Decoding Ranking Systems Related to Industrial Safety

A user's guide to understanding ranking protocols

Introduction

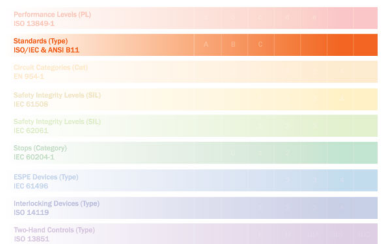
When EH&S personnel and controls engineers collaborate with suppliers to implement protective measures for industrial equipment, the discussion can quickly run astray as various terminologies are used – often with little to no true understanding of what the terms actually mean. For the uninitiated, the jargon can (and often does) appear to be an entirely different language.

As is the case in many specific fields of study, one must first be acquainted with the basic expressions that are often used in order to speak intelligently about a given topic – and industrial safety is no different. In the safety marketplace, safety standards are heavily relied upon to present basic concepts and specific definitions to establish common ground. For better or worse, many of the nomenclatures used in these standards rely on seemingly simple ranking systems, but confusion is introduced because many of the classifications utilize alphabetical or numerical designators, as shown in Figure 1.

Performance Levels (PL) ISO 13849-1	a	b	c	d	e		
Standards (Type) ISO/IEC & ANSI B11	A	B	C				
Circuit Categories (Cat) EN 954-1		B	1	2	3	4	
Safety Integrity Levels (SIL) IEC 61508			1	2	3	4	
Safety Integrity Levels (SIL) IEC 62061			1	2	3		
Stops (Category) IEC 60204-1		0	1	2			
ESPE Devices (Type) IEC 61496				2	3	4	
Interlocking Devices (Type) ISO 14119			1	2	3	4	
Two-Hand Controls (Type) ISO 13851			I	II	IIIA	IIIB	IIIC

Figure 1: Ranking Protocols Used Within the Safety Industry
NOTE: *This image is not intended to imply any equivalency across standards or rating systems*

Brief descriptions of the ranking systems are provided below, in no particular order. These can be used as an aid to translate language that is already understood by industry insiders, but often misapplied by newcomers.



Stratification of Safety Standards [Type-A, -B and -C]

The primary purpose of most safety standards is to provide the audience (readers) with an overall framework and guidance for decisions during the entire lifecycle of machinery to enable them to maintain machines that are safe for their intended use. Many standards developing organizations (SDOs) use the following structure, which is also represented in Figure 1:

- **Type-A standards** (basic safety standards) giving basic concepts, principles for design and general aspects that can be applied to machinery;
- **Type-B standards** (generic safety standards) dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery:
    - **Type-B1 standards** on particular safety aspects (e.g., safety distances, surface temperature, noise);
    - **Type-B2 standards** on safeguarding device (e.g., two-hand controls, interlocking devices, pressure-sensitive devices, guards);
- **Type-C standards** (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

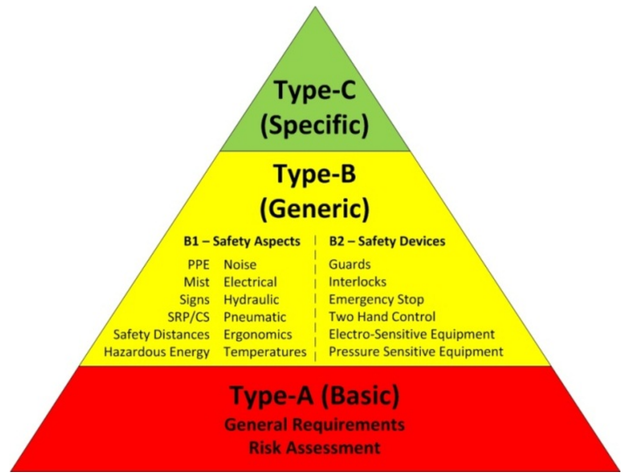


Figure 1: Structural Organization of Standards

This stratification was first developed by ISO/IEC Guide 51[i] and was implemented in Europe during the development of European Norms (EN) standards. These EN documents were then elevated to international (ISO or IEC) standards, and the interrelationships as laid out were maintained. Many standards development organizations around the world follow the direction provided by ISO/IEC Guide 51, which was recently updated in April 2014. The intent of the guide is to establish common terminology and methodologies to standards writers when addressing key concepts of risk reduction. As a practical application of this structure in use in North America, the ANSI B11[ii] series of standards for machine tools has implemented a similar organization as shown in Figure 2.

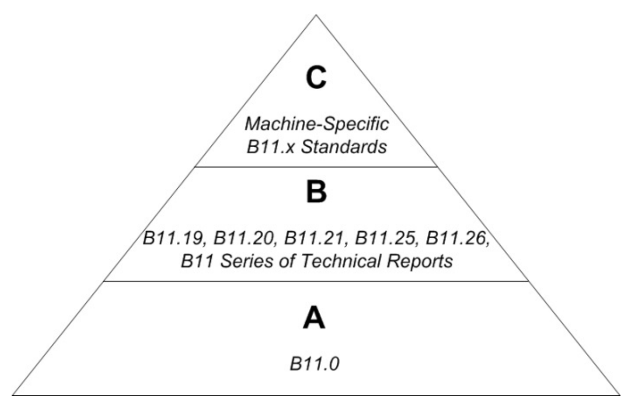
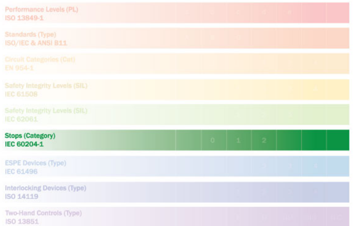


Figure 2: ANSI B11 Organization of Standards



Stop Functions [Category 0, 1 and 2]

