer our products by listening to and working closely with our customers and authorized distributors. We also provide you with:

- » Experienced assistance
- » Expert guidance in application, integration and maintenance
- » World-class support through Omron's global network of 250 sales locations in 65 countries

Welcome to OMRON Automation & Safety

Solutions from Components to Consulting for Enhanced Worker Safety

1 Safety Light Curtains

Models are simple to install, and available in a wide selection of protected heights and resolutions.



F3SJ-A



F3SJ-B



F3SG-RA



F3SJ-E



MS4800



OS32C

2 Safety Laser Scanners

Our OS32C is a very compact safety laser scanner. It has 70 zone configurations for complex guarding parameters. Safety coverage up to 4 m at 270 degrees.

Industry First!
EtherNet/IP capable of status and measurement data reporting.

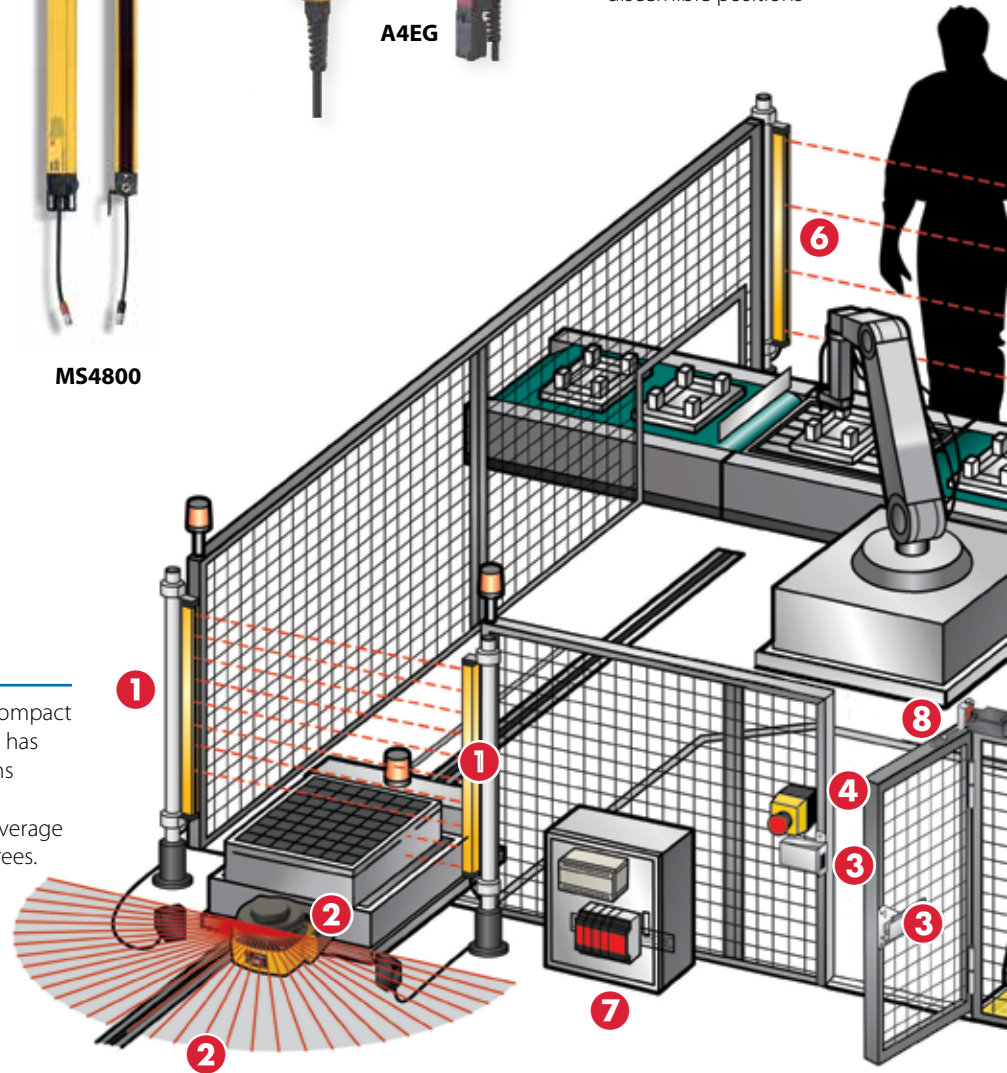
8 Enabling Switches

Provides the additional protection needed during set-up, programming and servicing of robotic and automatic equipment.

- Has distinct clicks for three easily discernible positions



A4EG



3 Safety Switches & Operator Controls

Tamper resistant switches enhance mechanical guarding methods.

- Guardlocking switches
- Hinge pin switches
- Non-contact switches
- Limit switches
- Tongue switches
- Explosion-proof versions



NEW

NX-S



NE1A



G9SP



G9SX

7 Safety Programmable Safety Systems

7 Safety Monitoring Relays

The NX-S series of controller offers Safety over EtherCAT, our first to offer integrated safety functionality into the Sysmac platform, suitable for mid to large sized applications; now with stand-alone capabilities.

The G9SP stand-alone programmable safety controller for mid-sized applications supports direct connection to safety mats and non-contact switches.

The NE1A DeviceNet safety network controller is well-suited for large complex applications, while safety monitoring relays are ideal for ensuring control reliability in smaller applications.

6 Perimeter Guarding

PA4600 models are available with single and multiple-beam models with an operating range to 70 meters. They're perfect when installing fences is not practical.

6



PA4600

4

5

5 Mats & Area Guarding

5 Safety Edges & Bumpers

Built tough for tough environments. Combine a mat with a controller to provide proven reliability.

4 Emergency Stop Devices

- Enclosed and panel-mounted models available with key-operated reset.
- Combination rope and push button actuated emergency stop switches.
- Heavy duty housing offering rope spans to 200 meters





NEW PRODUCTS!

What's new and hot this year? Check out our latest additions!

Safety Light Curtains

F3SG-RA

Our newest light curtain brings a new standard, offering both robustness in severe environments and global reliability

Omron's new F3SG-4RA global light curtain advanced series features a rugged housing with optical synchronization and advanced safety functions such as muting, blanking and reduced resolution to solve every application. This new series also includes productivity improvements with easy mount brackets, SmartClick™ cables and smart phone troubleshooting guide and more indicators to expedite installation and reduce maintenance downtime.



Programmable Safety Systems

NX-S

Now with Stand-Alone Safety System Capabilities

The NX-S allows connection of up to 32 safety I/O units, standard digital inputs and outputs can be directly mapped into the NX-SL3300 safety CPU according to the project needs. Monitor with EtherNet/IP.



Contents

Section	Products
A	Expert Area
B	Safety Light Curtains
C	Safety Laser Scanners
D	Programmable Safety Systems
E	Safety Mats & Edges
F	Safety Door Switches
G	Emergency Stop Devices
H	Safety Switches & Operator Controls
I	Safety Monitoring Relays
J	Safeguard Integration Services

The applications described in this catalog are for informational and instructional purposes only, and may not represent actual usage. This publication has been carefully checked for accuracy and is thought to be fully consistent with the product it describes. However, OMRON Automation and Safety does not assume liability for the contents of this publication or the use of any products described herein. OMRON Automation and Safety reserves the right to make changes to the products and/or documentation without further notification.

© 2015 by OMRON Electronics LLC.
All rights reserved.

Omron conforms to ISO 9001:2008 requirements,
as certified by TUV America Inc.



For complete specifications and additional models and accessories visit www.omron247.com



The OMRON Automation and Safety Difference



Customer Focused for Continued Success

Adding value beyond the basics means that we are committed to our customers. Our knowledge and experience adds value. We are focused on their needs. OMRON Automation and Safety provides innovative engineering and system solutions to our customer's evolving application problems. We provide technical assistance in the field, and by phone.

Instant Information — Call us or go to www.omron247.com

OMRON Automation and Safety is easy to reach, technical support is easy to contact, and critical information accessible 24 hours a day via our website. Support engineers are also available to answer technical questions and provide application assistance. For a complete list of support phone numbers, visit www.omron247.com.

Find Information Fast — Quick Link Shortens Your Search

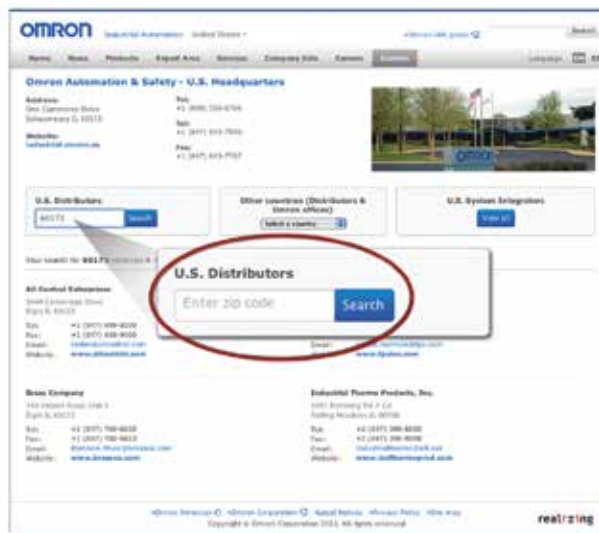
Quick Links are unique codes assigned to Omron products listed in this catalog. Enter these codes in the Search box on omron247.com to access detailed information on products in this catalog:

- Datasheets
- Manuals
- Brochures
- CAD, EDS and ESI Files
- Application Examples
- ... and more!



Finding Automation & Safety Expertise

To find an authorized Omron Automation and Safety Distributor in your area, simply use our Distributor Lookup on www.omron247.com.



Global Solutions with Local Support

Keeping You Current on Safety Requirements

In today's marketplace, it is important to keep our customers up-to-date on the latest technology advances and safety trends. Omron offers full-day seminars, on-site workshops, and Safety & Sandwiches Sessions. These training sessions provide you with theory, hands-on demonstrations, and examples of real applications that may be helpful in determining your own safety needs.

Authorized Distributors: Uniquely Qualified to Offer Solutions

We have found that the best way to respond quickly and effectively to our customers' needs is through our extensive network of distributors. Through this network, we are able to offer immediate local service and support.

To be a distributor, an organization must commit to a set of stringent requirements, including factory training of sales engineers. Sales engineers continue to receive training throughout the year through in-house seminars and on-line classes. This effort guarantees that when you have a safety problem, the sales engineer you work with will have the knowledge to help analyze your situation, aid you in selecting products, and support you through installation. This commitment to training and safety expertise ensures the best solution for your application, from start to finish.

Unbiased, Single-Source Solutions

Everything you need for a complete safety system is available through one source – OMRON Automation and Safety. Supplying an extensive array of safety solutions guarantees that we will give you an unbiased recommendation for what will work best in your particular situation. Our wide product line means we don't have to force your application to fit our products. OMRON Automation and Safety has the correct product for the job.

Globally Approved Products

The majority of our products have been agency approved to a variety of international standards including UL, CSA, CE, DIN, IEC, and EN. In the U.S., our safety products meet ANSI and OSHA standards.



Services Offered* and What to Expect

Many companies appreciate the value of outsourcing special services such as engineering, purchasing and maintenance to partners who specialize in these areas. Omron is uniquely equipped to be your partner when it comes to machine safety compliance.

We provide all the necessary machine safeguarding services, including machine guarding assessment, risk level identification, risk reduction planning, documentation, review of safety system and circuit designs, and complete safety system integration.

Turn-key Safety Integration

OMRON Automation and Safety specializes in offering safeguarding systems for industrial fabrication equipment, manufacturing systems, and robot cells compliant with all applicable North American safety standards. Our service includes an on-site project manager to monitor quality and ensure that the safety measures are installed properly. Expert installers fabricate custom guards on-site and our specially

trained electricians ensure that control reliability requirements of safety circuitry are met.

Safeguarding Assessment/ Risk Level Identification/ Risk Reduction Planning

OMRON Automation and Safety offers detailed risk level identification including risk reduction recommendations to bring your equipment into compliance with applicable OSHA Regulations and/or ANSI, RIA, NFPA, NEC, CSA, EN, IEC, and ISO standards. We inspect perimeter and point of operation guarding in addition to power isolation, including pneumatic, hydraulic and electrical lockout. Our detailed report provides you with the initial risk level, written recommendations for compliance, a plan view drawing of the equipment with recommended safeguards, the estimated risk level achieved after all recommended safeguards are properly installed, photos and an estimate to properly safeguard the machine or process.

Safety Project Engineering/Design

After complete risk level identification, any gaps in compliance need to be filled. If you prefer, we can engineer and design the required safeguards and provide you with the materials and components necessary to complete the project yourself. Our engineers will design control reliable circuitry as required and custom fabricate guards to meet your needs.

Safety Standards Writing

Let us help you create or improve your corporate safety standard. Our active participation on OSHA, ANSI, and RIA standards writing committees provides us with a wealth of information to share. We can write your standard for you or review and edit your existing standards for compliance with the most current regulations and standards.

Machine Safety Seminars

OMRON Automation and Safety offers on and off-site training. The seminars vary from half-day to 2-day sessions and may include topics such as:

- Risk Level Identification/Risk Reduction Process
- Introduction to Safeguarding Technologies
- Control Reliability (circuit requirements)
- Requirements for Barrier Guards
- Stop Time and Safety Distance Measurement
- Stop/E-Stop/Safety Stop Summary
- Lockout/Tagout & Alternative Methods to Control Hazardous Energy
- General Requirements for Machine Tools

These seminars are targeted for EH&S Managers, Safety Personnel, Single Point Accountable Person(s) for Machine Safeguarding, and Safety Engineers.



