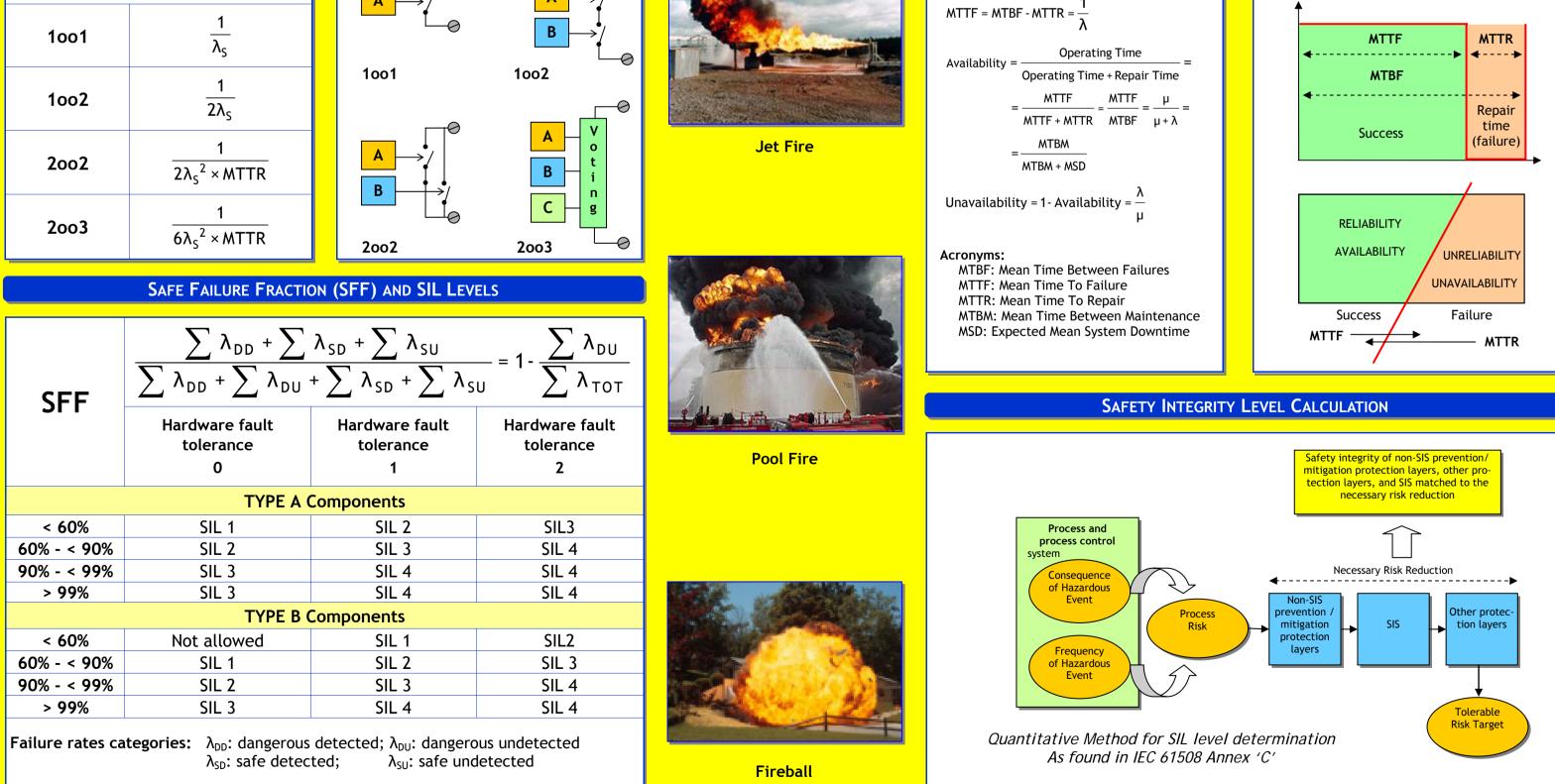
IEC 61508

UNDERSTANDING SAFETY INTEGRITY LEVELS



SIL LEVELS ACCORDING IEC 61508 / IEC 61511				TOLERABLE RISKS AND ALARP (ANNEX 'B')		
IL Safety Integrity Level	PFDavg Average probability of failure on demand per year (low demand)	RRF Risk Reduction Factor	PFDavg Average probability of failure on demand per hour (high demand)	SAFETY: FREEDOM FROM	Untolerable Region	Risk cannot be justified except in extraordinary circumstances
SIL 4		100000 to 10000	≥ 10 ⁻⁹ to < 10 ⁻⁸	UNACCEPTABLE RISK	The ALARP or	Tolerable only if further risk reduction is impracticable or if its cost are
SIL 3 SIL 2	$\ge 10^{-4} \text{ to } < 10^{-3}$ $\ge 10^{-3} \text{ to } < 10^{-2}$	10000 to 1000 1000 to 100	≥ 10^{-8} to < 10^{-7} ≥ 10^{-7} to < 10^{-6}		tolerability Region Risk is undertaken only if	grossly disproportional to the gained improvement. As the risk is reduced, the less proportionately, it is necessary to
SIL 1	≥ 10 ⁻² to < 10 ⁻¹	100 to 10	≥ 10 ⁻⁶ to < 10 ⁻⁵		a benefit is desired	spend to reduce it further, to satisfy ALARP. The concept of diminishing
A	VERAGE PROBABILITY OF FAILUR	RE ON DEMAND (P	FDAVG)			proportion is shown by the trian-
PFDavg	$\frac{\text{Tolerable accident frequency}}{\text{Frequency of accidents without protections}} = \frac{1}{\text{RRF}}$				Broadly Acceptable Region No need for detailed working	It is necessary to maintain assurance that risk remains at this level
	Simplified equations Without common causes With common causes (Beta factor)		to demonstrate ALARP		RISK IS NEGLIGIBLE	
	TI		causes (beta factor)	Contraction of the second		
1001	$\lambda_{DU} \times \frac{11}{2}$	$\lambda_{DU} \times \frac{TI}{2}$.				