When designing and implementing circuits to initiate a stop, there are three classifications of stop functions as follows:

- **Stop category 0:** Stopping by immediate removal of power to the machine actuators (i.e., an uncontrolled stop)
- **Stop category 1:** A controlled stop with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved
- **Stop category 2:** A controlled stop with power left available to the machine actuators

These definitions of stop categories are harmonized in both international[iii] and domestic[iv] standards, and form the basis for the functional requirements when discussing different types of stop circuits. As a general primer to the typical types of stop circuits, the American standard ANSI B11.19[v] provides a clear differentiation between the common purposes for stop circuits as follows:

- **Normal stop:** The stopping of a machine, initiated by the control system, at the completion of a cycle
- **Emergency stop:** The stopping of a machine, manually initiated, for emergency purposes [requirements for emergency stop functions are clearly addressed in NFPA 79, ANSI B11.19, and ISO 13850[vi]]
- **Protective stop:** The stopping of a machine initiated by safeguarding for safeguarding purposes [this was referred to in earlier standards as *safety stop*]

Table 1, on the following page, provides an expanded overview of the differences in requirements for these types of stops.

	Stop	Emergency Stop	Protective (Safety) Stop
Location	Personnel have quick, unobstructed access. Stop Category 0 required on every machine (other categories may be used as determined by a risk assessment). Required on all operator stations.	Personnel have quick, unobstructed access. Required on all operator stations and other locations as determined by a risk assessment.	Located such that an individual cannot access the hazard. Determined by the safety distance formula.
Initiation of stop signal	Manual or automatic	Manual only	Manual or automatic
Stop category *(see above)*	0, 1 or 2	0 or 1 only	0, 1, or 2
Circuit performance	As determined by a documented risk assessment		
	Typically single channel (non-safety-rated)	Minimum single channel safety rated controls. Greater performance may be required when interfaced with a safeguarding device(s).	Typically control reliable
Circuit reset	Manual only	Manual only	Manual or automatic (hardware or software)
Bypass and mute	Allowed (for cycle completion, etc.)	Not allowed	Allowed (for muting, modes of operation, set up, etc.)
Use frequency	Variable; frequent (every cycle) to infrequent	Infrequently; only in emergency	Variable; frequent (every cycle) to infrequent
Effect	De-energize the relevant circuit and override related start functions	Remove all energy sources to hazards and override all other functions and operations in all modes	Remove or control energy sources to the safeguarded hazard and override all other functions and operations in all modes associated with the safeguarded hazard
Final removal of power	Electromechanical or solid-state components	Electromechanical components or solid state output devices (drives) designed for safety related functions	Electromechanical or solid-state components

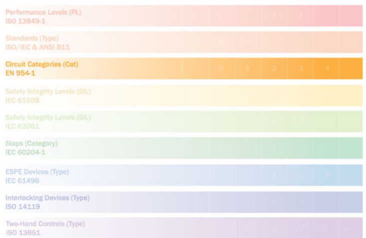
Table 1: Comparison of Stop, Emergency Stop and Protective Stop Requirements

Circuit Performance and Reliability Requirements

Certain parts of machinery control systems are frequently assigned safety functions, and these parts are referred to as the safety-related parts of the control system (SRP/CS). These parts can be separate or integrated parts of the control system, consist of both hardware and software, and are intended to provide the safety functions of control systems.

Safety functions define how risks are reduced by engineering controls, and must be defined for each hazard that has not been eliminated through design measures. At its core, a "safety function" is any element of the protective system whose failure leads to an immediate increase of risk.

In order to accurately design, implement and validate safety functions to achieve the required level of risk reduction, it is necessary to provide a precise description of each safety function. The type and number of components required for the function are derived from the definition of the safety function. Many different safety functions are possible, and some applications may require more than one function in order to adequately reduce risk. Likewise, it is also possible for a single protective measure (safeguarding component) to play a part in more than one safety function simultaneously. Further discussion of safety functions is provided in a previous White Paper, *Functional Safety for Machine Controls*.



Circuit Architecture [Category B, 1, 2, 3 and 4]

The first predominant standard developed and used in Europe to functionally describe circuit design requirements was EN 954-1[vii]. This document classified 5 categories (B, 1, 2, 3 and 4) of performance for SRP/CS with respect to the occurrence of faults. The categories can be applied to:

- control systems of all kinds of machinery, from simple (such as small kitchen appliances) to complex manufacturing installations (such as packaging machinery, printing machines, or presses);
- control systems of protective equipment (such as two-hand control devices, interlocking devices, electro-sensitive protective devices and pressure sensitive protective devices).

According to EN 954-1, the design of SRP/CS and the selection of categories was based on a risk assessment methodology, as shown in Figure 3.