*Machine Safeguarding Services are available in North America, Europe, South America and South East Asia.

Justifying the Cost of Safeguarding Equipment

Machinery safeguarding represents one of the best investments on the plant floor. For example, in a study conducted by the Liberty Mutual Group for the US, 61 percent of executives say they save \$3 for every dollar invested in safety equipment and programs. This is just one example of many worldwide studies that show the importance of investing in machinery safety.

No one discounts the impact that an accident has on plant operations. However, the cost of an accident can be staggering. In addition to the emotional cost to employees and managers, the direct and indirect costs of an accident accelerate quickly. Direct medical expenses and workers' compensation benefits are just the tip of the iceberg. The indirect costs of lost production, OSHA fines, replacing damaged goods and machinery, and paying higher workers' compensation premiums can represent a larger portion of the total cost of an accident.

The same survey of executives indicates that executives figure to spend \$3 to \$5 of indirect costs for every dollar of direct costs of an accident. For example, an accident with direct costs of \$10,000 has additional indirect costs of \$30,000 to \$50,000. The impact of just this one accident becomes even more significant when a company realizes that the bulk of these costs are not covered by insurance.

OSHA offers a software program, \$AFETY PAYS, as part of its eTools and Electronic Products for Compliance Assistance. This interactive package helps employers determine the potential impact of occupational injuries by estimating both direct and indirect costs.

A user supplies information about company profit margins, and the program calculates the additional sales needed to cover the cost of an injury. The program uses real insurance company claim data and an expert software system. It can be found on the OSHA web site at: <http://www.osha.gov/dcsp/smallbusiness/safetypays/estimator.html>.



Perimeter guarding system to guard aluminum coil slitting line.

Why You Should Partner with Omron

Because..

- The expertise required in all phases of the safeguarding process is not a core competency of most manufacturers or maintenance personnel.
- EH&S personnel have to be involved with every area of Environmental, Health & Safety. They are too busy to get involved with required details of guarding systems and safety interfaces.
- It needs to get done right the first time.
- We have an established history of providing companies with safe work environments.
- Our employees stay up-to-date with industry-related trends by participating with and contributing to standards committees.
- Our employees are members of various industry trade organizations.

Peace of Mind...

- Knowing that your machines or process lines are safeguarded correctly to the current standards.
- With 100% compliance – not 90% or less.
- Having documented risk level identification and risk reduction strategy.
- Knowing machine operators are trained on the safety systems installed.
- By saving money because it only needs to be done once.

Our Wide Selection Guarantees You'll Get Exactly What You Need

Safety Light Curtains



CE

Powerful Solutions for Today's Tough Automation Guarding Obstacles

OMRON Automation and Safety provides safety light curtains to solve your optical guarding needs. From compact models designed for machine locations where space is tight, to larger, robust light curtains powerful enough to guard large perimeters. Omron offers you a choice, because when it comes to automation safeguarding, one size does not fit all.

NEW

■ F3SG-RA

Our newest light curtain brings a new standard, offering both robustness in severe environments and global reliability

Omron's new F3SG-4RA global light curtain advanced series features a rugged housing with optical synchronization and advanced safety functions such as muting, blanking and reduced resolution to solve every application. This new series also includes productivity improvements with easy mount brackets, SmartClick™ cables and smart phone trouble-shooting guide and more indicators to expedite installation and reduce maintenance downtime.

From tight spaces to perimeter guarding, when it comes to machine safeguarding, Omron knows that ...

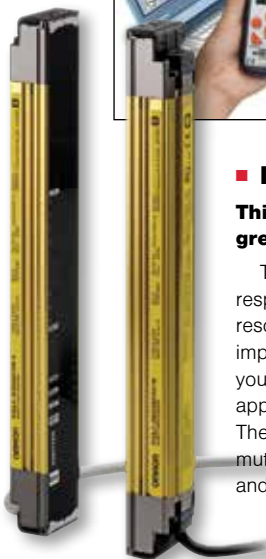
One size **DOES NOT** fit all.



■ F3SJ-A

This small profile, safety light curtain offers the greatest number of possible configurations.

The F3SJ-A safety light curtain combines fast response time with 14, 20, 25, 30 or 55 mm object resolutions. The protected heights of the F3SJ-A are impressive, and Omron allows you to buy just what you need. The F3SJ-A is easy to use for your basic applications and feature rich for the more advanced. These features include a warning zone function, partial muting and position detection muting in addition to fixed and floating blanking.



■ F3SJ-E and F3SJ-B

The "EASY" and "BASIC" type light curtains are ideal for easy, simple and affordable protection.

The F3SJ-E "EASY type" light curtain is recommended for those who need simple and affordable hand protection.

The F3SJ-B "BASIC" type light curtain offers simple hand protection, series connection and muting functions.

■ **MS4800 Series**

The MS4800 light curtain family is an all-purpose light curtain available in three distinct versions.

These versions are identified as the Advanced (MS4800A), the Basic (MS4800B) and the Standard (MS4800S). All versions can be cascaded, are available in resolutions of 14, 20, 30 and 40 mm, and have the Omron patented Individual Beam Indicators. Just another way we offer the right solution for your application.



“Two-Box” Solution

The F3SJ, MS4800, and PA4600 are several examples of a “two-box” safety light curtain. Safety output connections to these models are all made at the receiver and a separate control box is not required.



■ **PA4600**

Our perimeter guarding devices are designed to meet your integration needs. With a wide choice of operating ranges, we’re sure to have the right beam configuration to fit your application.

Omron offers the PA4600 series in single and multiple safety beam configurations. The PA4600 may be configured with up to six beams, meeting the ANSI/RIA R15.06-1999 (R2009) and EN999:1998 optical configuration requirements.

Area Guarding and Detection

OS32C Safety Laser Scanner

The Compact OS32C Safety Laser Scanner

Now with EtherNet/IP Connectivity for Status and Measurement Data Reporting

The OS32C-DM safety laser scanner is the industry's first to feature Ethernet/IP communications, capable of reporting both status and measurement data. Additionally, its class-leading small size; Individual Sector Indicators; light weight and low power consumption; two-hundred seventy degree detection area; and up to seventy sets of safety and warning zone combinations provide the versatility to tackle many guarding situations.

Industry Best!

Flexible zone configurations

Industry First!

Integrated Monitoring and Analysis via Ethernet

EtherNet/IP™



Lowest Profile

Small Size **104.5** mm

Compact and versatile safety laser scanner

Lightweight **1.3** kg

Lightweight body for easy handling and installation

Low Power Consumption **5** W

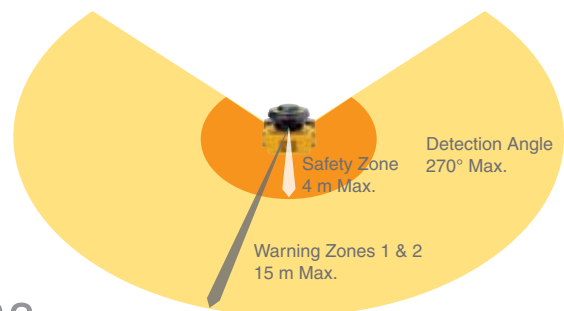
Low power consumption reduces battery load on AGVs (3.75 W in standby mode)

Easy handling and installation

SIMPLE and **VERSATILE**
to solve many applications.

Power consumption savings up to 50%

4 m Safety Range Models!



270° detection angle

Low profile allows installation in small spaces

For collision avoidance of AGVs (Automated Guided Vehicles)

For intrusion detection through an entrance

For presence detection within a machine's hazardous area

Collision Avoidance

Small, light & compact body provides for easy installation on an AGV.

Low power consumption (5 W reduces battery load on the AGV (3.75 W in standby mode))

Up to 70 zone set combinations support complex AGV tracks.



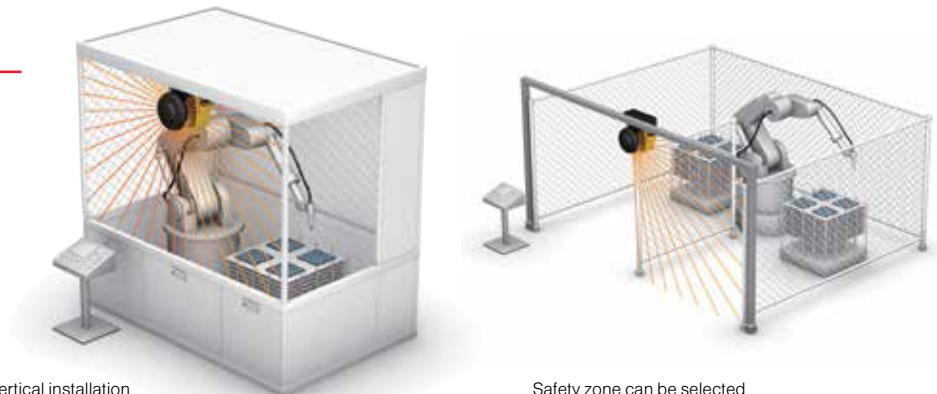
Front/Rear Monitoring

All-around Monitoring

Intrusion Detection

Reference Boundary Monitoring function supports intrusion detection without physically blocking the entrance.

Supports various operation patterns by switching zone sets.



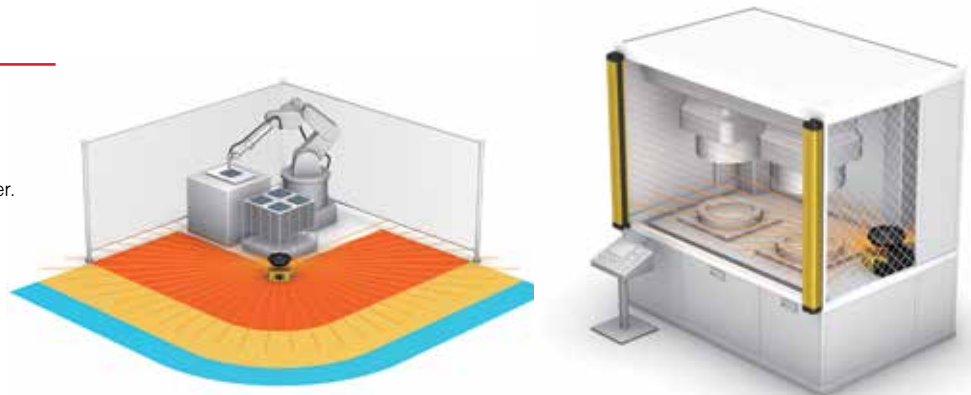
Intrusion detection with vertical installation

Safety zone can be selected

Presence Detection

Compact body allows for use inside the machine.

Detection angle of 270° provides coverage of two sides with one scanner.



Presence detection of 270°

Guarding inside the machine

Area Guarding and Detection

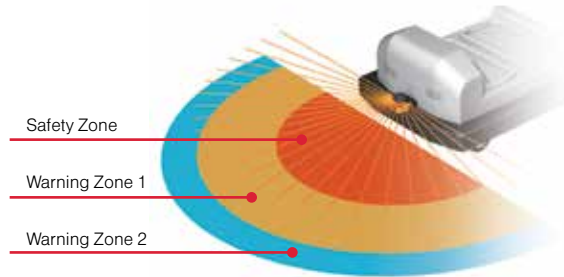
OS32C Safety Laser Scanner (continued)

Convenient and Easy-to-Use Functions

Industry Best!

Flexible zone configurations

For complex AGV applications, up to 70 combinations can be set – each with one safety zone and two warning zones. The two warning zones can be set to support various purposes such as warning sound and speed control.



Industry First!

Integrated monitoring and analysis via Ethernet

Industry's first Ethernet-compliant Safety Laser Scanner allows the user to check operating state and analyze the cause of an emergency stop via LAN even in large-scale applications using multiple scanners.



Simplified wiring

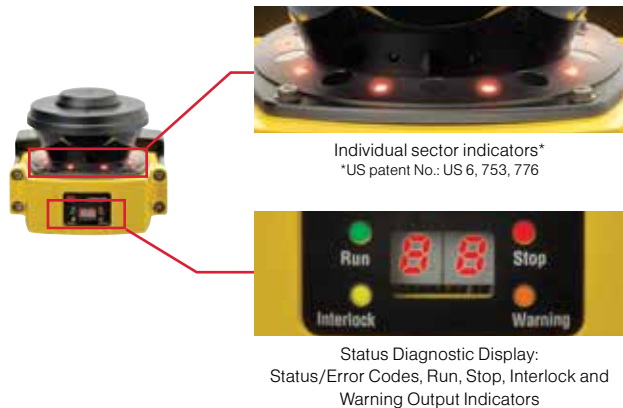
Omron's innovative I/O method requires fewer inputs when configuring multiple zones. Only 4 inputs are required to select from 6 zone sets. If all 8 inputs are used, up to 70 zone sets are available.

Response time can be set from 80 ms to 680 ms

Response time adjustment can filter out erroneous detections (machine stoppage) caused by pollutants in the environment.

Operating state can be determined at a glance

Eight sector indicators show the direction of intrusion. Front display shows operating state and error codes.



Replaceable sensor, no reprogramming needed

No reprogramming needed, the configuration is stored in the I/O block. Replacing a damaged sensor is fast and easy.



