




Functional safety

Protection of people, environment and plants



Smart in sensing



Alexander Wiegand
Chairman and CEO, WIKA

About us

As a family-run business acting globally, with over 10,200 highly qualified employees, the WIKA group of companies is a worldwide leader in pressure and temperature measurement. The company also sets the standard in the measurement of level, force and flow, and in calibration technology.

Founded in 1946, WIKA is today a strong and reliable partner for all the requirements of industrial measurement technology, thanks to a broad portfolio of high-precision instruments and comprehensive services.

With manufacturing locations around the globe, WIKA ensures flexibility and the highest delivery performance. Every year, over 50 million quality products, both standard solutions and customer-specific solutions, are delivered in batches of 1 to over 10,000 units.

With numerous wholly owned subsidiaries and partners, WIKA competently and reliably supports its customers worldwide. Our experienced engineers and sales experts are your competent and dependable contacts locally.

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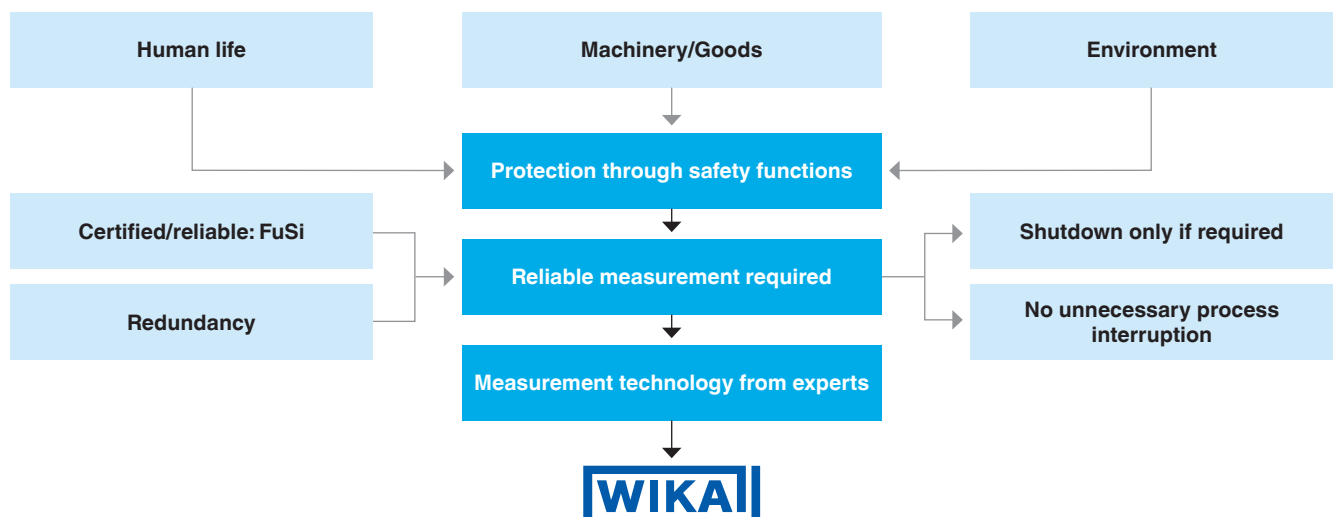
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Functional safety

In logistics, in the energy sector and in industry in general, machinery and plants are used which, for all of their advantages, can cause a great deal of damage. People, the environment and the plants themselves must be protected from these dangers.

This is done by safety systems which, depending on the hazard level, have to work very reliably and securely. Typical safety functions are emergency shutdowns for overpressure or too high temperatures, shutdown for overload or also the monitoring of dangerous movements. Safety systems usually consist of a sensor, a controller and an actuator.

A risk assessment of a plant or machine determines the safety integrity level. Depending on the required safety function, suitable components are selected and combined to form a safety system. The higher the hazard (e.g. danger to human life), the higher the required level of the system.