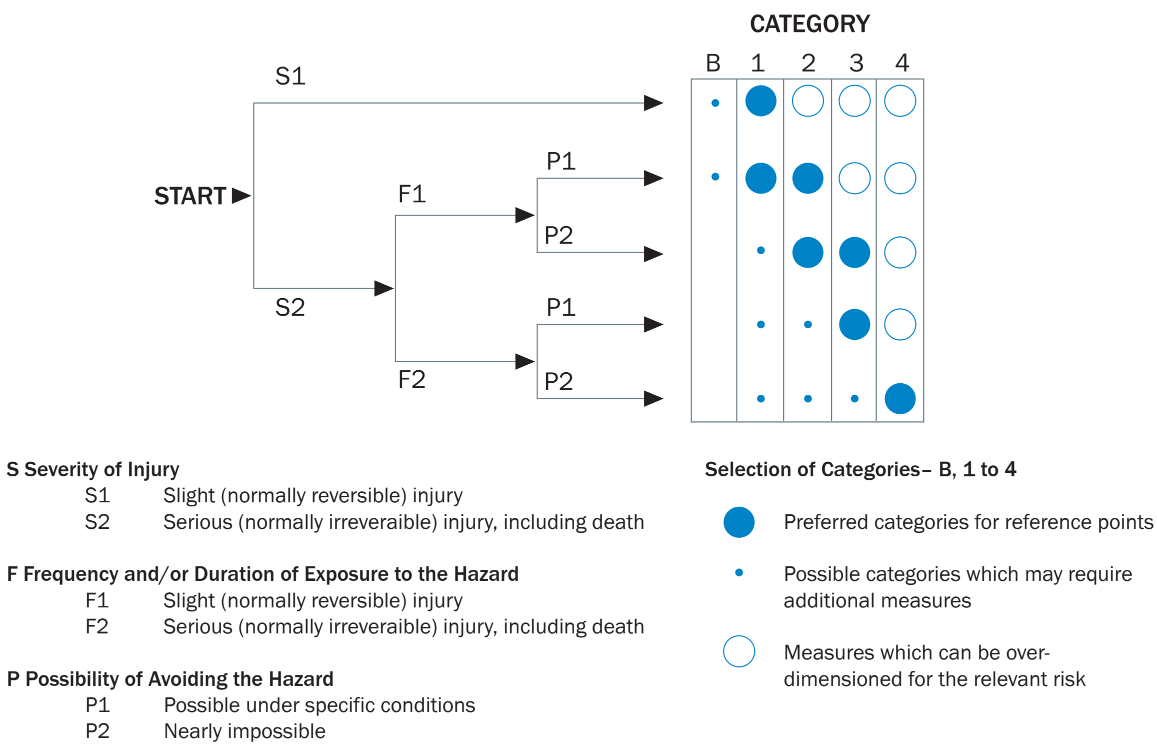
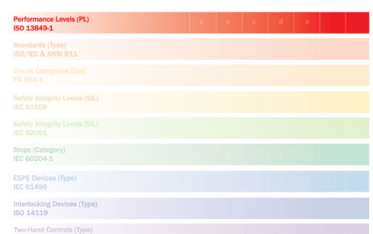


Figure 3: EN 954-1 Selection of Categories for SRP/CS

The categories presented in EN 954-1are summarized in Table 2 below. These definitions provided a clear basis upon which the design and performance of any SRP/CS could be assessed. This document was subsequently elevated to the status of an international standard[viii] with no changes to the requirements.

Category	Brief Summary of Requirements	System Behavior	Principles for Achieving Safety
B	The safety-related parts of control systems and/or their protective devices, as well as their components, must be designed, built, selected, assembled, and combined in compliance with applicable standards so that they are able to tolerate anticipated influencing factors.	• The occurrence of a fault can result in the loss of the safety function.	Primarily characterized by component selection
1	The requirements of category B shall be met. Proven components and proven safety principles shall be used.	• The occurrence of a fault can result in the loss of the safety function, but the probability of occurrence is lower than in category B.	
2	The requirements of category B shall be met and proven safety principles used. The safety function must be checked by the machine controller at appropriate intervals (test rate 100 times higher than requirement rate).	• The occurrence of a fault can result in the loss of the safety function between checks. • The loss of the safety function is detected by the check.	Predominantly characterized by the structure
3	The requirements of category B shall be met and proven safety principles used. Safety-related parts shall be designed such that: • A single fault in any of these parts will not lead to the loss of the safety function • Wherever it is reasonably possible, the single fault is detected.	• When the single fault occurs, the safety function is always retained. • Some, but not all faults are detected. • Accumulation of undetected faults may lead to loss of the safety function.	
4	The requirements of category B shall be met and proven safety principles used. Safety-related parts shall be designed such that: • A single fault in any of these parts will not lead to the loss of the safety function and • The single fault is detected on or before the next request for the safety function. If this is not possible, an accumulation of faults will not lead to the loss of the safety function.	• The safety function is always retained when faults occur. • The faults are detected in a timely manner to prevent the loss of the safety function.	

Table 2: Categories of Safety-Related Parts of Control Systems (SRP/CS)



Performance Levels [PL a, b, c, d and e]

Building on the guidance initially provided by EN 954-1 (and the later ISO 13849-1 in 1999), the concept of safety performance was explored on an even deeper level with the release of a revised document in 2006[ix]. While the architecture of the circuit design has a direct effect on the overall performance of an SRP/CS, it was subsequently acknowledged that other factors play an equally important role. The updated (and still current) ISO 13849-1 document was revised to focus on a higher order concept of control system performance and integrity, known as Performance Level.

Contrary to what some people may believe, the defined Categories first established in EN 954-1 did not get replaced or supplanted by Performance Levels. Instead, Performance Level (PL) recognizes that additional factors must be accounted for to determine the overall performance of a circuit. As shown in Figure 4 below, these factors are:

1. **Structure and behavior of the safety function under fault conditions (category)**
   This is the same circuit architecture concerns addressed previously in EN 954-1, utilizing the same category ratings (B, 1, 2, 3 and 4) described above.

2. **Reliability of individual components defined by mean time to a dangerous failure (MTTFd) values**
   This value represents a theoretical parameter expressing the probability of a dangerous failure of a component (not the entire subsystem) within the service life of that component.

3. **Diagnostic coverage (DC)**
   The level of safety can be increased if fault detection is implemented in the subsystem. The diagnostic coverage (DC) is a measure of capability to detect dangerous faults.

4. **Common cause failure (CCF)**
   External influencing factors (e.g., voltage level, over temperature) can render identical components unusable regardless of how rarely they fail or how well they are tested. These common cause failures must always be prevented.

