

# Non-contact Safety Switches & Relays

## **Safety Product Series Catalog**

- Non-contact Safety Interlock Door Switches
- Safety Relay Unit



## Features of Non-contact Safety Interlock Door Switches



### High Reliability

The internal architecture is designed to ensure safety even in the unlikely event of an emergency.



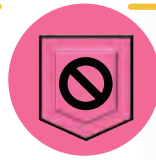
### High Durability

Safety door switches of non-contact type are free from mechanical wear or failure which happens to the ones of mechanical type.



### Laser Printed Housing

Surface of stainless steel housing is laser printed.  
No contamination by foreign materials from safety switch itself.



### Prevent Invalidation

Coding is achieved using combination of multiple magnets, which prevents invalidation of safety functions.



### Excellent Dust & Waterproof Performance

IP68 for plastic type and IP69K for stainless steel type by sealing the housings.  
Good for applications under harsh environment.



### For Stand-Alone Applications

No relay unit is required for SS2 or SS3 series, which can lower the investment cost.



Plastic Type (IP68)



Stainless Steel Type (IP69K)



### Easy Mounting and Adjustment

Non-contact method makes it easy to mount and adjust installation position.  
Small type is ideal for a narrow space.



### Applicable to Safety Category

Applicable up to safety category 4, by combining our safety switch with a safety relay unit.



**NOTE: Applicable safety category depends on model number.**

## SS2 Series

For both stand-alone use & combined use with relay.  
Safety Switch (Stainless Steel Type available)

- PLd per ISO 13849-1 in stand-alone applications  
Cross monitoring between two channels
- Multiple units can be connected to one safety relay unit
- Robust stainless steel housing available



### MODELS

Plastic Type (SS2-P)    Stainless Steel Type (SS2-OX)

Models	Safety Output	Auxiliary Output	Enclosure Material	
SS2-P-110	Relay	N.O. Contact x 1	Polyamide 66 (PA66)	
SS2-P-120		N.C.(SSR Output) x 1		
SS2-P-130		N.C.(PNP Open Collector Output) x 1		
SS2-P-210		N.C.(NPN Open Collector Output) x 1		
SS2-P-220		N.O. Contact x 2		
SS2-P-230		N.C.(SSR Output) x 1		
SS2-P-310		N.C.(PNP Open Collector Output) x 1		
SS2-P-320		N.C.(NPN Open Collector Output) x 1		
SS2-P-330		N.O. Contact x 1		N.C.(SSR Output) x 1
SS2-OX-110	Relay	N.C.(SSR Output) x 1	Equivalent to SUS316L (SCS16)	
SS2-OX-120		N.C.(PNP Open Collector Output) x 1		
SS2-OX-130		N.C.(NPN Open Collector Output) x 1		
SS2-OX-210		N.O. Contact x 2		
SS2-OX-220		N.C.(SSR Output) x 1		
SS2-OX-230		N.C.(PNP Open Collector Output) x 1		
SS2-OX-310		N.C.(NPN Open Collector Output) x 1		
SS2-OX-320		N.O. Contact x 1		N.C.(SSR Output) x 1
SS2-OX-330		N.C. Contact x 1		N.C.(PNP Open Collector Output) x 1
		N.C.(NPN Open Collector Output) x 1		

### COMMON PRODUCT SPECIFICATIONS

<b>Power Supply Voltage</b>	24VDC (-15%/+10%)*	
<b>Operating Distances</b>	Rated Operating Distance : 0.47" [12mm] Assured Switch ON Distance : 0.39" [10mm] Assured Switch OFF Distance : 0.59" [15mm] Hysteresis : 0.079" [2mm] Repeat Accuracy : <5%	
<b>Dimensions</b>	SS2-P : Transmitter Unit : 3.62 x 0.98 x 0.67" [92 x 25 x 17mm] SS2-P : Receiver Unit : 3.62 x 0.98 x 0.96" [92 x 25 x 24.5mm] SS2-OX : Transmitter Unit : 3.62 x 1.14 x 0.71" [92 x 29 x 18mm] SS2-OX : Receiver Unit : 3.62 x 1.14 x 0.94" [92 x 29 x 24mm]	
<b>Safety Output Protection</b>	Internal Fuse 2A	<b>Weight (Including Cable)</b>
<b>Operating Temperature</b>	-13 - +140°F [-25 - +60°C]	SS2-P : Transmitter Unit : 2.82oz [80g] SS2-P : Receiver Unit : 8.11oz [230g]
<b>Type / Coding Level</b>	4 / Low	SS2-OX : Transmitter Unit : 6.7oz [190g] SS2-OX : Receiver Unit : 13.1oz [370g]
<b>MTTFd</b>	> 100 Years	
<b>Complied Standards</b>	ISO 13849-1, ISO 14119, IEC 60204-1, IEC 61508-1, IEC 61508-2, IEC 62061, IEC 60947-5-3, UL 60947-1, UL 60947-5-2, CSA C22.2 No. 60947-1, CSA C22.2 No. 60947-5-2, CE, RoHS	