Cable access options

To tailor the OS32C to your installation, eight options are available for the location of the power and ethernet connections.

Model	Range (m)	EIP & Measurement Data	Cable Access
OS32C-BP	3	No	Back
OS32C-SP1	3	No	Left side
OS32C-BP-DM	3	Yes	Back
OS32C-SP1-DM	3	Yes	Left side
OS32C-BP-4M	4	No	Back
OS32C-SP1-4M	4	No	Left side
OS32C-BP-DM-4M	4	Yes	Back
OS32C-SP1-DM-4M	4	Yes	Left side

These can be selected according to the needs of AGV or facilities design.



OS32C with cable access on the back (OS32C-BP)

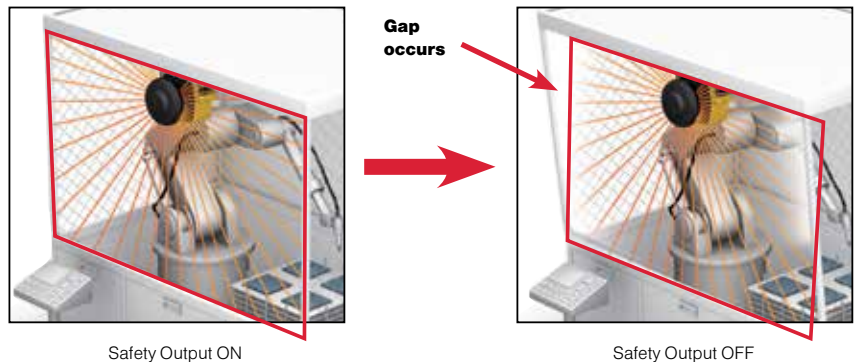


OS32C with cable access on the left side (OS32C-SP1)

Reference boundary monitoring function

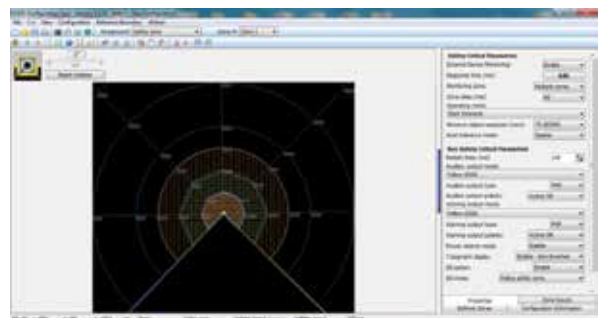
The OS32C constantly monitors reference points and turns OFF the safety outputs when a shift in its position is detected.

(Per international standard IEC 61496-3, area scanners used in applications where the angle of approach exceeds $\pm 30^\circ$ with respect to the detection plane, must use Reference Boundary Monitoring in the detection zone.)



Free software for easy configuration

The configuration of the safety zone and warning zones can be done in real time using a PC. Configurations can also be created or modified offline.



Making Safety Simple

Programmable Safety Systems

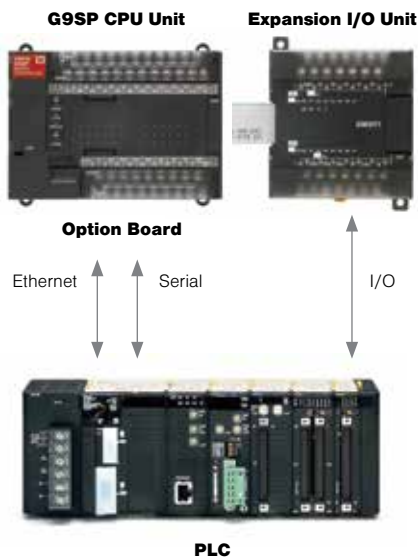
System Setup Made Simple

Omron's line-up of Programmable Safety Controllers reshape previous thinking about safety systems. Until now, safety control circuit design was cumbersome. The process involved tedious wiring and any changes required direct modification of the wiring. Programmable safety circuits simplify the design process. Safety I/O terminals make system modifications easy and allow the safety I/O capacity to be increased without extensive rewiring.

The new NX Safety System is integrated into the architecture of Omron's EtherCAT controller platform; this allows direct access to the status and monitoring of all safety I/O through the PLC making programming and monitoring more simple and powerful than ever before.

G9SP Compact Programmable Controllers

- Direct connection to non-contact switches and safety mats
- Programmable via PC or removable memory cassette
- Easily monitored by PLCs via Ethernet (FINS), EtherNet I/P, or serial (RS-232C) connection
- Ideal for small to mid-size applications
- EN ISO 13849-1 (PL e)



Transparent diagnosis

Connect to PC/PLC via Ethernet makes the Omron G9SP fully accessible. Diagnosis, troubleshooting and program modification is simple, thanks to the USB programming interface and removable memory card.

Simple Unit Replacement

Because the Omron G9SP is a software-based controller, replacement is effortless. All settings, parameters and function blocks can be saved on a PC or stored on the Memory Cassette for easy transfer from one unit to another.

NB Human Machine Interface

- Simple plug-n-play touchscreen for the G9SP to easily view the status of safety inputs and outputs

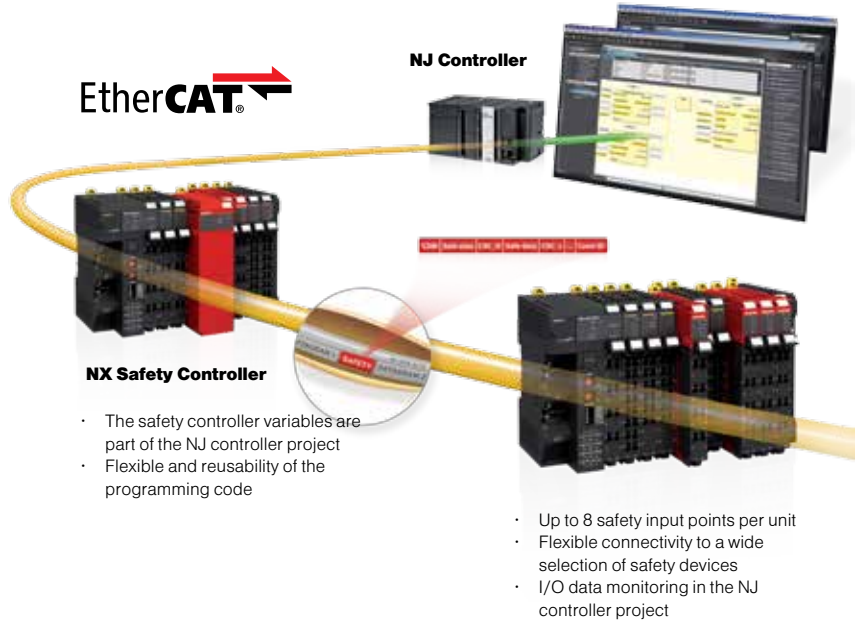
NX-S Integrated Safety Controller: Safety Over EtherCAT



Now with Stand-Alone Safety System Capabilities

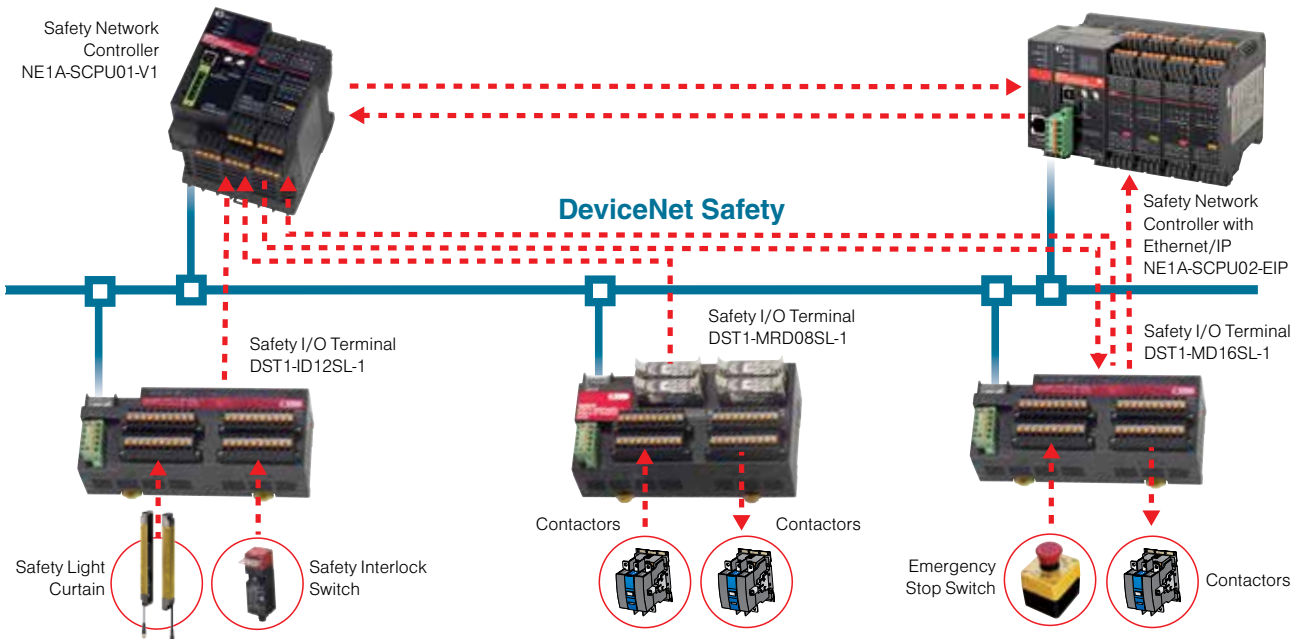
The NX-S allows connection of up to 32 safety I/O units, standard digital inputs and outputs can be directly mapped into the NX-SL3300 safety CPU according to the project needs.

- Monitor with EtherNet/IP



NE1A Safety Network Controllers

- Eliminates long runs of complicated wiring
- Compatible with the DeviceNet Open Network
- Provides individual I/O status and error indicators
- Minimizes the need to rewire when making machine modifications
- Conforms to global safety standards
- Meets IEC 61508 SIL3



For complete specifications and additional models and accessories visit www.omron247.com



Built Tough for Tough Treatment

Pressure Sensitive Mats & Edges

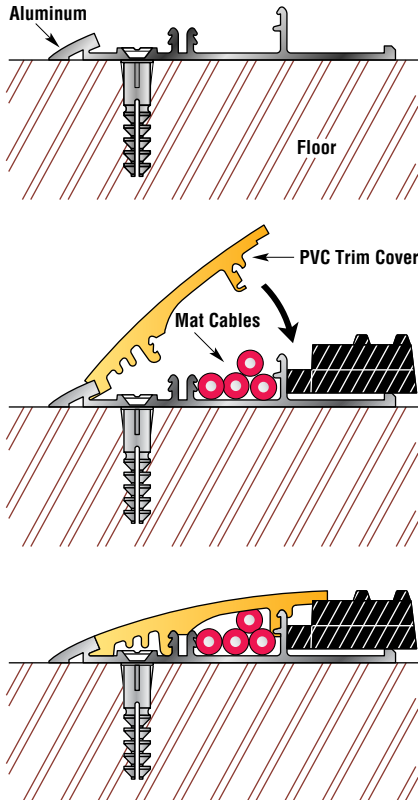


Omron Universal Safety Mats and MC3, MC4, or MC6 Controllers

Rugged Omron Universal Safety Mats guard machine operators against some of the potential hazards and dangers of a modern manufacturing environment. Compared with other guarding methods, such as mechanical barriers, sliding gates or pull back restraints, safety mats offer operators freedom of movement and flexibility that not only provides enhanced safety, but may also reduce the occurrence of cumulative trauma disorders. When combined with an MC3, MC4, or MC6 controller and trim, the Omron Universal Safety Mats form a mat system which complies with standard ISO 13856-1:2001, ANSI B11.19-2010, ANSI/RIA 15.06-1999 (R2009), CSA Z432-04, and EN1760-1: 1998 and is entitled to display the CE mark.

Two Safety Mat Trims to Choose From

Omron offers two types of safety mat trim, the industry standard 6063-T5 aluminum and a safety yellow PVC trim in an aluminum mounting base with an integrated wiring channel. In addition to the PVC cover for the 2-part trim, an aluminum cover is available (see the mat section for drawings and details on this trim). In multiple mat applications, our patented joining trim (also with an integrated wiring channel) provides a fully active mat area even at 3 and 4 mat intersections.



Standard Mat Features:

- Heavy-duty PVC for impact resistant construction
- Available in many standard and metric sizes
- Single piece molded construction will not delaminate
- Exceptional chemical and abrasion resistance including excellent resistance to acids, alkalis and salts
- Expected life of over one million actuations
- Standard with 4-wire quick disconnect cable
- Traction dot pattern allows configuration in any orientation

UMQ Series Quick-Disconnect Mat

The Omron UMQ Series Safety Mats incorporates a design that features a quick disconnect located on the mat. The cables can be attached after the mat is in place to minimize damage during mat installation. The patented connector is designed and tested to meet IP67 requirements. The quick disconnect has been designed to be backward compatible with the current mat cable location.



PATENTED CONNECTOR

Safety Mat Controllers Provide Proven Reliability

Omron Safety Mat Controllers are used in conjunction with four-wire, normally open, safety mats where perimeter guarding is required. Their control reliable design sends a stop signal to the guarded machine whenever an object with sufficient weight is detected on the active mat surface. Also, when the controller detects any of the mat wires are missing, broken, or misconnected a stop signal is generated.