High on the agenda: Safety

In principle, technical plants and systems should function smoothly and become safer in order to reduce hazards for people, the environment and machinery. The level of safety required in each case is regulated by standards and directives. Therefore the demands on operators are continuously increasing, which is why experts are needed to ensure that sensors initiate shutdown reliably at critical moments – but only then.



Safety systems are also becoming increasingly important and complex since machinery and plants are carrying out more and more and, with higher productivity, the hazards are generally also increasing.

Guidelines and standards have been created to help every plant operator to operate his or her plant to the highest levels of safety. Failure analyses and risk assessments serve as a basis for decision-making. The aim is to reduce the risk presented by a technical system to an acceptable risk by means of safety measures.

The machinery directive 2006/42/EC and the technical standards of individual applications demand the minimisation of risks. Functional safety is a legal obligation in many areas.

The more complex an electronic system is, the more diverse the error possibilities are. For this reason, the IEC 61508 series of standards demands the avoidance of systematic faults during development, monitoring during operation and the safe control and elimination of detected errors.

This brochure gives an overview of functional safety and presents suitable sensors with application examples.

Which standards are relevant?

The machinery directive 2006/42/EC is the most important guideline for functional safety. The most important standards are:

- **DIN EN/IEC 61508:** Functional safety of safety-related electrical/electronic/programmable electronic systems
- **DIN EN/IEC 61511:** Functional safety – Safety instrumented systems for the process industry
- **DIN EN ISO 13849:** Safety of machinery – Safety-related components of control systems
- **DIN EN/IEC 62061:** Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

The last two standards are harmonised, so the presumption of conformity applies here, but not to DIN EN/IEC 61508.



For security: two safety systems



Both the performance level (PL) and the safety integrity level (SIL) define the reliability of safety functions in machinery and plants. Each safety-related component of a control system has its specific PL or SIL, which represents the ability to reduce a risk.

Each safety function has a specific target level that must be maintained in order to reduce the risk of a malfunction. When evaluating safety functions, the combination of all components results in a performance level or safety integrity level, which may differ from the level of the individual components.



Performance level

The DIN EN ISO 13849 standard defines the term 'performance level'. It describes the ability of a control system to perform a safety function.

A required risk minimisation is defined for each individual safety function of a machine. This specifies the value PL r (required). The basis for this value is basically the probability of a dangerous failure per hour.

The performance level of the safety function must be greater than or equal to PL r. The scale ranges from PL a (lowest level) up to PL e. Up to level PL c, manufacturers may make the assessment themselves, for PL d and e the equipment must be tested by an independent third party.



Safety integrity level (SIL)

This value system originates from DIN EN/IEC 61508 and DIN EN/IEC 61511. The safety integrity level is used to assess the reliability of the safety functions of electrical, electronic and/or programmable electronic systems.

Here, too, a SIL r (required) is defined, which the application must comply with, i.e. it must be greater than or equal to it. The scale ranges from safety integrity level 1 as the lowest level to the highest level SIL 4. SIL 1 and 2 can be assessed by the manufacturers themselves. Levels 3 and 4 require an assessment by an independent third party.

Performance level	Probability of a dangerous failure per hour	Safety integrity level*	Probability of a dangerous failure per hour**
PL a	$\geq 10^{-5}$ and $< 10^{-4}$	No equivalent	
PL b	$\geq 3 \times 10^{-6}$ and $< 10^{-5}$	SIL 1	$\geq 10^{-6}$ and $< 10^{-5}$
PL c	$\geq 10^{-6}$ and $< 3 \times 10^{-6}$	SIL 1	$\geq 10^{-6}$ and $< 10^{-5}$
PL d	$\geq 10^{-7}$ and $< 10^{-6}$	SIL 2	$\geq 10^{-7}$ and $< 10^{-6}$
PL e	$\geq 10^{-8}$ and $< 10^{-7}$	SIL 3	$\geq 10^{-8}$ and $< 10^{-7}$
		SIL 4	$\geq 10^{-9}$ and $< 10^{-8}$