5. **Process**
   The process for the correct implementation of safety-relevant topics is a management task and includes appropriate quality management, including thorough testing and counter checking, as well as version and change history documentation.

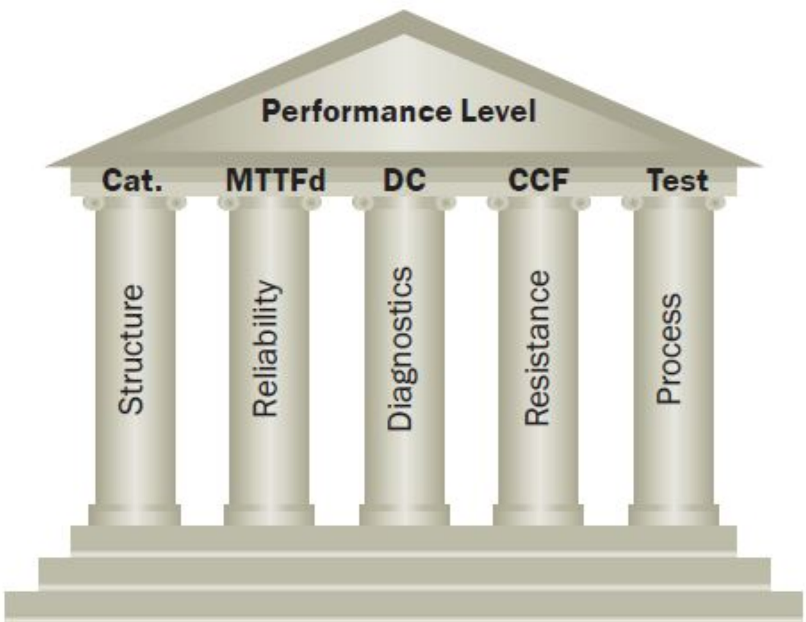


Figure 4: Performance Level (PL) Considerations

As was the case in EN 954-1, the required Performance Level (PL_r) of the SRP/CS must be based upon an evaluation of the inherent risk associated with the hazard, as shown in Figure 5.

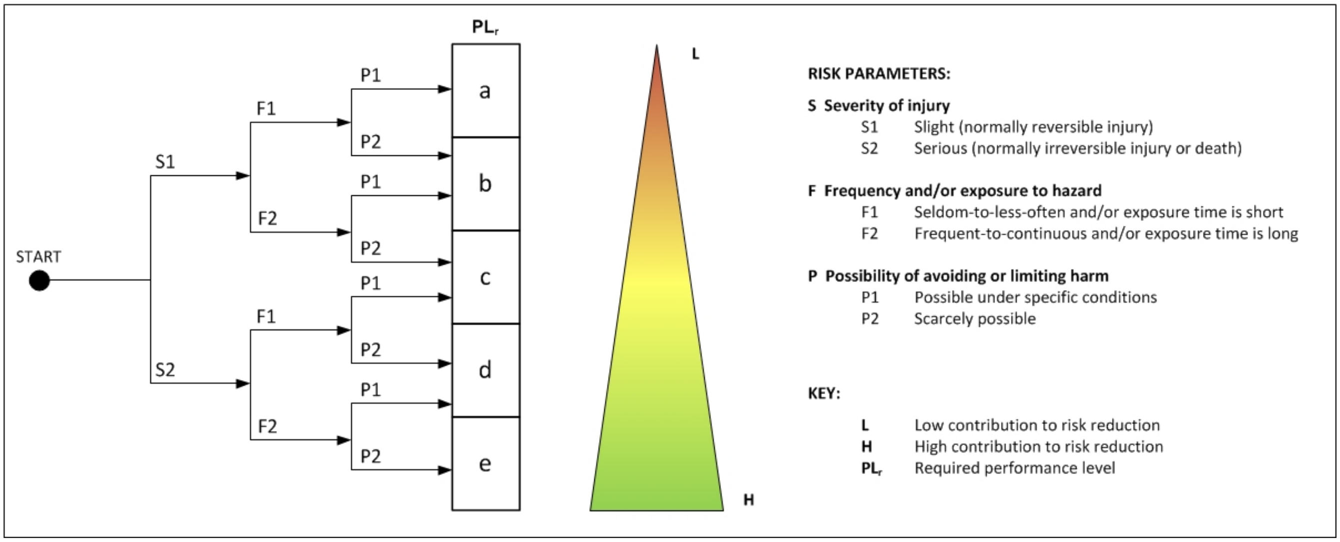


Figure 5: Risk Graph for Determining Required Performance Level (PL_r) for Safety Functions

Based on the assessment of risk, the PL_r determined can be achieved through a variety of combinations of circuit architecture (utilizing Categories), diagnostic coverage (DC), and reliability of components (based on Mean Time to Dangerous Failure, $MTTF_d$), as long as Common Cause Failures (CCF) and the overall process are accounted for. This concept is visually represented in Figure 6.