When combined with a four-wire safety mat these controllers improve productivity while providing access guarding. Full visibility of and accessibility to the work area is always maintained.



MC3



MC4



MC6

What are Pressure Sensitive Safety Edges?

Omron Safety Edges are rubber profiles enclosing a pressure sensitive safety contact. These products can be used to protect pinch points on scissors lifts, automatic gates, and other applications. Nine different profiles are available in lengths up to 6100 mm. When combined with the available controllers, the system complies with standard EN954.

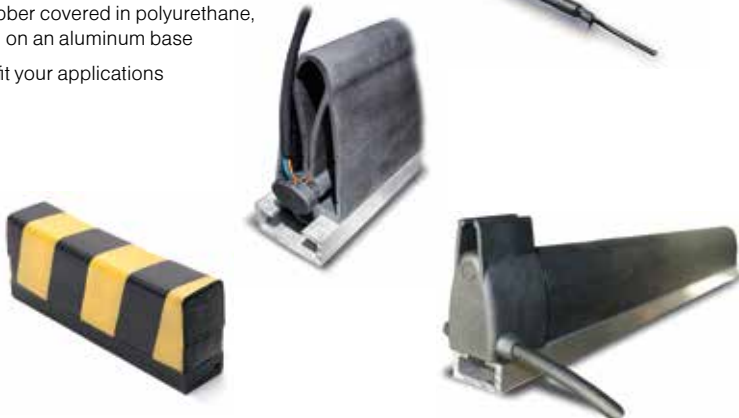
Safety Edges

- Profile materials EPDM, NBR or TPE rubber
- Provides housing for safety contact
- Available in 9 sizes and two styles to fit many applications



Safety Bumpers

- Foam rubber covered in polyurethane, mounted on an aluminum base
- Sized to fit your applications



SCC Safety Edge Controllers

- 120 VAC or 24 VDC power

Ensuring Operator Safety

Mechanical Guarding Systems



Tamper Resistant Safety Interlock Switches and Emergency Stop Devices Enhance Mechanical Guarding Methods

Omron Safety Interlock Switches and Emergency Stop Devices are available in a wide variety of models to satisfy most machine guarding applications. Models range from rope-operated emergency stop switches and non-contact magnetic and hinge-pin-operated interlocks, to solenoid-actuated guard-door locking switches that restrict access until safe conditions exist.



Force-Guided Relays

Force-guided (or positively-guided) relays have contacts that are mechanically interlocked such that two contacts on the relays will not contradict each other, even in the event that the relay welds. Force-guided relays have contacts that are mechanically linked and conform to IEC60947-1-1 as required for use in safety-related control systems.



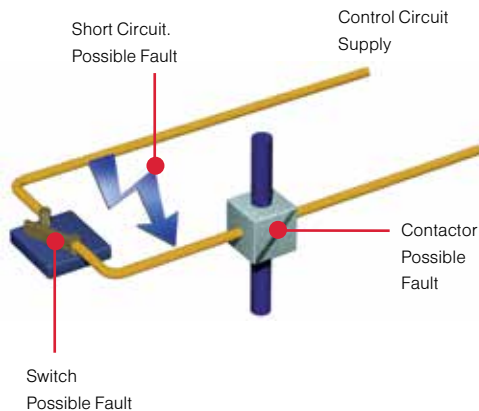
The G7Z multi-pole power contactor with mirror contacts is capable of carrying and switching 40 A at 440 VAC

Monitoring Safety Relays Ensure the Highest Level of Circuit Integrity

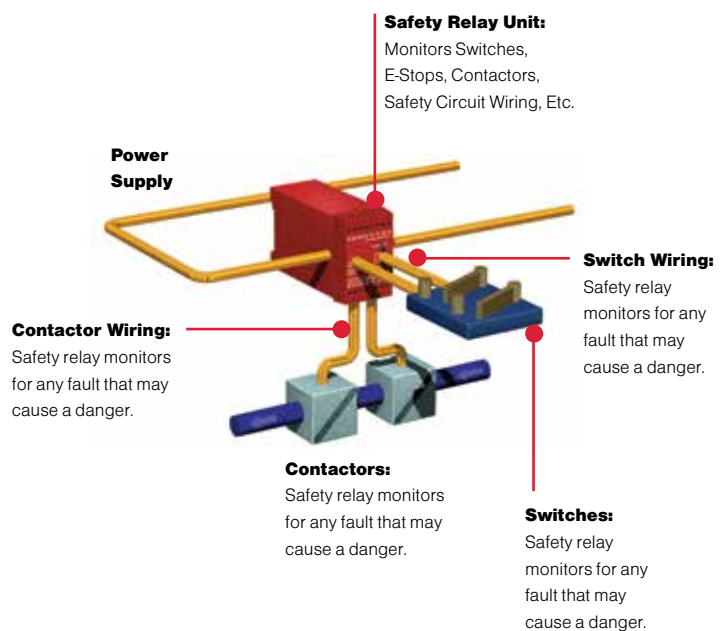
Safety Monitoring Relays are designed to provide higher levels of reliability for any safety circuit through better diagnostics in fault detection, longer life expectancy, and redundancy. Whether designing circuits to meet European and International Performance Level requirements (ISO 13849-1) or North American control reliability requirements (ANSI B11.19), Omron safety monitoring relays offer preconfigured and tested circuits to meet your most demanding needs. Products range in function from simple single channel relays to specialty relays including time-delayed outputs, two-hand control, and stop-motion detection. All safety relays meet North American and European requirements and carry one or more of the following designations: CE, UL, CSA, C-UL, UR and TUV. In addition, some relays carry markings and ratings for specific countries such as China, Korea and Germany.



Without Safety Relay



With Safety Relay



Maintaining Safety in

Hazardous Environments

Safeguarding a Hazardous Location... No Problem

The Omron line of process safeguarding products extends to hazardous locations, or flammable environments, as well. An advantage of mechanical trapped key systems is that they can be designed to isolate all electrical energy sources in and around hazardous areas. With key exchange system and mechanical locks, the energy can be isolated in a "safe area" and the key transferred to a mechanical lock in the "hazardous area."

Safety Light Curtains for Hazardous Locations

OMRON Automation and Safety offers enclosures for use in hazardous locations for the MS4800 and PA4600 safety light curtains. These enclosures are rugged cast-aluminum, designed to contain an ignition of explosive gas. This allows for the automatic safeguarding of machinery in explosive atmospheres, such as paint booths, chemical production and distilling.



The MS4800 and PA4600 safety light curtains are available with enclosures for use in hazardous areas.

Safeguarding Machine Operators

Special Safety Devices

An Ergonomic Alternative to a Mechanical Palm Button Switch

The Omron TouchStart is a capacitive palm button designed to detect the presence of an operator's hand and provides a machine start signal with a mere touch of a button.



Safety at All Times

The A4EG Enabling Switch Device provides the margin of safety needed during troubleshooting, set-up, programming, or servicing of robotic or automated machinery when no other safety devices are possible or practical. It has distinct clicks for three easily discernible positions.

Expert Area

Contents

REGULATIONS & DIRECTIVES

OSHA Regulations	A-2
North American Safety Standards	A-3
Harmonized European Standards	A-6

SAFETY STRATEGY & RISK ASSESSMENT

Safety Strategy — Hazard Identification & Risk Evaluation	A-8
Machine Safeguarding Checklist	A-15

CONTROL RELIABLE CIRCUITS & WIRING DIAGRAMS

Safety-Related Control Systems	A-16
Common Circuit Examples	A-27

TYPES OF PROTECTIVE MEASURES

Choice of Protective Measures	A-41
-------------------------------	------

Safety Light Curtains

Type 2 vs. Type 4 Light Curtains	A-45
Light Curtains — Installation Requirements & Calculating the Minimum Safe Distance	A-49
Sample Checkout Procedure Log	A-67
Sample Test Procedure	A-68
Safely Muting an Industrial Process	A-69

Safety Mats

Safety Mats — Theory of Operation, Selection & Installation	A-71
--	------

Safety Interlock Switches & Monitoring Relays

Understanding IP Ratings	A-73
--------------------------	------

Emergency Stop Devices

Proper Installation of Rope or Wire Pull Emergency Stop Devices	A-74
--	------

OSHA Regulations

In the United States, machine safeguarding is governed by OSHA, the Occupational Safety and Health Administration. OSHA's mission is to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.

While OSHA regulations cover many aspects of health and safety the area of machine safeguarding is addressed by the regulations in Part 1910 Subpart O - Machinery and Machine Guarding.

The regulations for machine guarding are:

- 1910.211 - Definitions.
- 1910.212 - General requirements for all machines. This section governs the guarding of all machines that are not called out specifically in one of the sections below.
- 1910.213 - Woodworking machinery requirements. Includes all saws and other machines used for woodworking
- 1910.214 - Reserved
- 1910.215 - Abrasive wheel machinery. Includes requirements for Grinders
- 1910.216 - Mills and calenders in the rubber and plastics industries.
- 1910.217 - Mechanical power presses.
- 1910.218 - Forging machines.
- 1910.219 - Mechanical power-transmission apparatus.



In addition, OSHA specifies regulations for lockout/tagout in 29 CFR 1910.147

The entire text of these regulations can be downloaded for free from the OSHA web site www.osha.gov. This site also has a wealth of explanatory and training materials relating to machine safeguarding.

These federal regulations may be supplanted by state OSHA requirements, as long as the state has an approved state plan. In all cases state plans are at least as stringent as the federal plan but may be more so, as state plans have a tendency to be more frequently reviewed and updated.

Because Federal OSHA requirements are not frequently updated the use of ANSI B11 Standards are often used to demonstrate compliance to the OSHA regulations.

North American Safety Standards

Application vs. Construction Standards

Safety standards fall into two categories: application standards and construction standards.

Application Standards

Application standards reference how to use a light curtain for machine guarding, for example, how to calculate the safe mounting distance. Although some may give condensed construction information, often the main thrust of an application standard is how to apply a light curtain for the type of machine covered by the standard. For example, ANSI/RIA R15.06 discusses the use of presence-sensing devices (light curtains) for robot guarding. ANSI B11.1 provides information on how to use presence-sensing devices on mechanical power presses.

Construction Standards

Construction standards provide design, construction and testing information on presence sensing devices. In North America, ANSI/UL 61496 entitled "Safety of Machinery - Electrosensitive Protective Equipment" is the construction standard for light curtains.

ANSI/UL 61496 covers specific items such as the number of outputs required, the need for a key-operated switch, transformer construction, and failure conditions. Test specifications require that the equipment be subject to a battery of tests including moisture and dust intrusion, power supply transients, electrical interferences, electrostatic discharges, component failure mode analysis and object sensing capabilities.

Machine Guarding

In the United States, installation and use of machine guarding is regulated by the Occupational Safety and Health Administration (OSHA). Some states have their own safety organizations with regulations that must be at least as strict as the federal OSHA standards.

In addition to OSHA, other organizations provide information on proper machine guarding. The American National Standards Institute (ANSI) publishes the B11 standards to provide information on the construction, care and use of machine tools. Certain standards are developed for specific types of machine tools.

Standards in the B11 series include:

- B11.0 - Safety of Machinery - applies to new, modified or rebuilt power driven machines, not portable by hand, used to shape and/or form metal or other materials
- B11.1 - Mechanical Power Presses - applies to only to those mechanically-powered machine tools commonly referred to as mechanical power presses
- B11.2 - Hydraulic Power Presses - applies to only to those machine tools, commonly referred to as hydraulic power presses
- B11.3 - Power Press Brakes - applies to those machine tools classified as power press brakes (hereinafter referred to simply as press brakes)
- B11.4 - Shears - applies to those mechanically, hydraulically, hydro-mechanically, or pneumatically powered shears used to cut material by shearing
- B11.5 - Ironworkers - applies to those combination, multipurpose powered machines that punch, shear, notch, cope and form metal
- B11.6 - Safety Requirements for Manual Turning Machines with or without Automatic Control - specifies safety requirements for the design, construction, operation and maintenance