* IEC 61508-1, heavy load or continuous operation

** heavy load or continuous operation

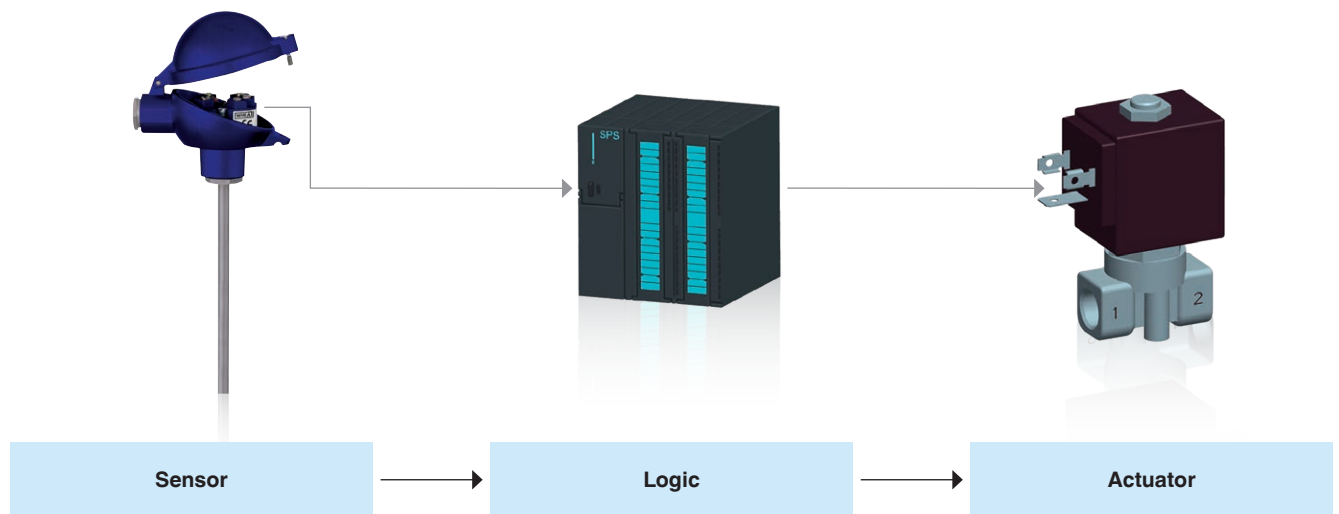
The overall system is the key

The safety integrity level always refers to the entire safety function. An element has no SIL, but may still be suitable for a SIL application. For example, the model T32.xS temperature transmitter on its own does not constitute a safety function. But it does help to implement a corresponding system.

As a manufacturer, we are happy to support you in designing a safety system. On the one hand, we comply with the requirements of the IEC 61508 standard, as, for example, in the development of the T32.xS. On the other hand, we provide you with safety-related characteristic data for the plant design and the evaluation of the safety function.