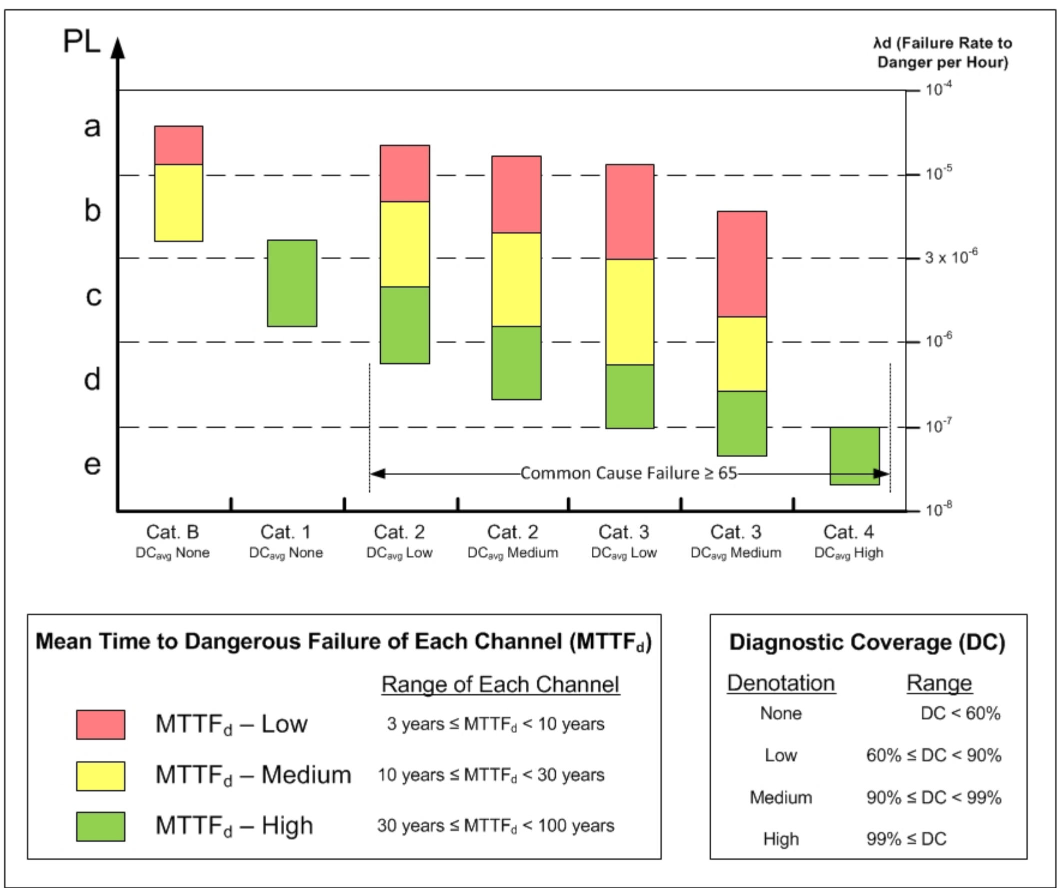
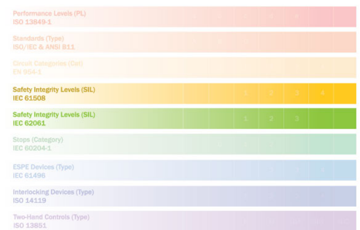


Figure 6: Determination of the Performance Level (PL) of a Subsystem

In North America, a new standard is currently in development to further address this topic. This standard, ANSI B11.26[x], builds upon the concepts of Performance Levels and provides detailed explanation and examples of Categories applied to real world scenarios. It is expected to be published by early 2015 and is intended to improve the understanding of electrical, pneumatic and hydraulic control circuits used in safety-related functions.



Safety Integrity Levels [SIL 1, 2, 3 and 4]

A similar approach to determining system performance and reliability uses terminology known as Safety Integrity Levels (SILs). The SIL concept is very similar to the PL approach in that it looks at many aspects of system design rather than simply concentrating on the architecture of the individual components.

When safety systems are comprised of electrical, electronic, and/or programmable electronic (E/E/PE) elements to perform safety functions, the applicable international standard is IEC 61508-1[xi]. The approach of this standard applies a rational and consistent technical development protocol for all electrically-based safety-related systems.

The essential objective is to ensure that control elements with safety-related functions will perform to a degree of reliability equivalent to the level of risk for the application. Table 3 identifies the average probability of a dangerous failure (PFD_{avg}) that is required to achieve each specified SIL level, depending on the level of demand placed on the elements.

Safety Integrity Level (SIL)	**Average probability of a dangerous failure on demand of the safety function (PFD_{avg})**	
	High Demand or Continuous Operation	**Low Demand**
4	$\geq 10^{-9}$ to $< 10^{-8}$	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-8}$ to $< 10^{-7}$	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-7}$ to $< 10^{-6}$	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-6}$ to $< 10^{-5}$	$\geq 10^{-2}$ to $< 10^{-1}$

Table 3: IEC 61508 Safety Integrity Levels (SILs) – Target Failure Measures for a Safety Function

Another standard that utilizes the SIL rating scale is IEC 62061[xii]. As a result of automation and the associated demand for increased production and reduced operator physical effort, this standard was developed to address Safety-Related Electrical Control Systems (SRECS) of machines. Since SRECS play an increasing role in the achievement of overall machine safety, they also increasingly employ complex electronic technology. Prior to the development of such standards, there had been a reluctance to accept SRECS in safety-related functions for significant machine hazards because of uncertainty regarding the performance of such technology.

In conjunction with IEC 61508, this standard was developed specifically for the machine sector and is intended to facilitate the performance specifications of the SRECS in relation to the significant hazards of machines. Similar to IEC 61508, this standard also relates the performance reliability of safety-related control functions (SRCF) to the probability of a dangerous failure per hour (PFH_D). As shown in Table 4, the performance requirements of Safety Integrity Levels 1 through 3 are identical to the IEC 61508 expectation for systems used in continuous operation or with high mode of demand. However, SIL 4 is not considered in IEC 62061 because it is not relevant to the risk reduction requirements normally associated with machinery, but rather those risks associated with the process industry (such as chemical, oil and gas, etc.).