\* Use power supply compliant with Safety Extra Low Voltage (SELV) or Protected Extra Low Voltage (PELV).

# Safety Products (Non-contact Safety Interlock Door Switches)

## PRODUCT SPECIFICATIONS

Models	SS2-P-110	SS2-P-120	SS2-P-130	SS2-OX-110	SS2-OX-120	SS2-OX-130
<b>Safety Output</b>	N.O. Contact x1      48VAC 2A (AC General Use), 30VDC 2A (DC Resistive), 5VDC 10mA Min.					
<b>Auxiliary Output (x1)</b>	N.C. x 1 (SSR Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)	N.C. x 1 (SSR Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)
	24VDC 200mA Max.					
<b>Operating Current</b>	60mA	215mA	60mA	60mA	215mA	60mA
<b>Safety Relay Unit</b>	Cannot be used in combination with safety relay unit					
<b>Protection Class</b>	IP68			IP69K		
<b>PL</b>	PLd (Safety Cat.3), SIL 2: Stand-alone use only *Up to 25 safety switches can be connected in series					
Models	SS2-P-210	SS2-P-220	SS2-P-230	SS2-OX-210	SS2-OX-220	SS2-OX-230
<b>Safety Output</b>	N.O. Contact x2      48VAC 2A (AC General Use), 30VDC 2A (DC Resistive), 5VDC 10mA Min.					
<b>Auxiliary Output (x1)</b>	N.C. x 1 (SSR Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)	N.C. x 1 (SSR Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)
	24VDC 200mA Max.					
<b>Operating Current</b>	60mA	215mA	60mA	60mA	215mA	60mA
<b>Safety Relay Unit</b>	Can be used in combination with SM1-301 of Line Seiki					
<b>Protection Class</b>	IP68			IP69K		
<b>PL</b>	PLd (Safety Cat.3), SIL 2: Stand-alone or with Safety Relay unit "SM1-301" *2 to 25 safety switches can be connected in series PLd (Safety Ca.3), SIL3: Combined with Safety Relay unit "SM1-301" *1 safety switch					
Models	SS2-P-310	SS2-P-320	SS2-P-330	SS2-OX-310	SS2-OX-320	SS2-OX-330
<b>Safety Output</b>	N.O. Contact x1      48VAC 2A (AC General Use), 30VDC 2A (DC Resistive), N.C. Contact x1      5VDC 10mA Min.					
<b>Auxiliary Output (x1)</b>	N.C. x 1 (SSR Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)	N.C. x 1 (SSR Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)
	24VDC 200mA Max.					
<b>Operating Current</b>	60mA	215mA	60mA	60mA	215mA	60mA
<b>Safety Relay Unit</b>	Can be used with safety relay unit receiving 1 N.O. + 1 N.C. input / Cannot be used with SM1-301 of Line Seiki					
<b>Protection Class</b>	IP68			IP69K		
<b>PL</b>	PLd (Cat.3), SIL2: Stand-alone (1 safety switch) Performance level depends on evaluation of entire system: Combined with a relay unit (1 N.O. + 1 N.C.)					