- B11.7 - Cold Headers - applies to only those mechanically-powered machines commonly referred to as cold headers and cold formers
- B11.8 - Manual Milling, Drilling - specifies safety requirements for the design, construction, operation and maintenance
- B11.9 - Grinding Machines - applies to all stationary grinding machines
- B11.10 - Metal Sawing Machines - specifies safety requirements for the design, construction, modification, operation and maintenance
- B11.11 - Gear (Spline) Cutting Machines - specifies safety requirements for the design, construction, operation and maintenance
- B11.12 - Roll Forming and Roll Bending Machines - applies to any power-driven metal-forming machine that changes the shape or the direction, or both, of materials
- B11.13 - Automatic Bar and Chucking Machines - applies to single and multiple spindle automatic bar and chucking machines in which all tool movement is controlled by the machine.
- B11.15 - Pipe, Tube and Shape Bending Machines - applies to any power-driven machine designed for bending pipe, tube, and shapes by means of dies
- B11.16 - Powder/Metal Compacting Presses - applies to those mechanically or hydraulically powered machine tools that are designed, modified, or converted for metal compacting
- B11.17 - Horizontal Hydraulic Extrusion Presses - applies to those horizontal hydraulically powered presses that extrude metals
- B11.18 - Coil Processing and Coil Slitting Machine - applies to machines, and groups of machines arranged in production systems, for processing strip, sheet, or plate metal from a coil
- B11.19 - Performance Criteria for Safeguarding - provides performance requirements for the design, construction, installation, operation and maintenance of the safeguarding
- B11.20 - Integrated Manufacturing Systems - specifies the safety requirements for the design, construction, set-up, operation and maintenance
- B11.21 - Machine Tools Using Lasers - applies to machine tools using a laser for processing materials, and its associated equipment.
- B11.22 - Turning Centers and Automatic Numerically - specifies the safety requirements for the design, construction, operation and maintenance
- B11.23 - Safety Requirements for Machining Centers and Automatic, Numerically Controlled Milling, Drilling and Boring Machines - specifies the safety requirements for the design, construction, operation and maintenance
- B11.24 - Transfer Machines - specifies the safety requirements for the design, construction, operation and maintenance
- B11.TR1 - Ergonomic Guidelines - this guideline provides a uniform approach to ergonomic considerations for machine tools within the workplace.
- B11.TR2 - Mist Control Considerations - provides guidelines for a uniform approach to the control of airborne contaminants generated by stationary machine tools
- B11.TR3 - Risk Assessment and Risk Reduction - provides a means to identify hazards associated with a particular machine or system
- B11.TR4 - Selection of Programmable Electronic Systems - provides guidance for the design or selection, integration, and validation of PESs
- B11.TR5 - Sound (Noise) Level Measurement Guideline - provides methods for measuring, evaluating and documenting sound levels emitted by a machine
- B11.TR6 - Safety Control Systems for Machines - provides guidance in understanding and implementing safety-related control functions
- B11.TR7 - Designing for Safety and Lean Manufacture - provides guidance on the practical application and integration of safety and lean manufacturing principles to machinery and manufacturing

Integrated Manufacturing Systems/Cells

An integrated manufacturing system is defined as a group of two or more industrial machines working together in a coordinated manner normally interconnected with and operated by a supervisory controller or controllers capable of being reprogrammed for the manufacturing of discrete parts or assemblies. This definition is provided by ISO 11161, *Safety of Integrated Manufacturing Systems*, an international standard covering requirements for the safe installation, programming, operation, maintenance or repair of these systems. A similar standard is ANSI B11.20, entitled *Manufacturing Systems/Cells - Safety Requirements for Construction, Care and Use*.

Both of these standards cover the safety of multiple machines under some type of common control. When machines in an integrated system operate separately or individually, or the safeguards are muted or suspended, the safety standards for the individual machines should be used as a supplement.

Robots and Robot Systems

Safety guidelines for applications using industrial robots result from the joint effort of ANSI and the Robotics Industries Association (RIA). In standard ANSI/RIA R15.06, an industrial robot is defined as a reprogrammable multifunctional manipulator designed to move material, parts, tools, or other devices. This standard does not apply to numerically controlled machine tools.

Ontario Regulation 7

Each Canadian province has created, or is developing its own specific safety regulations. The province of Ontario may have the most complete set. Of particular interest to users of industrial machinery is Regulation 7 of the *Regulations for Industrial Establishments*.

Regulation 7 outlines the requirements for a *Pre-Start Health and Safety Review (PHSR)*. The intent of a PHSR is three-fold:

1. Provide for a timely professional review to identify specific standards.
2. Ensure hazards are removed or controlled before start-up.
3. Ensure that worker protection as required under the applicable provisions of the *Regulations for Industrial Establishments* is provided.

What is a Pre-Start Health and Safety Review?

A PHSR is conducted upon the construction, addition or installation of a new machine, structure or protective element, or the modification of an existing installation.

The end result of a PHSR is a written report. This report details the actions, steps or engineering controls required to bring the subject application into compliance with the provisions of the *Regulations for Industrial Establishments*.

Benefits of a PHSR include:

- Prevention of hazardous incidents
- Assurance of uniform quality inspections
- Reduced cost of protection
- Assurance that high risk areas are addressed
- Raises standards for OEM manufacturers

Although specific to the Canadian province of Ontario, Regulation 7 and the resulting PHSR report incorporate the risk assessment principals found elsewhere in the Expert Area.

The Canadian Standards Association (CSA)

CSA is a Canadian laboratory that tests and certifies the electrical integrity and safety of products. CSA is accredited by OSHA as a Nationally Recognized Test Laboratory (NRTL) which covers testing of all products under OSHA's jurisdiction.

The NRTL/C mark (Canadian/US certification) on our products indicates certification for Canada as well as the United States and is considered to comply with applicable CSA and UL requirements.

The NRTL/C mark is a counterpart to the Underwriter's Laboratory C-UL mark. Both marks indicate that a product is in compliance with both CSA and UL standards.

The NRTL/C mark on our products precludes the necessity of having both CSA and UL agency logos. All STI safety light curtains are CSA listed (file number LR90200).

Corporate Standards

In order to provide employees with a safe work environment, many corporations have authored their own standards for safety light curtains and personnel protection. These standards are frequently more stringent than those required by OSHA and can only be met by the most technically advanced products. Omron listens closely to industry requirements and has responded with such patented features as the FlexSafe and Individual Beam Indicator lights. The MPCE and MTS feature were also originally engineered at the request of a customer.

Harmonized European Standards

These standards are common to all EC and EFTA countries and are produced by the European Standardization bodies CEN and CENELEC. Their use is voluntary but designing and manufacturing equipment to them is the most direct way of demonstrating compliance with the EHSRs. They are divided into 3 groups: A, B and C standards.

A Standards

Cover aspects applicable to all types of machines.

B Standards

Subdivided into 2 groups.

- B1 STANDARDS - Cover particular safety and ergonomic aspects of machinery.
- B2 STANDARDS - Cover safety components and devices.

C Standards

Cover specific types or groups of machines.

It is important to note that complying with a C Standard gives automatic presumption of conformity with the EHSRs. In the absence of a suitable C Standard, A and B Standards can be used as part or full proof of EHSR conformity by pointing to compliance with relevant sections.

Agreements have been reached between CEN and CENELEC and with other world-wide Standardization Bodies. This should ultimately result in common world-wide standards.

This section lists some of the relevant A and B Standards

EN ISO 12100 (EN 292) PARTS 1 & 2 - Safety of machinery – Basic concepts, general principles for design.

This A standard outlines all the basic principles including risk assessment,

guarding, interlocking, emergency stops, trip devices, safety distances and much more. It references other standards and also includes the essential safety requirements from the Machinery Directive.

EN 60204-1 – Safety of machinery – Electrical equipment of machines – Pt 1 General requirements.

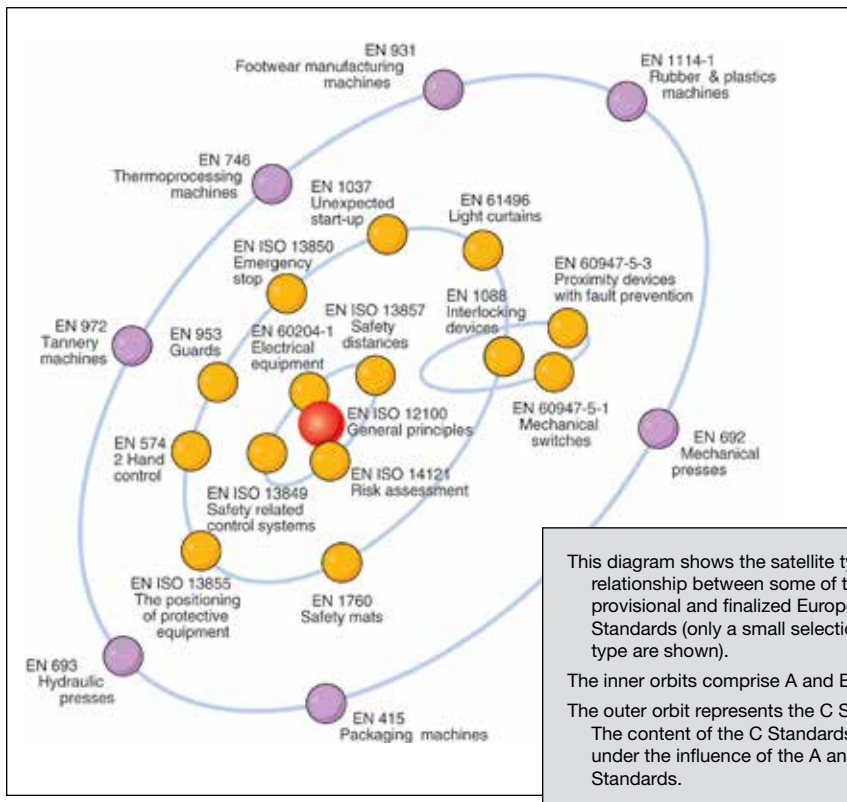
This standard gives general and specific recommendations for Safety-Related aspects of wiring and electrical equipment on machines.

EN ISO 13857 (EN 294) – Safety of machinery – Safety distances to prevent danger zones being reached by the upper and lower limbs.

Gives data for calculation of safe aperture sizes and positioning for guards etc.

EN 349 – Safety of machinery – Minimum distances to avoid crushing parts of the human body.

Gives data for calculation of safe gaps between moving parts etc.



EN 1088 — Safety of machinery — Interlocking devices associated with guards — Principles for design and selection.

Gives principles for the design and selection of interlocking devices associated with guards.

In order to verify mechanical switches it refers to **EN 60947-5-1 — Electromechanical control circuit devices.**

In order to verify non-mechanical switches it refers to **EN 60947-5-3 — Particular requirements for proximity devices with fault prevention measures or defined behavior under fault conditions.**

EN ISO 13849 — Safety of machinery — Safety-Related parts of control systems — Pt 1: General principles for design.

This standard outlines requirements for safety critical parts of machine control systems. It is important to achieve a working knowledge of this document as its categories are the common “language” for describing the performance of Safety-Related control systems.

EN ISO 13855 (EN 999) — Safety of machinery — The positioning of protective equipment in respect of approach speeds of parts of the human body.

Provides methods for designers to calculate the minimum safety distances from a hazard for specific safety devices. In particular for electro sensitive devices (eg: light curtains), pressure sensitive mats/floors and two-hand controls.

EN ISO 14121-1 (EN 1050) — Safety of machinery — Principles for risk assessment.

Outlines the process of assessing the risks during the life of the machinery.

EN 574 — Safety of machinery — Two-hand control devices — Functional aspects — Principles for design.

Provides requirements and guidance on the design and selection of two-hand control devices, including the prevention of defeat and the avoidance of faults.

EN ISO 13850 (EN 418) — Safety of machinery — Emergency Stop devices, functional aspects — Principles for design.

Gives design principles and requirements.

EN 61496-1&2 — Safety of machinery — Electro sensitive protective equipment Pt 1: General requirements and tests. Pt 2: Particular requirements for equipment using active opto-electronic protective devices.

Part 1 gives requirements and test procedures for the control and monitoring aspects of electro sensitive protective equipment. Subsequent parts deal with aspects particular to the sensing side of the system.

Part 2 gives particular requirements for safety light curtains.

EN 1760-1 — Safety of machinery — Pressure Sensitive Safety Devices — Pt 1: Mats & Floors.

Gives requirements and test procedures.

EN 1760-2 — Safety of machinery — Pressure Sensitive Safety Devices — Pt 2: Edges & Bars.

Gives requirements and test procedures.

EN 953 - Safety of machinery — General Requirements for the Design and Construction of Guards.

Gives definitions, descriptions and design requirements for fixed and movable guards.

EN 1037 — Safety of machinery — Isolation and energy dissipation — Prevention of unexpected start-up.

Defines measures to isolate machines from power supplies and dissipate stored energy to prevent unexpected machine start-up and allow safe intervention in danger zones.

NOTE: Many of these European Standards are being revised and adopted as international standards with new number designations. During the transition period, the documents may carry an IEC/ISO number or an EN number or both.

Safety Strategy - Hazard Identification & Risk Evaluation

From a functional point of view the more efficiently a machine performs its task of processing material the better it is. Life, however, is not that simple and in order for a machine to be viable it must also be safe. Safety must be regarded as a prime consideration.

To achieve a proper safety strategy there must be:

1. Risk Assessment based on a clear understanding of the **machine limits and functions which must be analyzed to identify** which ones pose a potential hazard. The degree of risk due to the hazard is then **estimated** in order to provide a basis for judgement at later stages. A **risk evaluation** is then required to determine if existing safety measures are satisfactory or whether additional measures are required to reduce the risk.

2. Risk Reduction is then performed if necessary and safety measures are selected based on the information derived from the risk assessment stage.

After the implementation of these measures the risk assessment is repeated to determine whether safety has in fact been achieved.

The manner in which this is done is the basis of the **Safety Strategy** for the machine.

A checklist should be followed to ensure that all aspects are considered and that the overriding principle does not become lost in the detail.

The first step is to ensure that the whole process is documented. This ensures a more thorough job and makes the results available for review by other parties. In Europe, the documented risk assessment is usually included in the technical file which supports the Declaration of Conformity for the Machinery Directive. Because the process is likely to be repeated, documenting the results means that needless repetition can be avoided.

If a machine is designed in conformity with a product standard specific to that machine, the standard should already incorporate most of the measures necessary for its safety. It is strongly recommended however, that a risk assessment is still performed to ensure that everything is considered.