Safety Integrity Level (SIL)	Probability of a dangerous Failure per Hour (PFH_D)
3	$\geq 10^{-8}$ to $< 10^{-7}$
2	$\geq 10^{-7}$ to $< 10^{-6}$
1	$\geq 10^{-6}$ to $< 10^{-5}$

Table 4: IEC 62061 Safety Integrity Levels (SILs) –
Target Failure Values for Safety-Related Control Functions (SRCFs)

In relation to industrial machine safety, the two primary methodologies to determine the likelihood of a dangerous failure are Performance Levels in accordance ISO 13849-1 and Safety Integrity Levels as addressed in IEC 62061. Generally speaking, design engineers apply the SIL process to applications with complicated electrical and electronic control systems, such as in process industries (e.g., oil and gas, chemical, aerospace, etc.). However, the PL process is more common in the industrial machine market which utilizes both electronic and electromechanical components. Figure 6 illustrates these methodologies in terms of probability to a dangerous condition.

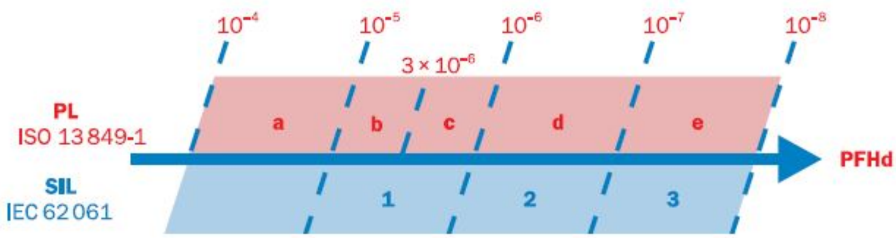
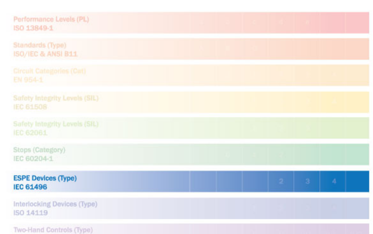


Figure 6: Scale of Functional Safety Levels

Subsystem (Product) Ratings

Additional standards exist to create classifications or tiers of specific product types. This type of standard is known as a product family standard and may be used as a normative reference in a dedicated product standard for the safety of machinery.



Electro-Sensitive Protective Equipment (ESPE) [Type 2, 3 and 4]
One of the most recognized – yet still misunderstood – product classification systems applies to electro-sensitive protective equipment (ESPE), or electro-optical devices. The primary standard for ESPE is IEC 61496-1[xiii] which defines both common and specific requirements for the different component technologies which comprise ESPEs.

This standard also defines the specific performance requirements necessary to achieve a Type qualification. Interestingly, there is no Type 1 designation; only Types 2, 3 and 4. Additionally, there are subsequent parts to this standard which provide specific requirements for each product technology. Table 5 identifies the various ESPE technologies considered, as well as the possible Type achievable for each.

Technology	Abbreviation	Applicable Standards	Possible Type Achievable	Examples
Active Opto-electronic Protective Devices	AOPD	• IEC 61496-1 • IEC 61496-2[xiv]	2 or 4	• Light curtains • Single/multiple beam systems • Close Proximity Point of Operation AOPDs (also known as *laser actuated AOPDs* in Europe)
Active Opto-electronic Protective Devices Responsive to Diffuse Reflection	AOPDDR	• IEC 61496-1 • IEC 61496-3[xv]	3	• Laser (area) scanners
Vision-Based Protective Devices	VBPD	• IEC 61496-1 • IEC 61496-4[xvi]	3	• Camera systems

Table 5: Types of ESPE Addressed by IEC 61496

As Table 5 indicates, Type 2 and Type 4 ratings are reserved for through-beam technologies, which utilize distinct transmitting (sender) and receiving (receiver) elements to constantly monitor an optical signal. Table 6 represents a comparison of the primary differences between these ratings.

	Type 2	Type 4
Functional safety	The protective function may be lost if a fault occurs between test intervals	The protective function is maintained even if multiple faults occur
EMC (electromagnetic compatibility)	Basic requirements	Increased requirements
Maximum aperture angle of the lens	10°	5°
Minimum distance **a** to reflective surfaces at a distance **D** of < 3 m	262 mm	131 mm
Minimum distance **a** to reflective surfaces at a distance **D** of > 3 m	= distance x tan (10°/2)	= distance x tan (5°/2)
Several senders of the same type of construction in one system	No special requirements (beam coding is recommended)	No effect or OSSDs shut down if they are affected

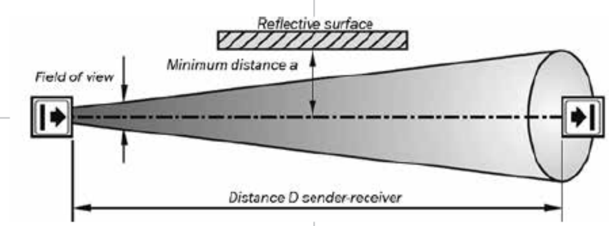


Table 6: Main Differences of Type 2 and Type 4
Active Optoelectronic Protective Devices (AOPDs) according to IEC 61496

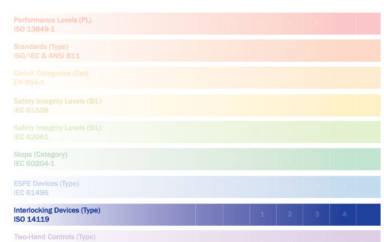
Since ESPEs contain logic components with self-checking and monitoring features performing safety functions, they are also considered sub-systems. In turn, these sub-systems can achieve specific Performance Levels and Safety Integrity Levels, as shown in Table 7.