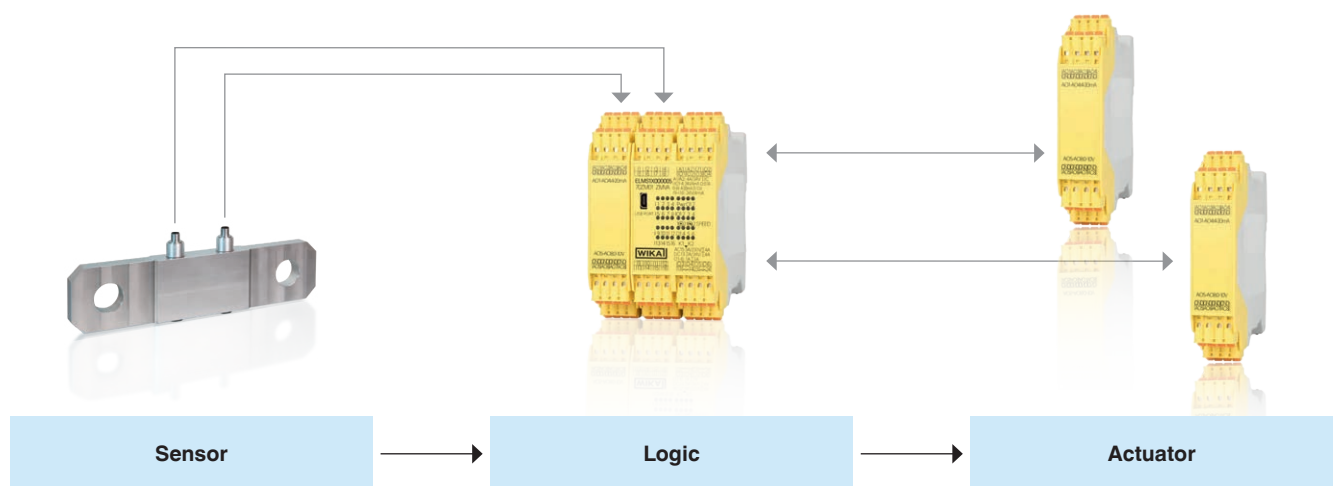
Example of a one-channel architecture for a safety instrumented system



A programmable electronic system basically consists of the elements of sensor, controller and actuator. In this case one refers to a one-channel architecture of the safety system.

The architecture describes the specific configuration of hardware and software elements in a system. The system is based on one channel that must operate safely so that the safety function can be performed.

Example of a two-channel architecture for a safety instrumented system



Depending on the hazard classification, a higher level may be needed in order to operate the machine. This is where the redundant thin-film sensor with integrated temperature sensor shows all its advantages, as two Wheatstone bridges can be realised on one sensor. This means that the signal synchronisation is excellent – better than with all other sensors on the market.

For the higher safety level, two channels are compared with each other at all times. So long as channel 1 and channel 2 both deliver the same result, it can be assumed that the measurement is correct. This leads to a higher availability of the machine, because fewer false alarms are triggered. Furthermore, a stricter monitoring limit is possible, which makes operation safer overall.

A safe harbour thanks to overload safety

There is always a lot going on in a port. Ships arrive, they are unloaded and loaded, ships leave again – 24/7, 365 days a year. All as fast as possible, because time is money. It is all the more important that everything runs smoothly. An important contribution to this is made by the ELMS1 overload protection.



Scenarios that must be prevented

If, when unloading the ship, containers become entangled with other containers and, at the same time, the water level sinks due to the tides, the load of the entire ship hangs on the loading crane. In line with its task, the crane then continues to try to lift the container, which would almost certainly cause it to collapse. For the safety of people, equipment and goods, an overload must not only be detected reliably, but also very quickly.

If the forces exceed certain limit values, the ELMS1 safety electronics shut off and release the rope, until the force falls below the limit value again. This happens, double-safe-guarded and within milliseconds. But the reverse case is also reliably detected. Slack rope detection is also integrated in the ELMS1.

Certified overload protection for crane systems

The machinery directive (2006/42/EC) regulates the requirements of safety control systems for use in practice, such as overload control or emergency shutdown switching. WIKA has developed the first system solution for overload protection in crane systems certified in Germany. As a result, the port operator has the great advantage of not having to request individual components, assemble them and, above all, have them approved, but can obtain everything from one source.



**ELMS1: Certified overload protection
for indoor and harbour cranes.**

ELMS1 secures cranes in a user-friendly way

The ELMS1 overload protection consists of up to eight redundant force transducers, a central control and the associated user software. Everything “made in Germany”. In addition, it offers software-based parameterisation and is certified in accordance with DIN EN ISO 13849 with PL d.