## SS3 Series

Stand-alone  
Small Safety Switch (Stainless Steel Type available)

- PLC per ISO 13849-1 in stand-alone applications
- Two channels
- Small type, slim designed, easy to install
- Robust stainless steel housing available



Plastic Type (SS3-P)



Stainless Steel Type (SS3-OX)

### MODELS

Models	Safety Output		Auxiliary Output	Enclosure Material
SS3-P-200	Relay	N.O. Contact x 2	-	Polyamide 66 (PA66)
SS3-OX-200				Equivalent to SUS316L (SCS16)

### PRODUCT SPECIFICATIONS

Models	SS3-P-200	SS3-OX-200
Power Supply Voltage	24VDC (-15%/+10%)*	
Current Consumption	60mA	
Operating Distances	Rated Operating Distance : 0.28" [7mm] Assured Switch ON Distance : 0.24" [6mm] Assured Switch OFF Distance : 0.39" [10mm] Hysteresis : 0.039" [1mm] Repeat Accuracy : <5%	
Safety Output	N.O. Contact x2      48VAC 250mA (AC Resistive, AC General Use), 30VDC 250mA (DC General Use), 5VDC 10mA Min.	
Safety Output Protection	Internal Fuse 250mA	
Safety Relay Unit	Cannot be used in combination with safety relay unit	
Dimensions	Transmitter Unit : 2.76 x 0.47 x 0.63" [70 x 12 x 16mm]	Receiver Unit : 2.76 x 0.63 x 0.63" [70 x 16 x 16mm]
Weight	Transmitter Unit : 1.06oz [30g] Receiver Unit (including cable) : 6.35oz [180g]	Transmitter Unit : 2.47oz [70g] Receiver Unit (including cable) : 7.41oz [210g]
Operating Temperature	-13 - +140°F [-25 - +60°C]	
Protection Class	IP68	IP69K
Type / Coding Level	4 / Low	
PL	PLc (Safety Cat.1), SIL2: Stand-alone use only *Up to 25 safety switches can be connected in series	
B10d	>100 Years	
Complied Standards	ISO 13849-1, ISO 14119, IEC 60204-1, IEC 61508-1, IEC 61508-2, IEC 62061, IEC 60947-5-3, UL 60947-1, UL 60947-5-2, CSA C22.2 No. 60947-1, CSA C22.2 No. 60947-5-2, CE, RoHS	

\* Use power supply compliant with Safety Extra Low Voltage (SELV) or Protected Extra Low Voltage (PELV).

## SS4 Series

Exclusive use in combination with relay  
Small Safety Switch (Stainless Steel Type available)

- Small type, slim designed, easy to install
- Up to PLe per ISO 13849-1 in combination with a safety relay unit
- Multiple units can be connected to one safety relay unit
- Robust stainless steel housing available



Plastic Type (SS4-P)



Stainless Steel Type (SS4-OX)

### MODELS

Models	Output	Auxiliary Output	Enclosure Material
SS4-P-420	SSR	N.O. Output x 2	N.C.(PNP Open Collector Output) x 1
SS4-P-430			(PA66)
SS4-OX-420			N.C.(PNP Open Collector Output) x 1
SS4-OX-430			N.C.(NPN Open Collector Output) x 1
			Equivalent to
			SUS316L (SCS16)

### PRODUCT SPECIFICATIONS

Models	SS4-P-420	SS4-P-430	SS4-OX-420	SS4-OX-430
<b>Power Supply Voltage</b>	24VDC (-15%/+10%)*			
<b>Current Consumption</b>	268mA	30mA	268mA	30mA
<b>Operating Distances</b>	Rated Operating Distance : 0.28" [7mm] Assured Switch ON Distance : 0.24" [6mm] Assured Switch OFF Distance : 0.39" [10mm] Hysteresis : 0.039" [1mm] Repeat Accuracy : <5%			
<b>Output</b>	N.O. Output x 2 ( To be connected to SM1-301)			
<b>Auxiliary Output (x1)</b>	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)	N.C. x 1 (PNP Open Collector Output)	N.C. x 1 (NPN Open Collector Output)
	24VDC 250mA Max.	30VDC 250mA Max.	24VDC 250mA Max.	30VDC 250mA Max.
<b>Dimensions</b>	Transmitter Unit : 2.76 x 0.47 x 0.63" [70 x 12 x 16mm]		Receiver Unit : 2.76 x 0.63 x 0.63" [70 x 16 x 16mm]	
<b>Weight</b>	Transmitter Unit : 1.06oz [30g] Receiver Unit (including cable) : 6.35oz [180g]		Transmitter Unit : 2.47oz [70g] Receiver Unit (including cable) : 7.41oz [210g]	
<b>Operating Temperature</b>	-13 - + 140°F [-25 - +60°C]			
<b>Protection Class</b>	IP68		IP69K	
<b>Type / Coding Level</b>	4 / Low			
<b>PL</b>	PLe (Safety Cat.4), SIL3: Combined with Safety Relay unit "SM1-301"			
	*Up to 25 safety switches can be connected in series			
<b>B10d</b>	2,000,000 times			
<b>Complied Standards</b>	ISO 13849-1, ISO 14119, IEC 60204-1, IEC 61508-1, IEC 61508-2, IEC 62061, IEC 60947-5-3, UL 60947-1, UL 60947-5-2, CSA C22.2 No. 60947-1, CSA C22.2 No. 60947-5-2, CE, RoHS			