Although this section may only seem to apply to machine manufacturers it is also relevant to machine users as machines are often used in circumstances unforeseen by the manufacturer. The user (or employer) has a legal requirement to provide a safe working environment. Regulations make it clear that the safety of work equipment is addressed from three aspects :

1. its initial integrity
2. the place where it is used
3. the purpose for which it is used.

For example, a milling machine used in a school workshop will need additional considerations compared to one which is used in an industrial tool room.

Remember that if a user acquires two or more independent machines and integrates them into one process they are, technically speaking, the manufacturer of the resulting combined machine.

Now let's consider the essential steps to a proper safety strategy. The following can be applied to an existing factory installation or a single new machine.

Risk Assessment

Why is a risk assessment necessary?

One reason is obvious - in the European Community it is a legal requirement. Most of the directives and regulations regarding machinery safety state that a formal risk assessment should be performed. Most of the harmonized European standards refer to it and the subject itself is covered by standard — ISO 14121-1 "Principles for Risk Assessment". Additionally, in North America ANSI has developed a technical report B11.TR3-2000. While not a "standard", this technical report provides guidance on how to estimate, evaluate and reduce risks associated with machine tools. People concerned with the safety of machinery know that risk assessment is an integral part of a complete safety strategy.

Risk assessment is a helpful process which provides vital information and allows the user or designer to make logical decisions about safeguarding methods.

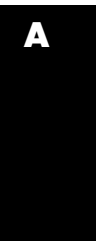
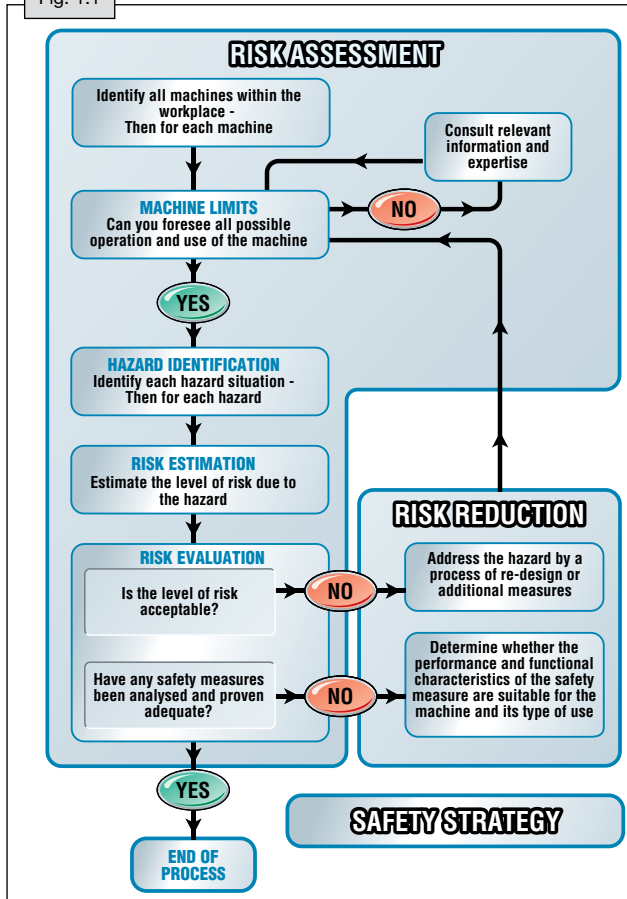


Fig. 1.1



Machine Limit Determination and Hazard Identification

A complete list of all machines should be made. Where separate machines are linked together, either mechanically or by control systems, they should be considered as a single machine. Each machine is then considered to see if it presents any sort of hazard and the list marked accordingly.

hazard. But if the gears are protected by an interlocked access panel they are a potential hazard which may become an actual hazard in the event of failure of the interlocking system.

Each machine with a hazard should be identified and marked on the list together with the types of hazard present. At this stage it is only the identity and type of hazard that is of concern. It is tempting to start estimating the degree of risk posed by the hazard but this is a separate process of risk estimation.

It is important to consider all stages in the life of a machine including installation, commissioning, maintenance, de-commissioning, correct use and operation. Also consider the consequences of reasonably foreseeable misuse or malfunction.

All hazards must be considered including crushing, shearing, entanglement, part ejection, fumes, radiation, toxic substances, heat, noise etc.

If a machine relies on anything other than its intrinsic nature for its safety it should be indicated as a hazard source. A machine with exposed gears has an obvious and direct

Risk Estimation

This is a fundamental aspect of machine safety. There are many ways of tackling this subject and the following pages provide a simple, effective approach. The method should be amended as necessary to suit individual requirements. An understanding of its importance is absolutely essential.

All machines that contain hazards present risk. It is important to be able to describe at which point the risk lies on a relative scale from minimum to maximum. The following pages provide a practical method for achieving this. First, let us look at some of the fundamental points.

1. The risk estimation must always be documented.

It is tempting to make a purely intuitive judgement. While often based on experience, it almost certainly will not take into account all the necessary considerations and cannot be easily checked or passed on to others.

You must follow a logical work pattern, write down the results and get other parties to review it. Remember, it is your evidence that you have shown due diligence in the task.

2. What is risk?

The term risk is often confused with the severity of an accident. Both the severity of potential harm AND the probability of its occurrence must be considered in order to estimate the amount of risk present.

3. It must take into account all foreseeable factors.

As with the Hazard Identification stage it is important to consider all stages of the machine's life including installation, commissioning, maintenance, de-commissioning, correct use and operation as well as the consequences of reasonably foreseeable misuse or malfunction.

4. It is an iterative process but work need not be repeated needlessly.

For example: A machine has an interlock guard door which, during an earlier risk evaluation, has been shown to be satisfactory. Provided that there are no changes which affect it, during subsequent risk assessments, no further measures will

be required as the risk has been satisfactorily reduced (or eliminated).

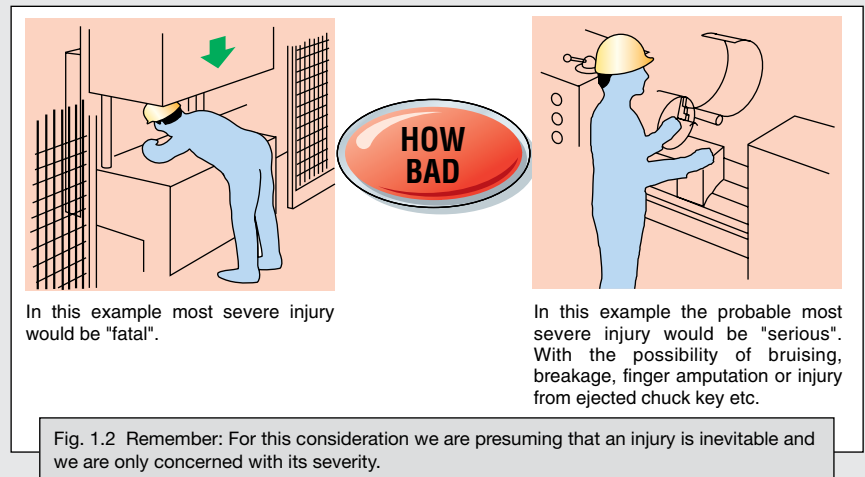
But if the machine has never been subjected to a formal risk assessment or its usage circumstances have changed then it cannot be automatically assumed that the interlocking system is satisfactory and the risk estimation should be repeated to verify its suitability.

The suggestion for risk estimation given on the following pages is not advocated as

the definitive method. Individual circumstances may dictate a different approach. **It is intended only as a general guideline to encourage a methodical and documented structure.**

It is intended to explain and complement the risk estimation section in the standard ISO 14121-1 "Principles for Risk Assessment". It uses the same well established principles as the standard but has a few minor variations in its approach.

Risk ESTIMATION - Step 1



1. THE SEVERITY OF POTENTIAL INJURY.

For this consideration we are presuming that the accident or incident has happened. Careful study of the hazard will reveal the most severe injury that can be reasonably conceived.

The severity of injury should be assessed as:

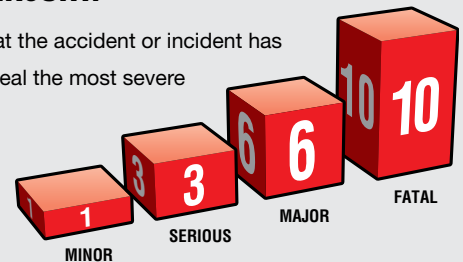
FATAL

MAJOR - (Normally irreversible)

Permanent disability, loss of sight, limb amputation, respiratory damage etc.

SERIOUS - (Normally reversible) Loss of consciousness, burns, breakages etc.

MINOR - Bruising, cuts, light abrasions etc.



Risk ESTIMATION- Step 2

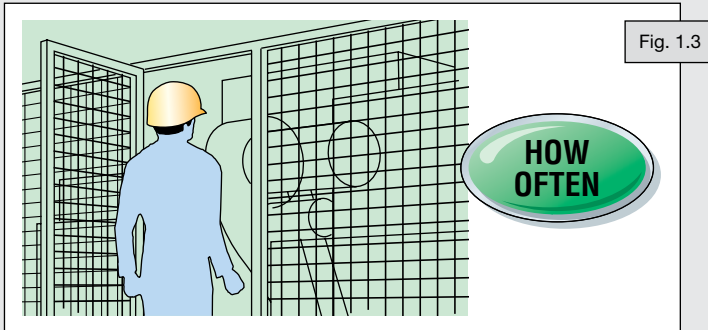


Fig. 1.3

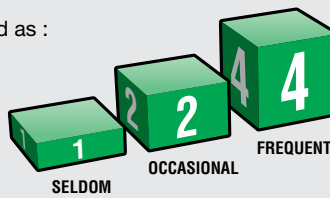
2. FREQUENCY OF EXPOSURE

The frequency of exposure to hazard can be classed as :

FREQUENT - Several times per day.

OCCASIONAL - Daily.

SELDOM - Weekly or less.



Risk ESTIMATION - Step 3

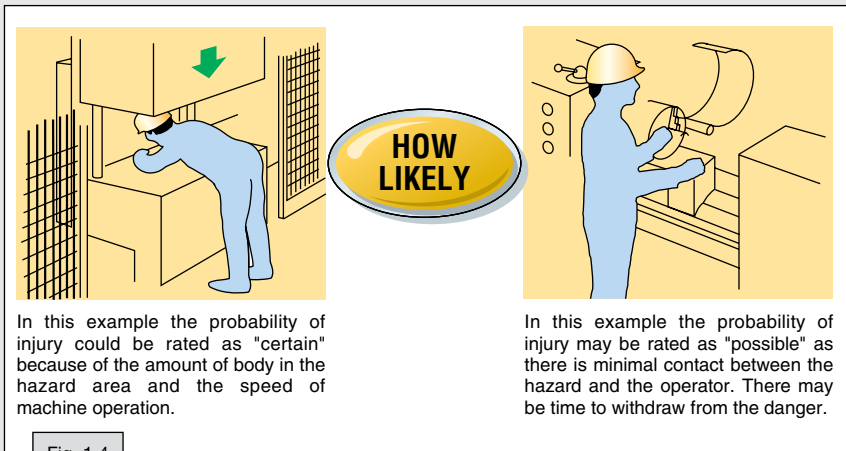


Fig. 1.4

In this example the probability of injury could be rated as "certain" because of the amount of body in the hazard area and the speed of machine operation.

In this example the probability of injury may be rated as "possible" as there is minimal contact between the hazard and the operator. There may be time to withdraw from the danger.

3. PROBABILITY OF INJURY

You should assume that the operator is exposed to the hazardous motion or process.

By considering the manner in which the operator is involved with the machine and other factors such as speed of start up etc., the probability of injury can be classed as:

CERTAIN

PROBABLE

POSSIBLE

UNLIKELY



Fig. 1.5 (Note: This is not based on the previous example pictures)

The following factors are taken into account:

1. The severity of potential injury.
2. The probability of its occurrence, which is comprised of two factors:
 - a. Frequency of exposure.
 - b. Probability of injury.

Dealing with each factor independently, values are assigned to these factors.

Make use of any data and expertise available. You are dealing with all stages of machine life so base your decisions on the worst case.

Remember, you should assume that there is no protective system or that it has failed to danger. For example, the machine power may not be isolated when a guard is opened or the machine may even start up unexpectedly while the guard is open.

All headings are assigned a value and they are now added together to give an initial estimate. **For example:**

The next step is to adjust the initial estimate by considering additional factors such as those shown in Figure 1.6. Often they can only be properly considered when the machine is installed in its operating location.

Depending on the type and usage of the machine there may be other relevant factors which should also be listed and considered at this stage.

Risk Reduction and Evaluation

Consider each machine and its risks separately and then address all of its hazards.

There are three basic methods to be considered and used in the following order:

1. Eliminate or reduce risks as far as possible by inherently safe machine design.
2. Take the necessary protective measures in relation to risks that cannot be eliminated.
3. Inform users of the residual risks due to the shortcomings of the protective measures adopted, indicate whether any particular training is required and specify the need to provide personal protective equipment.

If the machine is still at the design stage it may be possible to eliminate the hazard by a change of approach.

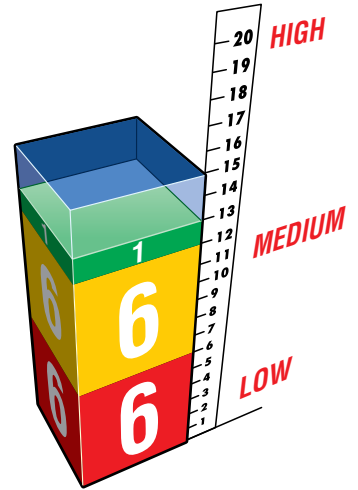
If design methods cannot provide the answer other action needs to be taken.

