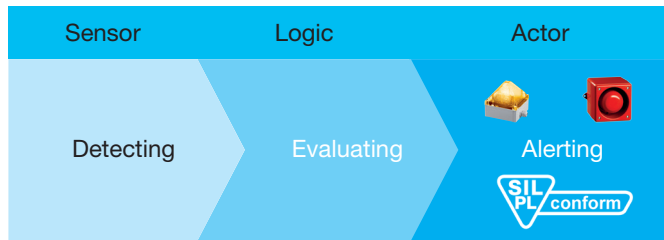


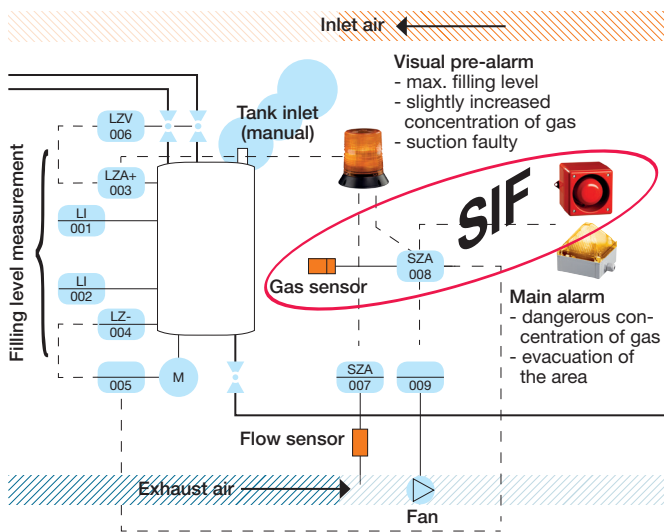
Functional safety

IEC 61508 / IEC 61511 (SIL)

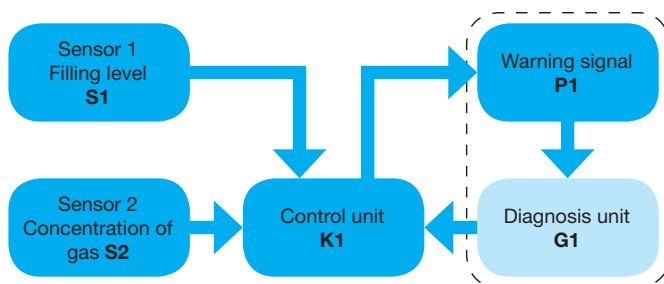
Safety Instrumented System SIS (Safety Loop)



Process safety e.g. gas alarm



Safety block diagram filling level / gas

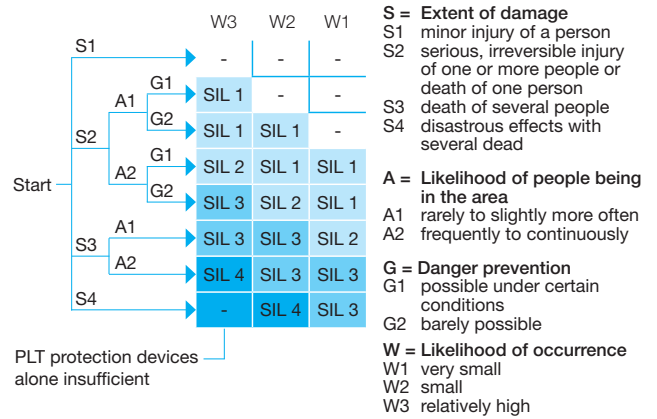


S1 – Sensor 1 (filling level in the tank)
 S2 – Sensor 1 (concentration of gas in plant room)
 K1 – Control unit
 P1 – Visual and audible warning signal
 G1 – Diagnosis unit for signaling devices

Safety integrity (type B) according to IEC 61508 SIL/PL (ISO 13849)					
	HFT				
SFF	0	1	2	SIL	PL
< 60%	–	SIL 1	SIL 2	1	b, c
60% up to < 90%	SIL 1	SIL 2	SIL 3	2	d
90% up to < 99%	SIL 2	SIL 3	SIL 4	3	e
99% up to > 99%	SIL 3	SIL 4	SIL 4	4	–

Requirement according to IEC 61508, type B (partially unknown failure conduct)
 Compare SIL/PL (IEC 61508 / DIN EN ISO 13849)

Hazard graph according to IEC 61508



Evaluation of the safety function

Required safety related parameters				
IEC 61508		Device type		
PFH/PFD SIL T1	–	Units with internal diagnosis		safety control safety switch gears
MTTF _d λ _d λ _s	DC, CCF, subsystem type	Units without internal diagnosis	Without components that are subject to wear and tear	sensors, signaling devices
B10 _d λ _d λ _s	DC, CCF, subsystem type, n _{op}		With components that are subject to wear and tear	emergency shut-down, relay, switch

CCF: failure due to common cause
 DC: Diagnostic coverage

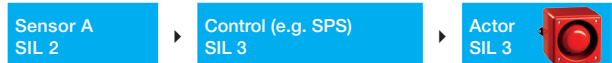
Calculation of an SIS with a SIL 2-actor

Given values:

PFD Sensor A	$1.5 \cdot 10^{-3}$	(suitable for SIL 2)
PFD Control	$1.3 \cdot 10^{-4}$	(suitable for SIL 3)
PFD Actor	$1.1 \cdot 10^{-3}$	(suitable for SIL 2)

Example for a 1001 Actor

(1 unit required for the functioning of 1 available unit)



$$\begin{aligned}
 PFD_{Sys} &= PFD_S + PFD_L + PFD_A \\
 PFD_{Sys} &= 1.5 \cdot 10^{-3} + 1.3 \cdot 10^{-4} + 1.1 \cdot 10^{-3} \\
 PFD_{Sys} &= 2.73 \cdot 10^{-3} \text{ (SIL 2)}
 \end{aligned}$$

By using this component, the SIS reaches the PFD for SIL 2.

Failure probability

SIL	Operating mode with low requirement rate – PFD (average failure probability of the function in case of demand)	Operating mode with continual requirement rate – PFH (probability of a failure that brings dangerous risk per hour)	PL
SIL 4	$\geq 10^{-5}$ up to $< 10^{-4}$	$\geq 10^{-9}$ up to $< 10^{-8}$	–
SIL 3	$\geq 10^{-4}$ up to $< 10^{-3}$	$\geq 10^{-8}$ up to $< 10^{-7}$	e
SIL 2	$\geq 10^{-3}$ up to $< 10^{-2}$	$\geq 10^{-7}$ up to $< 10^{-6}$	d
SIL 1	$\geq 10^{-2}$ up to $< 10^{-1}$	$\geq 10^{-6}$ up to 3×10^{-6}	c
		$\geq 3 \times 10^{-6}$ up to $< 10^{-5}$	b