\* Use power supply compliant with Safety Extra Low Voltage (SELV) or Protected Extra Low Voltage (PELV).

# SM1-301

Safety Relay Unit

- 0.91" [23mm] width, compact space-saving type
- Applicable to the conditions of Category 4 per ISO 13849-1
- 25 units of SS4-Series models can be connected in series, still applicable to the conditions of Category 4 per ISO 13849-1
- Monitor contacts of emergency stop devices and/or limit switches
- 3 safety outputs (N.O.) with force guided contacts



## PRODUCT SPECIFICATIONS

<b>Models</b>	<b>SM1-301</b>
<b>Power Supply Voltage</b>	24VAC / 24VDC (-15%/+10%)
<b>Power Consumption</b>	5VA (AC) 2.5W (DC)
<b>Short-circuit Protection</b>	Electronic Fuse
<b>Safety Input</b>	Number of Input Channels: N.O . input x 2 channels Input Current: 166mA max. per channel
<b>Safety Output</b>	N.O. Contact x 3 250VAC 6A (AC Resistive), 250VAC 5A (AC General), 24VDC 5A (DC General)
<b>Auxiliary Output</b>	N.C. Contact x 1 250VAC 5A (AC Resistive), 250VAC 5A (AC General), 24VDC 5A (DC General)
<b>PL</b>	PLe (Safety Cat.4), SIL 3
<b>Contact Material</b>	AgSnO <sub>2</sub>
<b>Minimum Contact Load</b>	5VDC 10mA
<b>Response Time</b>	20ms max.
<b>Operating Temperature</b>	-4 - +140°F [-20 - +60°C]
<b>Dimensions</b>	3.94 x 0.91 x 4.49" [100 x 23 x 114mm]
<b>Weight</b>	6.35oz [180g]
<b>Performance Level</b>	IP20
<b>MTTFd</b>	>100 times
<b>Complied Standards</b>	ISO 13849-1, IEC 60204-1, IEC 61508-1, IEC 61508-2, IEC 62061, IEC 61326-1, IEC 61326-3-1, IEC 60068-2-1, IEC 60068-2-2, UL 60947-1, UL 60947-5-1, CSA C22.2 No. 60947-1, CSA C22.2 No. 60947-5-1, CE, RoHS

\* Use power supply compliant with Safety Extra Low Voltage (SELV) or Protected Extra Low Voltage (PELV).





# The Importance of Safety Products

## International Standard Attitude toward Ensuring Safety

**Safety Confirmation System:** The machine can be activated only after the safety is ensured.

**Safety Integrated Design:** Safety design is integrated into the machine so that any human errors or machine failure will not cause any accident.



**System Establishment:** A system is established which can operate only when human security is ensured.

## What is Risk Assessment for safety design of machinery?

Risk assessment is a procedure in which the degree of risk is evaluated to exclude risk of a machine and ensure safety when you design or redesign the machine. It is an important method which is internationally standardized as ISO 12100/ISO 14121.

## What is corporate responsibility?

More and more responsibility for worker injuries is required of a corporation. Therefore, not only is a company subject to criminal, and civil liability, which may require compensation for damages but also its public image will seriously be tainted if neglecting its liability.