The hierarchy of measures to be considered include:

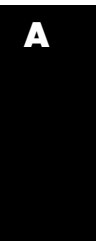
- (a) Fixed enclosing guards.
- (b) Movable (interlocked) guards or safe-guarding devices e.g. light curtains, presence sensing mats, etc.
- (c) Protection appliances (jigs, holders, push sticks etc.) used to feed a workpiece while keeping the operators body clear of the hazard zone. These are often used in conjunction with guards.

Fig. 1.6 The results of any additional factors are then added to the previous total as shown.

Additional Factor	Suggested Action
More than one person exposed to the hazard.	Multiply the severity factor by the number of people.
Protracted time in the danger zone without complete power isolation.	If time spent per access is more than 15 minutes, add 1 point to the frequency factor.
Operator is unskilled or untrained.	Add 2 points to the total



- (d) Provision of information, instruction, training and supervision. It is important that personnel have the necessary training in the safe working methods for a machine. This does not mean that measures (a), (b) or (c) can be omitted. It is not acceptable merely to tell an personnel that he must not go near dangerous parts (as an alternative to guarding them).



In addition to the above measures it may also be necessary for the operator to use equipment such as special gloves, goggles, respirators etc. The machinery designer should specify what sort of equipment is required. The use of personal protective equipment is usually not the primary safeguarding method but complements the measures shown above.

Each measure from the hierarchy should be considered in turn starting from the top and used where practical. This may result in a combination of measures being used.

If access is not required to dangerous parts the solution is to protect them by some type of fixed enclosing guarding.

If access is required then life becomes

a little more difficult. It is necessary to ensure that access can only be gained while the machine is safe. Protective measures such as interlocked guard doors and/or trip systems will be required. The choice of protective device or system should be heavily influenced by the operating characteristics of the machine. This is extremely important as a system which impairs machine efficiency is likely to be removed or bypassed.

The safety of the machine in this case will depend on the proper application and correct operation of the protective system even under fault conditions. Once the proper application has been dealt with by the appropriate choice of general type of

protective system the correct operation of the system must now be considered.

In an ideal world every protective system would be perfect with absolutely no possibility of failing to a dangerous condition. In the real world however we are constrained by the limits of knowledge and materials. Another constraint is, of course, cost. Because of these factors, a sense of proportion is required. Common sense says that it is ridiculous to insist that the integrity of a safety system on a machine that may cause mild bruising to be the same as that required to keep a jumbo jet in the air. The consequences of failure are drastically different and therefore we need to have some way of relating the extent of

Fig. 1.7

Company - MAYKIT WRIGHT LTD
 Facility - **Tool room - East Factory.**
 Date - **29/8/95**
 Operator profile - **Apprentice / Fully skilled.**

Equipment identity & date	Directive Conformity	Risk Assmnt Report no	Accident history	Notes	Hazard identity	Hazard type	Action required	Implemented & inspected - reference
Bloggs center lathe. Serial no. 8390726 Installed 1978	None claimed	RA302	None	Electrical equipment complies with BS EN 60204 E stops fitted (replaced 1989)	Chuck rotation with guard open	Mechanical Entanglement Cutting	Fit guard interlock switch	25/11/94 J Kershaw Report no 9567
					Cutting fluid	Toxic	Change to non toxic type	30/11/94 J Kershaw Report no 9714
					Swarf cleaning	Cutting	Supply gloves	30/11/94 J Kershaw Report no 9715
Bloggs turret head milling m/c Serial no 17304294 Manuf 1995 Installed May 95	M/c Dir. EMC Dir	RA416	None		Movement of bed (towards wall)	Crushing	Move machine to give enough clearance	13/4/95 J Kershaw Report no 10064

the protective measures to the level of risk obtained at the risk estimation stage.

Whichever type of protective device is chosen, it must be remembered that a “safety-related control system” may comprise many elements including the protective device, wiring, power switching device and sometimes parts of the machine’s operational control system. All these system elements should have suitable performance characteristics relevant to their design principle and technology.

The International Standard ISO 13849-1 “Safety-related parts of control systems” describes a process for determining the performance level for safety-related control

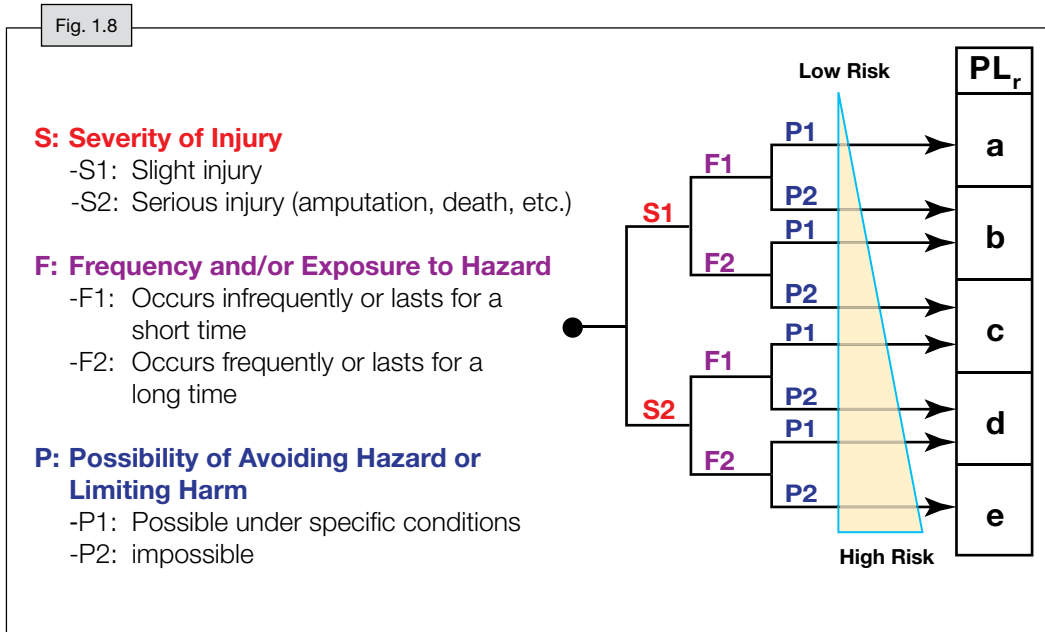
systems and how to relate risk reduction to required performance level. *Figure 1.8* is a simplified chart that shows the relationship of risk and required performance level. Performance levels will be discussed further in the section on safety-related control systems.

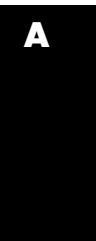
The table shown in *Figure 1.7* is suggested as part of a documented process to account for all safety aspects of the machine being used. It acts as a guide for machine users but the same principle can be used by machine manufacturers or suppliers. It can be used to confirm that all equipment has been considered and it will act as an index to more detailed reports on risk assessment.

The table shows that where a machine carries a mark from a recognized test lab (e.g. UL), it simplifies the process, as the machine hazards have already been considered by the manufacturer and the necessary measures have been taken. Even with equipment that has been approved by a recognized test lab, there may still be hazards due to the nature of its application or material being processed which the manufacturer did not foresee.

After the risk estimate is completed, implement the required safety related control system and performance levels according to the estimated risk level.

How to Determine Required Performance Level (PL_r) in accordance with ISO 13849-1





Machine Safeguarding Checklist

OMRON STI

Machine Services Division, 4545 East La Palma Avenue, Anaheim, CA 92807-1907 USA

The Machine Safeguarding Checklist MUST be performed by qualified personnel.

Company Name:		Machine Type:	
Location:		Manufacturer:	
Date:		Model #:	
Inspector:		Serial #:	
Department:		Asset / ID #:	

<p>1. Point of operation guard(s) position and/or distance.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - Point of operation guards appear to be compliant at this time and the safe mounting distance has been calculated and recorded. <input type="checkbox"/> No - Point of operation guards are missing, misapplied, or not securely fastened. Individuals can reach over, under, around or through the guards to the point of operation or the guards are missing or can be easily removed. <input type="checkbox"/> May not be compliant - The safe mounting distance and/or position needs to be checked. <input type="checkbox"/> N/A - Not applicable. 	<p>2. Perimeter guards position and/or distance.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - Perimeter guards appear to be compliant at this time and the safe mounting distance has been calculated and recorded. <input type="checkbox"/> No - Perimeter guards are missing, misapplied, or not securely fastened. Individuals can reach over, under, around or through the guards to the point of operation or the guards are missing or can be easily removed. <input type="checkbox"/> May not be compliant - The safety control system needs to be thoroughly reviewed for compliance with the required level of reliability. <input type="checkbox"/> N/A - Not applicable. 	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Comments</p>
<p>3. Mechanical power transmission apparatus guard(s) position and/or distance.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - All mechanical power transmission apparatuses below 8 ft. have guards which appear to be compliant at this time. <input type="checkbox"/> No - Mechanical power transmission guards are missing, misapplied, or not securely fastened. Individuals can reach over, under, around or through the guards to the point of operation or the guards are missing or can be easily removed. <input type="checkbox"/> May not be compliant - The safe mounting distance and/or position needs to be checked. <input type="checkbox"/> N/A - Not applicable. 	<p>4. Safety control system meets performance requirements.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - The safety control system has been reviewed by a trained engineer and has been determined to be compliant at this time. <input type="checkbox"/> No - The existing control system does not use safety rated components, such as safety monitoring relays, force guided relays, or a safety rated PLC. <input type="checkbox"/> May not be compliant - The safety control system needs to be thoroughly reviewed for compliance with the required level of reliability. <input type="checkbox"/> N/A - Not applicable. 	
<p>5. Safeguarding (protective) devices are safety-rated and properly installed.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - All components of the safety system are rated for human safety and have been tested and listed for such use. <input type="checkbox"/> No - Safeguarding devices are missing, are not safety rated, or are misapplied. The effective protected area is not of adequate height, width, or depth to detect entry of an individual into the hazardous area. <input type="checkbox"/> May not be compliant - The safe mounting distance and/or position needs to be checked. <input type="checkbox"/> N/A - Not applicable. 	<p>6. Emergency stop location and compliance with NFPA 79 (when required).</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - The emergency stop devices appear to be compliant at this time. <input type="checkbox"/> No - The emergency stop devices: <ul style="list-style-type: none"> • are missing • are not self-latching • do not use positive guided contacts: or • are not active in all modes: or • are not Type 0 or Type 1 stop circuits: or • are guarded or not readily accessible AND <ul style="list-style-type: none"> • are not mushroom style (for pushbuttons): • do not have slack detection or are mounted without springs (for cable pulls). <input type="checkbox"/> May not be compliant - The contact blocks need to be checked for positive guided contacts or the stop circuit needs to be checked for Type 0 or Type 1. <input type="checkbox"/> N/A - Not applicable. 	
<p>7. Compliant energy isolation device for each source of hazardous energy.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - All required energy isolation devices appear to be compliant at this time. <input type="checkbox"/> No - All hazardous energy sources are not capable of being controlled. <input type="checkbox"/> May not be compliant - Other potentially hazardous energy sources may exist. <input type="checkbox"/> N/A - Not applicable. 	<p>8. Controls have drop-out protection.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Yes - The control system has been tested for the required drop-out protection. <input type="checkbox"/> No - Machine motion starts automatically when power is restored to the machine. <input type="checkbox"/> May not be compliant - Could not test at time of inspection. <input type="checkbox"/> N/A - Not applicable. 	



For complete specifications and additional models and accessories visit www.omron247.com



Safety-Related Control Systems

First of all, what is a safety-related control system (often abbreviated to SRCS)?

It is that part of the machine control system which prevents a hazardous condition from occurring. It can be a separate dedicated system or it may be integrated with the normal machine control system.

Its complexity will vary from a typical simple system, such as a guard door interlock switch and emergency stop switch connected in series to the control coil of power contactor, to a compound system comprising both simple and complex devices communicating through software and hardware.

In order to reliably provide the safety function, the system must continue to operate correctly under all foreseeable conditions.

The International Standard ISO 13849-1 "Safety-Related parts of control systems" gives guidance on the design and analysis of safety-related machine control systems and defines a system of five Performance Levels (PL = a to e) that are quantified in terms of "the average probability of a dangerous failure per hour".

The table shown here is a summary of the 5 Performance Levels and the figures on the next pages show the relationship of the circuit structure (categories B, 1, 2, 3, and 4), diagnostics and reliability in determining Performance Level. Previous versions of ISO 13849-1 considered the structure of the control circuit (e.g. single channel, dual channel, test and monitoring circuits) as sufficient factors to determine safety performance. The new version of ISO

13849-1 adds (in addition to the previous requirements for categories) reliability and diagnostics as factors necessary to determine the safety performance of a control system. The new version of ISO 13849-1 also includes requirements and guidance for the development of software.

The safety-related performance of a machine control system can also be defined in terms of Safety Integrity Levels (SIL = 1, 2 or 3) in accordance with the International Standard IEC 62061 "Functional safety of safety-related electrical, electronic and programmable electronic control systems". This standard provides a process which is most useful for complex control systems based primarily on programmable electronics. However, IEC 62061 is not applicable to non-electrical control systems.