		Performance Level (PL) per ISO 13849-1					
		a	b	c	d	e	Device Examples
ESPE Type per IEC 61496-1	2						Safety light curtains, single-beam photoelectric safety switches, multiple light beam safety devices
	3						Safety laser scanners, safety camera systems
	4						Safety light curtains, single-beam photoelectric safety switches, multiple light beam safety devices
			1		2	3	
			Safety Integrity Level (SIL) per IEC 62061				

Table 7: Achievable Reliability of Safety Functions with Active Optoelectronic Protective Devices (AOPDs)

It is important to point out a key difference between most North American and European/International standards. Very few application standards in North America require ESPE to be certified by a third-party testing organization to any of the Types defined above, whereas most EN and ISO type-C standards set minimum Type requirements when ESPEs are utilized as part of the risk reduction solution. For instance, when an ESPE is utilized for presence sensing device initiation (PSDI), not only must the minimum object sensitivity be 30 mm, but the device must also be a Type 4 component per IEC 61496. While the regulatory requirements and consensus standards in North America do not stipulate that ESPEs meet a specific rating system (such as the Types defined by IEC 61496), many proactive organizations – both suppliers and end users – have a higher degree of confidence in the overall reliability of their safeguarding systems when such devices are used.

With that said, it is also interesting to point out that Underwriters Laboratory (UL) – one of the leading third-party testing organizations in North America – has developed a series of test standards based strongly on the IEC standards. At this time, they have a standard for general requirements[xvii] as well as another for AOPDs[xviii].



Interlocking Devices [Type 1, 2, 3 and 4]

Another example where a standard identifies a product classification system using 'Types' with numeric rankings is ISO 14119[xix] for interlocking devices. This standard describes the technology and typical characteristics of the defined four types of interlocking devices. The four types of interlocking devices are not presented in a hierarchical order, and other solutions may be adopted as long as they comply with the principles of the standard. The correct application of each type of interlocking device must always be determined by a risk assessment for the specific machine application.

Since interlocking methods involve a broad spectrum of technological aspects, interlocking devices can be classified using many different criteria. This may include grouping according to the nature of the link between the guard and the output system, or by the type of technology (electromechanical, pneumatic, electronic, etc.) associated with the output system. Table 8 shows the actuation principles and actuators for the defined interlocking device types, as well as examples of products available on the market to fill many of the categories.

Designation	Actuation		Actuator		SICK product	
	Principle	Example	Principle	Examples	Example	
Type 1	Mechanical	Physical contact, force, pressure	Not coded	Switching cam	i10P	
				Turning lever	i10R	
				Hinge	i10H	
Type 2			Coded	Shaped actuator (switching rod)	i16S	
				Key	–	
Type 3	Electro-sensitive	Inductive	Not coded	Suitable ferromagnetic materials	IN4000	
		Magnetic		Magnets, electromagnets	MM12 1)	
		Capacitive		All suitable materials	CM18 1)	
		Ultrasonic		All suitable materials	UM12 1)	
		Optical		All suitable materials	WT 12 1)	
Type 4		Magnetic	Coded	Coded magnet	RE11	
		RFID		Coded RFID transponder	TR4 Direct	
		Optical		Coded optical actuator	–	

1) *These sensors are not designed for safety applications. If they are used as interlocking devices, the designer shall give very careful consideration to systematic and common cause failures and take additional measures accordingly.*

Table 8: Overview of Interlocking Devices and Product Examples

As a basic introduction to this technology, interlocking devices are utilized to perform a function of monitoring the position of a guard to sense whether the guard is closed or open. The device is then intended to produce a stop command when the guard is not in the closed position. Additionally, interlocking devices can be used to control other functions (e.g., application of a brake to stop hazardous machine functions before access is permitted).

Furthermore, some interlocking devices also have a guard locking function to keep the guard locked while hazardous machine function is present or simply to prevent interruption of the machine process. The guard locking device is often an integral part of an interlocking device, but it may also be a separate unit. Monitoring the status of the guard locking device determines whether the device is engaged or released and produces an appropriate output signal accordingly. The operating principles and associated terminology for these devices are addressed in Table 9.

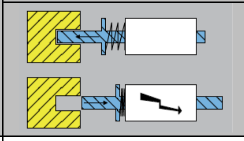
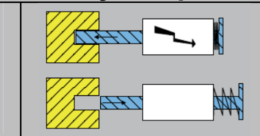
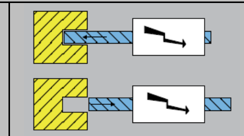
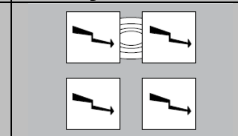
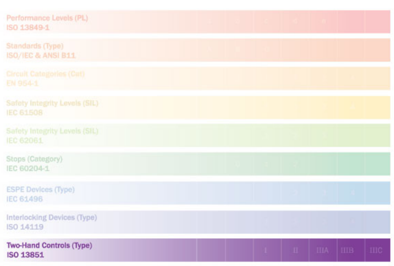
Principle		By Shape			By Force
					
Principle of Operation	**Actuation (locking)**	Spring	Power ON	Power ON	Power ON
	Release (unlocking)	Power ON	Spring	Power ON	Power OFF
Terminology		Mechanical locking device (preferred for safeguarding)	Electrical locking device (preferred for process protection)	Pneumatic / hydraulic locking device	Magnetic locking device

Table 9: Principles of Operation and Terminology for Locking Interlock Devices



<u>Two-Hand Controls [Type I, II, IIIA, IIIB and IIIC]</u>
Two-hand control devices are another example where subcategories are defined using terminology with alpha-numeric 'Types.' As used within the industrial safety market, a two-hand control device is a safety device which provides a measure of protection for the operator. The level of risk reduction is gained by preventing the operator from reaching danger zones during hazardous situations by locating the control actuating devices at a specific position and distance.