# Risk Reduction

Based on the degree of risk which was evaluated through risk assessment, procedures and measures to for risk reduction are defined by ISO 12100.

Our safety products will assist in reducing risk when they are embedded in machinery as safeguards.

## Risk Factors

### Mechanical Risk

- Crushed
- Pinched
- Impaled
- Amputated
- Clashed

### Electrical Risk

- Contact with an energized part
- Defective insulation
- Static electricity

### Thermal Risk

- Fire
- Explosion
- Radiant heat
- Burn injury

### Noise Risk

- Hearing loss
- Tinnitus

- ① Risk reduction by inherently safe design measures
- ② Risk reduction by safeguarding & complimentary protective measures
- ③ Risk reduction by information for use
- ④ Description in user's manual of the machine (Warnings, labels, symbols, etc.)



Safety technology compensates **human errors/machine failures** which cannot be completely prevented through education or training, thereby safety is verified

## Risk Factors

### Vibrational Risk

Serious disabilities of hands, arms, back, and entire body

### Radiation Risk

- Low-frequency wave
- High-frequency wave
- Ultraviolet ray
- Infrared rays
- X-ray

### Material Risk

- Hazardous substances
- Stimulation
- Dust
- Explosion

### Ergonomic Risk


- Unhealthy posture
- Human error

# Safety Comparison between General Switches and Our Non-contact Safety Interlock Door Switches

## General Switches (Ex. Mounting on a door)

When machine door is open: Switch is OFF → Machine is stopped. (Machine cannot be operated.)  
 When machine door is closed: Switch is ON → Machine is running or can be operated.  
 In addition, machine is stopped if machine door is opened during its operation.


① **Safety cannot be ensured in case of unexpected breakdown**




**Contact welding!**

Overcurrent can cause loss of functions

② **Switch can be invalidated**



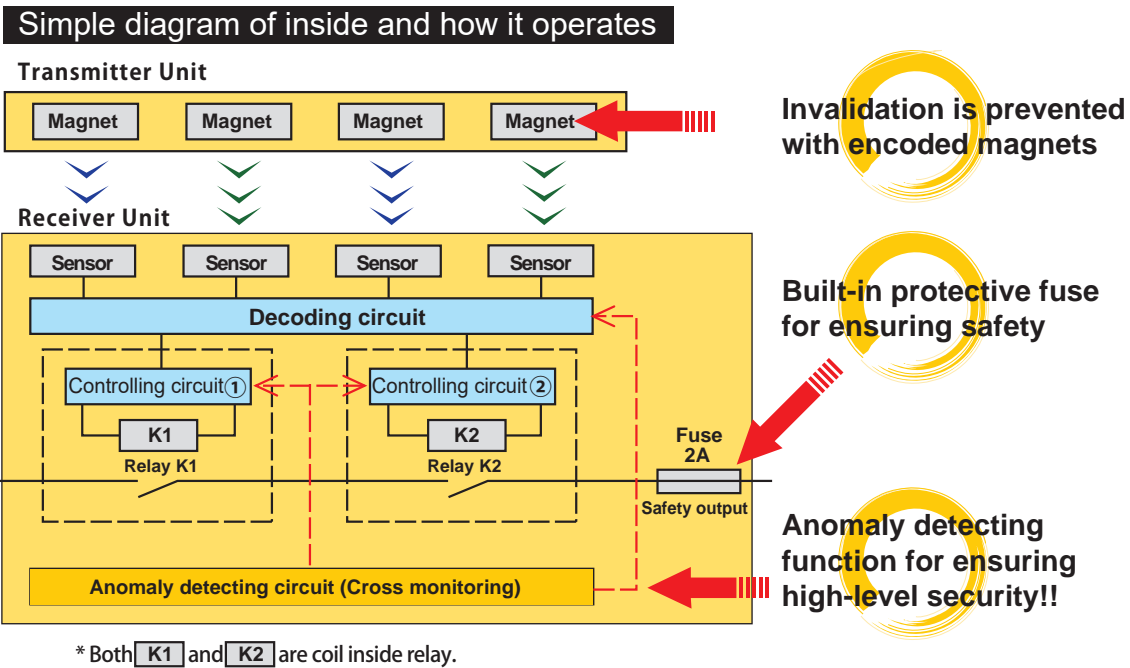
**Intentionally fix actuator**



**Put magnet on detecting unit**

Very dangerous for workers because machine can be activated even when machine door is open.