ISO 13849-1 will be more useful for industrial machine control systems because it has requirements for all kinds of machine control technologies regardless of energy used (e.g. electrical, hydraulic, pneumatic, and mechanical). ISO 13849-1 has the additional benefit of continuing the use of the same circuit categories (B, 1, 2, 3 and 4) that machine builders are already familiar with.

Note—In December 2009 the previous version of ISO 13849-1 will be cancelled and the use of categories alone will no longer be adequate to describe the performance level of safety-related control systems.

Control Reliability

Control reliability is defined by ANSI standard B11.19-2010, as "*The capability of the machine control system, the safeguarding, other control components and related interfacing to achieve a safe state in the event of a failure within their Safety-Related functions.*"

The term has been in use for several years but is rapidly becoming obsolete due to the wide acceptance of the International Standards ISO 13849 and IEC 62061 which provide a more complete and verifiable means of specifying the safety performance level of control circuits.

Based on common practice, control reliability corresponds to a minimum of performance level PL d in accordance with ISO 13849-1 or safety integrity level SIL 2 in accordance with IEC 62061.

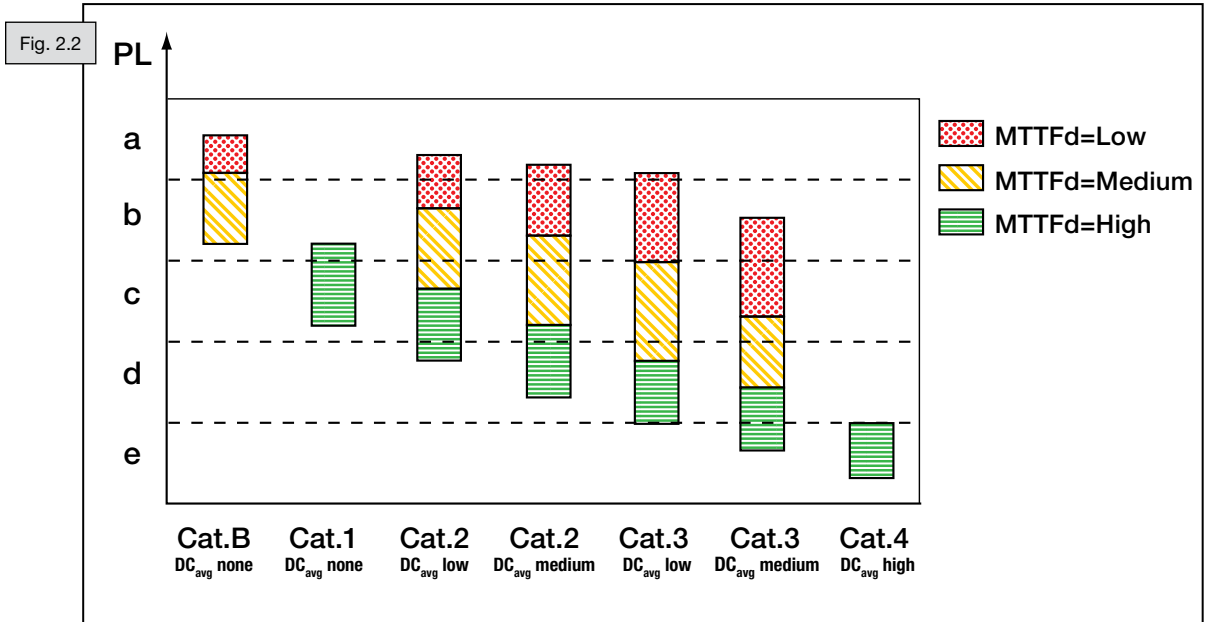
Performance Levels (PL)

PL	Average probability of dangerous failure per hour (1/h)
a	$\geq 10^{-5}$ to $< 10^{-4}$
b	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$
c	$\geq 10^{-6}$ to $< 3 \times 10^{-6}$
d	$\geq 10^{-7}$ to $< 10^{-6}$
e	$\geq 10^{-8}$ to $< 10^{-7}$

NOTE: Besides the average probability of dangerous failure per hour, other measures are also necessary to achieve a PL. (e.g. proper installation, maintenance and protection against environmental influences).

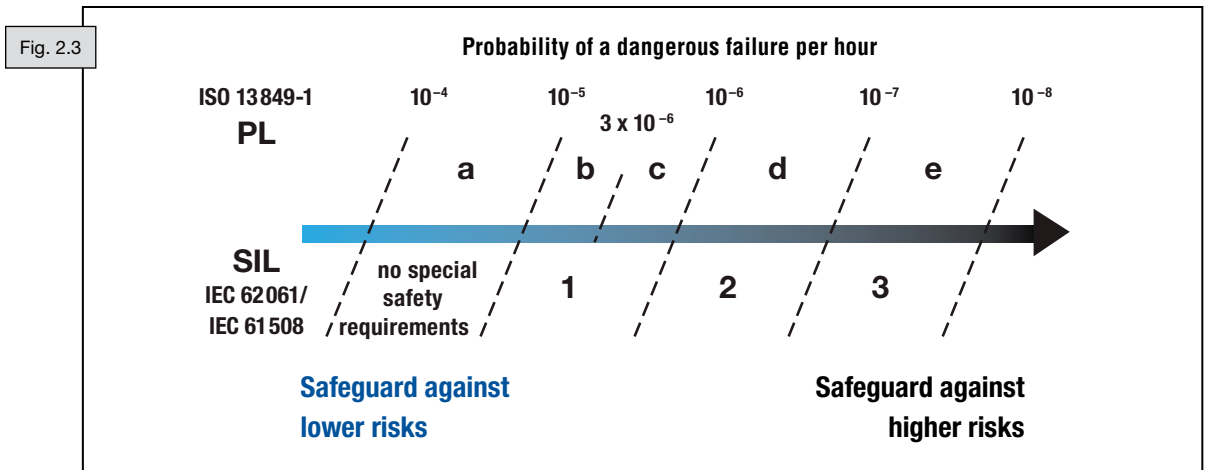
Fig. 2.1

Performance Level (PL) is determined from a combination of category, reliability and diagnostic coverage. For complete details, see ISO 13849-1.



NOTE: Categories 2, 3, and 4 must also be protected against common cause failures (CCF).

Relationship Between Safety Integrity Levels (SIL) and Performance Levels (PL)



Requirements For Categories

Fig. 2.4

Category	Summary of Requirements	Safety Principle
B	Will perform the required safety function. Designed to withstand expected stresses (for example, electrical load, vibration, EMC).	Quality of components Prevention of faults
1	Requirements of Category B and Use well tried safety components and safety principles.	
2	Requirements of Category B and The safety function is tested or inspected at suitable intervals. (NOTE: The safety function can fail in between test intervals.)	
3	Requirements of Category B and Single faults will not prevent the safety function. Single faults are detected whenever practical.	Structure of circuit Detection of faults
4	Requirements of Category 3 and Single faults are detected when or before performing the safety function. Accumulated faults will not prevent the safety function.	
NOTE: For complete descriptions and requirements for categories of circuit structure, see ISO 13849-1.		

Mean Time to Dangerous Failure (MTTF_d)

Fig. 2.5

<ul style="list-style-type: none"> • Average time for the system to encounter a dangerous failure • Classified into three levels: Low, Medium, and High 	
Low	$3 \text{ years} \leq \text{MTTF}_d < 10 \text{ years}$
Medium	$10 \text{ years} \leq \text{MTTF}_d < 30 \text{ years}$
High	$30 \text{ years} \leq \text{MTTF}_d \leq 100 \text{ years}$
NOTE: Results of more than 100 years are classified as High.	

Diagnostic Coverage (DC)

Fig. 2.6

<ul style="list-style-type: none"> • Diagnostic Coverage is the percentage of all dangerous faults that are detected. • Classified into four levels: None, Low, Medium, and High. 	
None	$\text{DC} < 60\%$
Low	$60\% \leq \text{DC} < 90\%$
Medium	$90\% \leq \text{DC} < 99\%$
High	$99\% \leq \text{DC}$
NOTE: For safety-related control systems consisting of several parts, an average value of DC will be used.	

So how do you decide on which category to use?

In order to translate these requirements into a system design specification there has to be an interpretation of the basic requirements.

The categories are intended as starting points which describe the structure of different types of safety-related control systems (or their constituent parts).

Categories B and 1 are aimed at the PREVENTION of faults. It is achieved by the use of suitable design principles, components and materials. Simplicity of principle and design together with the use of materials with stable and predictable characteristics are the keys to this category.

Categories 2, 3 and 4 are aimed at the DETECTION of faults (and appropriate action taken). Monitoring and checking are the keys to these categories. The most common (but not the only) method of monitoring is to duplicate the safety critical functions (i.e. redundancy) and compare their operation.

In the following examples, the reliability of the components used and the completeness of the fault detection are

critical factors in the final determination of the safety performance level of the control circuit.

The example in *Figure 2.7* is a simple system comprising a guard door interlock switch connected in series to the control coil of a power contactor.

If the goal is toward complete reliability with no possibility of a failure to a dangerous condition, which of the categories is most appropriate?

Figure 2.7 also shows the location and nature of potential dangerous faults.

For this simple case, which circuit structure would be most appropriate? The prevention of faults or the detection of faults?

The first step is to separate the system into its major components and consider their modes of potential failure.

In this example the components are:

- Interlock switch
- Contactor
- Wiring

The interlock switch is a mechanical device. The task which it performs is a simple one i.e. opening the contacts when a guard door is opened. It fulfills the requirements of category 1 and by

the use of correct design principles and materials it can be demonstrated that, when used within its stated operating parameters, it will have no failures to a dangerous condition. This is made feasible because the device is relatively simple and has predictable and provable characteristics.

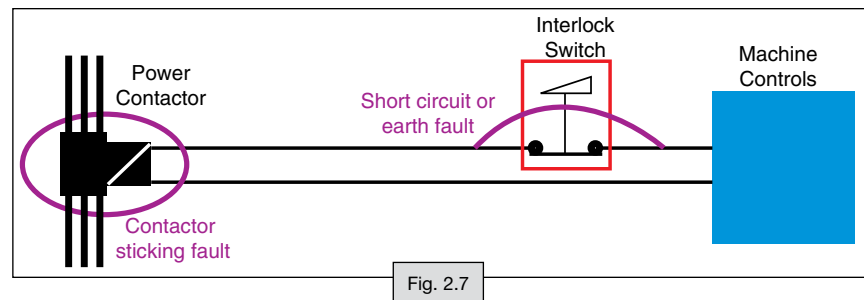
The contactor is a slightly more complex device and may have some theoretical possibilities for failure. Contactors from reputable manufacturers are extremely reliable devices. Statistics show that failures are rare and can usually be attributed to poor installation or maintenance.

Contactors should always have their power contacts protected by an overcurrent cut-out device to prevent welding.

Contactors should be subject to a regular inspection routine to detect excessive contact pitting or loose connections which can lead to overheating and distortion.

The contactor should comply with relevant standards which cover the required characteristics and conditions of use.

By attending to these factors it is possible to keep the possibilities of failure





NOTE: FOR PREVIEW ONLY!
Partial PDF due to overall file size.



OMRON AUTOMATION AND SAFETY • THE AMERICAS HEADQUARTERS • Chicago, IL USA • 847.843.7900 • 800.556.6766 • www.omron247.com

OMRON CANADA, INC. • HEAD OFFICE

Toronto, ON, Canada • 416.286.6465 • 866.986.6766 • www.omron247.com

OMRON ELECTRONICS DE MEXICO • HEAD OFFICE

México DF • 52.55.59.01.43.00 • 01-800-226-6766 • mela@omron.com

OMRON ELECTRONICS DE MEXICO • SALES OFFICE

Apodaca, N.L. • 52.81.11.56.99.20 • 01-800-226-6766 • mela@omron.com

OMRON ELETRÔNICA DO BRASIL LTDA • HEAD OFFICE

São Paulo, SP, Brasil • 55.11.2101.6300 • www.omron.com.br

OMRON ARGENTINA • SALES OFFICE

Cono Sur • 54.11.4783.5300

OMRON CHILE • SALES OFFICE

Santiago • 56.9.9917.3920

OTHER OMRON LATIN AMERICA SALES

54.11.4783.5300

OMRON EUROPE B.V. • Wegalaan 67-69, NL-2132 JD, Hoofddorp, The Netherlands. • +31 (0) 23 568 13 00 • www.industrial.omron.eu

Authorized Distributor:

Automation Control Systems

- Machine Automation Controllers (MAC) • Programmable Controllers (PLC)
- Operator interfaces (HMI) • Distributed I/O • Software

Drives & Motion Controls

- Servo & AC Drives • Motion Controllers & Encoders

Temperature & Process Controllers

- Single and Multi-loop Controllers

Sensors & Vision

- Proximity Sensors • Photoelectric Sensors • Fiber-Optic Sensors
- Amplified Photomicrosensors • Measurement Sensors
- Ultrasonic Sensors • Vision Sensors

Industrial Components

- RFID/Code Readers • Relays • Pushbuttons & Indicators
- Limit and Basic Switches • Timers • Counters • Metering Devices
- Power Supplies

Safety

- Laser Scanners • Safety Mats • Edges and Bumpers • Programmable Safety Controllers • Light Curtains • Safety Relays • Safety Interlock Switches

Printed on recycled paper. ♻️