The international standard ISO 13851[xx] describes the main characteristics of two-hand control devices used in safety applications and sets out combinations of functional characteristics for three types. Short of a detailed review, Table 10 provides a brief overview of the functional requirements for each device type as defined by the ISO standard.

Requirement	**Type** per ISO 13851 I	II	III A	III B	III C	**North American Requirements** OSHA 29 CFR 1910.217	ANSI B11.19	CSA Z432
Use of both hands (simultaneous actuation)	x	x	x	x	x	x	x	x
Relationship between input and output signal	x	x	x	x	x	x	x	x
Cessation of the output signal	x	x	x	x	x	x	x	x
Prevention of accidental operation	x	x	x	x	x	x	x	x
Prevention of defeat	x	x	x	x	x	x	x	x
Re-initiation of the output signal	a	x	x	x	x	x	x	x
Synchronous actuation			x	x	x	x	x	x
Use of Category 1 circuit architecture	x		x				a	a
Use of Category 3 circuit architecture		x		x		b	a	a
Use of Category 4 circuit architecture					x		a	a

a Dependent on a risk assessment
b OSHA refers to circuit architecture in terms of 'control reliable'

Table 10: Minimum Safety Requirements for Two-Hand Control Devices and Type Classifications

In some applications, enabling devices and hold-to-run devices may comply with the definition of a two-hand control device, but the ISO standard is not intended to apply to these special control devices.

In contrast to the ISO standard, the North American market does not segment the requirements for two-hand control devices into different classifications. Instead, the OSHA regulation[xxi] and the ANSI[xxii] and CSA[xxiii] standards set forth a single group of requirements, as identified in the last column of Table 10.

Commonalities of Product Classifications
As we have seen with the international Type-B standards categorizing product segments, the standards do not specify which machines require specific classifications of devices. They also do not specify which types of device shall be used. Instead, the standards provide requirements and guidance addressing the design and selection (based on a risk assessment) while also establishing performance requirements for design and certification of devices used in safety functions.

Conclusion

As reviewed in the discussion presented above, it should hopefully now be apparent that the various ranking systems used within the industrial safety marketplace are each unique. Some of these ranking systems utilize common terminology (such as 'Category' or 'Type') or similar classification levels (either with alphabetical or numerical identification systems). However, the context of the terminology is the most important element to ensure that all parties understand the intended meaning of the message being communicated.

Based upon this review, a safety professional should hopefully better understand their control engineers when they hear the following:

> "We've designed a functional safety system to exceed the requirements of the Type-C standard. This system is comprised of an emergency stop device used in a Category 0 stop circuit with Category 2 architecture, as well as a separate protective stop circuit with a Category 2 stop function achieving PLd with Category 3 architecture. The protective stop circuit has the following components compliant with the applicable Type-B standards; a Type 4 light curtain rated as PLe and SIL 3, a Type 2 power to unlock guard locking interlock device, and a Type IIIB two-hand control device."

While many EH&S personnel may not be able to review the control schematics in order to confirm the component selection and circuit design, the language used by control engineers should hopefully now have clearer meaning – or at least it should be more understandable. As is the case in any type of communication, misunderstanding is often the root of many disappointments. Conversely, proper use of industry-specific language can only aide in achieving intended goals.

This white paper is meant as a guideline only and is accurate as of the time of publication. When implementing any safety measures, we recommend consulting with a safety professional.

For more information about ranking protocols used within the industrial safety market visit our web site at www.sickusa.com.

References

The following standards were referenced for the content of this white paper.

	Document	Revision	Title
i	ISO/IEC Guide 51	2014	Safety aspects – Guidelines for their inclusion in standards
ii	ANSI B11.0	2010	Safety of Machinery – General Requirements and Risk Assessment
iii	IEC 60204-1	2005	Safety of machinery – Electrical equipment of machines – Part 1: General requirements
iv	NFPA 79	2015	Electrical Standard for Industrial Machinery
v	ANSI B11.19	2010	Performance Criteria for Safeguarding
vi	ISO 13850	2006	Safety of machinery – Emergency stop – Principles for design
vii	EN 954-1	1996	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
viii	ISO 13849-1	1999	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
ix	ISO 13849-1	2006	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
x	ANSI B11.26	2015*	Functional Safety for Equipment (Electrical/Fluid Power Control Systems) – Application of ISO 13849 – General Principles for Design
xi	IEC 61508-1	2010	Functional safety of electrical, electronic, programmable electronic safety-related systems – Part 1: General requirements
xii	IEC 62061	2005	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
xiii	IEC 61496-1	2012	Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests
xiv	IEC 61496-2	2013	Safety of machinery – Electro-sensitive protective equipment – Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)
xv	IEC 61496-3	2008	Safety of machinery – Electro-sensitive protective equipment – Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse reflection (AOPDDR)
xvi	IEC/TR 61496-4	2007	Safety of machinery – Electro-sensitive protective equipment – Part 4: Particular requirements for equipment using vision based protective devices (VBPD)
xvii	UL 61496-1	2002	Standard for Electro-sensitive protective equipment, Part 1: General Requirements and Tests
xviii	UL 61496-2	2002	Standard for Electro-sensitive protective equipment, Part 2: Particular Requirements for Equipment Using Active Opto-Electronic Protective Devices (AOPDs)
xix	ISO 14119	2013	Safety of machinery – Interlocking devices associated with guards – Principles for design and selection
xx	ISO 13851	2002	Safety of machinery – Two-hand control devices – Functional aspects and design principles
xxi	OSHA 1910.217	1971	Mechanical power presses
xxii	ANSI B11.19	2010	Performance Criteria for Safeguarding
xxiii	CSA Z432	2004 (R14)	Safeguarding of machinery

* *Expected publication date; currently in final draft / ballot stage.*