## Non-contact Safety Interlock Door Switch "SS2 Series"



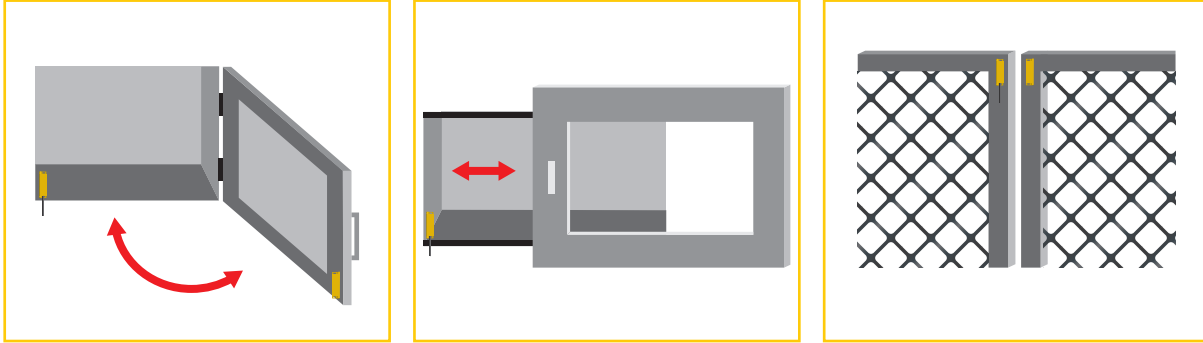
## How Non-contact Safety Interlock Door Switches Work

- ① Magnetic sensors in decoding circuit detect polarities of multiple magnets in transmitter unit.
- ② Relay K1 and K2 make output only when decoding circuit detects a specific combination of polarities.
- ③ Failure detecting circuit monitors controlling circuit ① & ② and decoding circuit to check whether there is any (single) failure in the circuits when a machine door is opened.
- ④ When a failure occurs in either controlling circuit, anomaly detecting circuit communicates the failure to the other controlling circuit, so that any output will not be made to the relay without failure.

\* Anomaly mentioned here means that a relay does not turn OFF due to its internal failure.

**It is designed to ensure safety with certainty by electrical means.**

## Example of Use



## Certifications



## About ISO 13849-1:2015

Conventionally, safety was designed and evaluated based on deterministic point of view, represented by such electrical parts (non-semiconductors) as switches and relays. However, as machinery/devices are getting more complex and software control is prevailing, such a conventional safety assessment method does not match real environment. Thus, safety design and evaluation have been revised as ISO 13849-1:2015 incorporating the concept of IEC 62061.

As a result, in addition to the conventional definition based on architecture, MTTFd (lifetime until dangerous failure at parts level) and DCavg (detection of dangerous failure) have been added, making it possible to evaluate the reliability of safety control system stochastically, therefore, it has become possible to evaluate the safety quantitatively based on actual machine operation.

### Evaluation System

ISO 13849-1:2015 requires to use PL (Performance Level) for evaluation.

### Main determinant factors of PL

#### Category

This is an architecture of safety-related parts in control system. Factors of category are the same to ISO 13849-1:1999, but I (Input device), L (Logic processing), and O (Output device) factors are used to specify basic architecture of each category.

#### MTTFd (Mean time to dangerous failure)

Average value of operation time a one-channel system can be expected to operate without dangerous failure.