1oo2 1oo2D	$\lambda_{DU_1} imes \lambda_{DU_2} imes rac{Tl^2}{3}$	$\frac{\left[(1-B) \times (\lambda_{DU} \times 3\right]}{3}$	$\frac{TI)^{2}}{2} + \frac{\left(B \times \lambda_{DU} \times TI\right)}{2}$	Vapor cloud explosion (BLEVE)	Residual Risk Tolerable Risk	EUC Risk
1003	$\lambda_{DU_1} imes \lambda_{DU_2} imes \lambda_{DU_3} imes rac{TI^3}{4}$	$\frac{\left[(1-B)\times(\lambda_{DU}\times\right.}{4}$	$\frac{TI)^{3}}{2} + \frac{\left(B \times \lambda_{DU} \times TI\right)}{2}$			Necessary risk reduction Actual risk reduction
2002	$\left(\lambda_{DU_{1}} + \lambda_{DU_{2}}\right) \times \frac{TI}{2}$		$[TI] + \frac{(B \times \lambda_{DU} \times TI)}{2}$		Partial risk covered by other technology safety-related systems Partial risk covered by E/E/PE safety-related system Partial risk covered by external risk reduction facilities	
2003	$ \begin{bmatrix} \left(\lambda_{DU_1} \times \lambda_{DU_2}\right) + \left(\lambda_{DU_1} \times \lambda_{DU_3}\right) \\ + \left(\lambda_{DU_2} \times \lambda_{DU_3}\right) \end{bmatrix} \times \frac{TI^2}{3} $	$\left[(1-B) \times (\lambda_{DU_1} \times \lambda_{DU_3}) \right] \times \frac{TI^2}{3} \qquad \left[(1-B) \times (\lambda_{DU} \times TI) \right]^2 + \frac{(B \times \lambda_{DU} \times TI)}{2}$			Risk reduction obtained by all safety-related systems and external risk reduction systems AVAILABILITY AND RELIABILITY	
1oo1 (E _t ≠ 100%)	$\lambda_{DU} \left[\left(Et \times \frac{TI}{2} \right) + (1 - Et) \frac{SL}{2} \right]$	TI: Proof Test t Et: Test Effecti λ _{DU} : dangerous		Flash Fire	Failure Rate :	Reliability
MEAN TIME TO FAILURE SPURIOUS SYSTEM ARCHITECTURES				$\lambda = \frac{\text{Failures per unit time}}{\text{Components exposed to functional fails}}$		
MTTFs					1 FIT = 1 × 10 ⁻⁹ Failures per hour MTBF = MTTF + MTTR	Operating time Time





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