The ELMS1 overload protection eliminates the time-consuming individual certification of the overload cut-off device. Retrofitting is also particularly easy when cranes are not newly built, but rather updated. The existing crane will be equipped with force transducers as well as the ELMS1 and will subsequently fulfil the safety requirements. This makes a customer-specific solution with certification particularly easy.

The world’s only certified “dual hoist twin mode”

The ELMS1 overload protection is the first dual-hoist system approved by TÜV (the central module is certified in accordance with DIN EN 13849-1:2016-06 category 4 PL e). The system can be extended to up to eight axes and then achieves up to PL d. In The system can be extended to up to eight axes and then achieves up to PL d. In the “dual hoist twin mode”, four containers can thus be lifted simultaneously. This makes WIKA the only manufacturer in the world to have a precertified system for the “dual hoist twin mode” for cranes.

Closed due to overfilling

Level sensors and switches ensure safety by preventing the overfilling of tanks. The certified components from WIKA increase plant safety, e.g. during hydrogen recovery or storage and similar critical applications.

LOHC technology stores hydrogen in an oil to make transport and storage simple and safe. This enables existing fuel infrastructure to be used, e.g. underground tanks at refuelling stations for trucks, ships and planes. On the road to decarbonisation, this could be an important building block because hydrogen could be produced ecologically where green energy is produced and then transported efficiently and safely for use.



Filling stations in towns

With LOHC technology, commercial hydrogen filling stations with over 1,000 kg of stored hydrogen are feasible, on-site, in densely populated areas. Combined with the low cost of supply infrastructure, LOHC technology can significantly reduce the cost of delivered hydrogen.

Large quantities for industry

At the same time, hydrogen is one of the most widely used industrial gases worldwide. However, there is a challenge with decentralised hydrogen supply: Transport is expensive, inefficient and associated with safety risks. Storing the hydrogen in an oil that is difficult to ignite solves all this.



Hazardous: Refuelling and storage

It doesn't matter whether the hydrogen is delivered to a filling station in the middle of a town or in large quantities to an industrial company. In both cases, the potential danger is very high. Accordingly, safety has top priority here. That is why many operators rely on the certified level sensors from WIKA.

Level sensors for many areas of application

The most important criterion for selecting the right level measuring instrument is therefore the area of application. Is it sufficient to detect only the limit levels of a tank, e.g. dry running or overfilling, or is a level limit switch necessary? However, if the contents of a tank are to be fully monitored, i.e. the current level between 0 and 100 % is to be measured, level sensors are used. With combined electronics, these can transmit both analogue signals and switching signals.

Pressure on the boiler

The development and manufacture of atmospheric and vacuum furnace systems is a demanding task in terms of safety. High-temperature brazing, annealing, hardening, ageing and sintering give rise to particularly hazardous situations. Many special manufacturers therefore rely on safety pressure switches from WIKA.

In many applications, it is not only vacuum that is needed for the process. High pressure is very often used during heat treatment processes. Therefore, the pressure switch must be able to withstand full vacuum without changing its performance. In addition, the switch must operate under very low pressure (30 mbar and less) and at the same time be able to withstand a pressure of up to 15 bar.



Reliable door interlocking for high-temperature vacuum furnaces

The challenge in this application is to monitor the pressure in the furnace so that it can be reliably controlled, while at the same time preventing a door from being opened while there is still pressure in the furnace. Opening the door under pressure could, in the worst case, result in death, or at least serious injury. Because the potential danger is so high, SIL approval for the switch is required to achieve the safety rating.



Foster safety

Pressure, temperature and level measuring instruments from WIKA are used worldwide in the extraction and processing of oil and gas – both offshore and onshore.

In oil and gas extraction, high working pressures meet aggressive, sometimes explosive, environments. Here, too, certified WIKA pressure switches and other components ensure safety.

Naturally, the hazard potential in high-pressure oil and gas extraction is enormous. Well control panels play an important role here to effectively prevent accidents in high-risk extraction and also in offshore platforms.