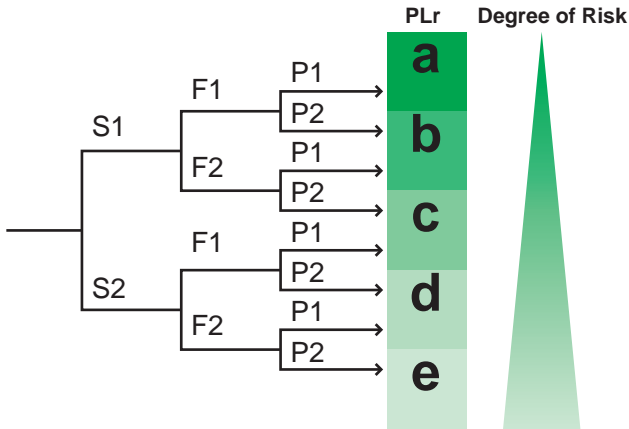
#### DCavg

Average of diagnostic coverage.  
Calculated by the following formula:  
(sum of detectable dangerous failure rates) ÷ (sum of all dangerous rates)

#### CCF (Common cause failure)

Failure where functions of multiple channels are impaired due to one common cause. For PL evaluation, measures & resistance against CCF (simultaneous failures of multiple channels) are scored.

## Determination of required Performance Level (PLr)



### S: Severity of injury

- 1 - Slight
- 2 - Serious (irreversible injuries or death)

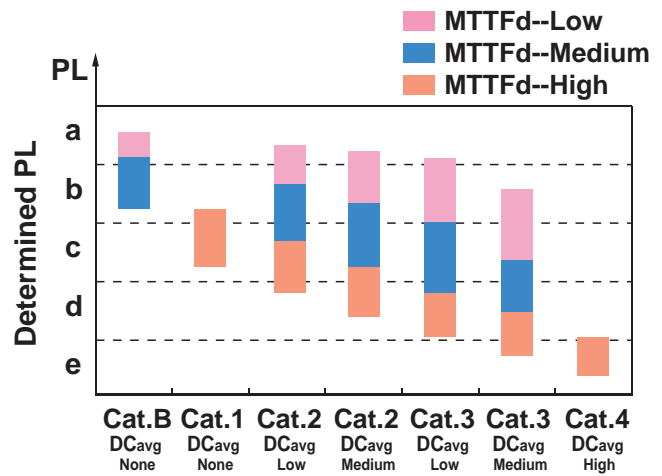
### F: Frequency and/or exposure to hazard

- 1 - Seldom-to-less-often and/or exposure time is short
- 2 - Frequent-to-continuous and/or exposure time is long

### P: Possibility of avoiding hazard or limiting harm

- 1 - Possible under specific conditions
- 2 - Scarcely possible

## Determination of Performance Level (PL)



### Mean time to dangerous failure (MTTFd)

- Low:  $3 \text{ years} \leq \text{MTTFd} < 10 \text{ years}$
- Medium:  $10 \text{ years} \leq \text{MTTFd} < 30 \text{ years}$
- High:  $30 \text{ years} \leq \text{MTTFd} < 100 \text{ years}$

### Average of Diagnostic Coverage (DCavg)

- None:  $\text{DC} < 60\%$
- Low:  $60\% \leq \text{DC} < 90\%$
- Medium:  $90\% \leq \text{DC} < 99\%$
- High:  $99\% \leq \text{DC}$

## Determination of Safety Integrity Level (SIL)

SIL is the quantification of a system's safety performance according to IEC 61508. When SIL is defined based on PFH avg (average frequency of a dangerous failure per hour), the maximum SIL that a subsystem can achieve is limited by HFT (Hardware fault tolerance) and SFF (Safe failure fraction) of the architecture.

### IEC 61508-1 :2010 Safety Integrity Level (High demand mode)

SIL	PFH avg
1	$\geq 10^{-6}$ to $< 10^{-5}$
2	$\geq 10^{-7}$ to $< 10^{-6}$
3	$\geq 10^{-8}$ to $< 10^{-7}$
4	$\geq 10^{-9}$ to $< 10^{-8}$

### IEC 61508-2 :2010 Maximum allowable safety integrity level

SFF	HFT		
	0	1	2
$< 60\%$	SIL 1	SIL 2	SIL 3
$60\% - < 90\%$	SIL 2	SIL 3	SIL 4
$90\% - < 99\%$	SIL 3	SIL 4	SIL 4
$\geq 99\%$	SIL 3	SIL 4	SIL 4



Address : 2-37-7 Chuo-cho, Meguro-ku, Tokyo  
152-0001 Japan

Contact : Please visit our company website for contact details  
E-mail : [webtrade@line.co.jp](mailto:webtrade@line.co.jp)  
Web : <https://www.line-seiki.com>

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