Unintentional emissions are also an accident

Likewise, it is important to prevent hydrocarbon emissions into the atmosphere or the environment. Pressure switches are used in control panels to monitor the pressure in the line and in the valve. The pressure switch serves as an alarm in the event of pressure spikes or leakages. In these cases, the switch shuts down the process.

The WIKA switches withstand aggressive environments with high working pressures (system pressure can be up to 1,000 bar). Our customers also rely on our process instrumentation in hazardous areas because the safety systems are so fundamentally important in having the process under control.

The certified ELMS1 overload system



Certified with PL d per DIN EN ISO 13849



ELMS1 safety electronics with PL e

PL d

PL e

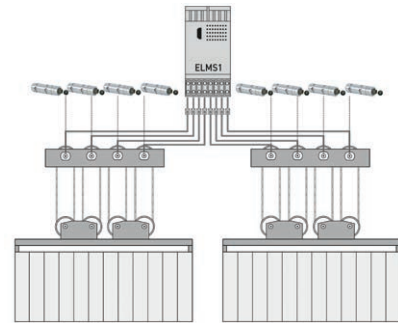
- Modular, extendable, configurable
- Connection to fieldbus (PROFIBUS®, ProfiNet®, EtherCat® and CANopen® etc.)
- Status display for the visualisation of the relevant data



Safety force transducer

PL d

- Load pin
- Tension link
- Tension/compression force transducer
- Bending beam



Safety application

PL d

- Individual load detection of up to 8 redundant force transducers
- Detection of the total load
- Signal normalisation
- Adaptations
- Shutdown on overload (individual and total load)
- Shutdown in the event of application errors

Certified process pressure transmitters



WIKA offers many process transmitters with SIL certification. They feature integrated displays, offer high measurement accuracies and freely scalable measuring ranges, communicate via digital bus signals

and can be delivered with a multitude of case variants. When connected with diaphragm seals, WIKA process transmitters are also suitable for the harshest operating conditions.



IPT-20

SIL 3



IPT-21

SIL 3



CPT20, CPT21

SIL 3



DPT-20

SIL 3

Electrical temperature measurement



Together with a temperature transmitter certified for safety-relevant applications, these electrical thermometers can be used in a safety-related system (IEC 61508 standard). The model T32.xS temperature transmitter has been developed for use in the process industry and certified by TÜV Rheinland for this application (IEC 61508 standard).



Electrical resistance thermometer TR10-C (with built-in TT)

SIL 2



Field temperature transmitter model TIF50, TIF52 (with built-in TT)

SIL 2



Temperature transmitter model T32.xS

SIL 2 (individual instrument)

SIL 3 (redundant circuit)

Certified level sensors



For level monitoring, different measurement principles can be used. The most important factor in the choice of measurement technology is whether continuous measurement or limit level detection is required.

- Bypass magnetic switch BGU (SIL 1)
- Bypass level transmitter BLM (SIL 2)
- Magnetostrictive level transmitter FLM (SIL 2)
- Float switch FLS (SIL 1)
- Horizontal float switch HLS (SIL 1)



Certified mechanical pressure and temperature switches



WIKA has a wide portfolio of SIL-certified switches: gauge pressure switches, differential pressure switches, absolute pressure switches and temperature switches, all SIL-certified in accordance with IEC 61508:2010 and DIN EN ISO 13849.

- Pressure and temperature monitoring and control of processes: direct switching of the electrical load
- Safety-critical applications in general process instrumentation – alarm applications
- Stand-alone applications without connection to a DCS, rather only to a PLC or relay
- Guaranteed function, even in the maintenance mode of the PLC



**Gauge pressure switch
MW**

SIL 3



**Differential pressure
switch DA**

SIL 3



**Absolute pressure switch
APW**

SIL 3



**Temperature switch
TAG**

SIL 3



**If you can't find the right product, ask our specialists!
We offer customer-specific and integrated solutions.**

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