

# What is the target failure measure for your SIF?

Blog by Rafal Selega, Senior Functional Safety Consultant, ABB



You may wonder: Which failure measure should I use for my Safety Instrumented Function (SIF)? Is Probability of Dangerous Failure on Demand Average (PFD<sub>avg</sub>) or Probability of Failure per Hour (PFH) more appropriate? Unfortunately, this question is rarely asked. Many process sector engineers use PFD<sub>avg</sub> as a default measure for any process application without any further consideration. As such, here are some facts you may like to consider in contrast to this ‘default’ position.

## Discussion Point # 1:

The formulas for PFD<sub>avg</sub> and PFH calculation given in IEC 61508-6 standard are ‘approximations’. To achieve a meaningful result, we must meet all the assumptions which were used to derive the PFD<sub>avg</sub> /PFH equations. First we need to take a closer look at PFD<sub>avg</sub> where IEC 61508-1 Table 2 states that a target failure measure for low demand mode is the PFD<sub>avg</sub> (see Figure 1)

Table 2 – Safety integrity levels – target failure measures for a safety function operating in low demand mode of operation

Safety integrity level (SIL)	Average probability of a dangerous failure on demand of the safety function (PFD <sub>avg</sub> )
4	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-2}$ to $< 10^{-1}$

Figure 1 IEC 61508-1 Table 2 showing target failure measure for low demand mode is the PFD<sub>avg</sub>

IEC 61508-4 defines low demand mode as “where the safety function is only performed on demand, in order to transfer the EUC into a specified safe state, and where the frequency of demands is no greater than one per year”.

Unfortunately, many engineers make their PFD<sub>avg</sub> vs PFH choice based on Safety Instrumented Function (SIF) demand frequency only and do not consider further conditions for PFD<sub>avg</sub>/PFH formulas provided within IEC 61508-6 Annex B. Clause B.3.1 of this Annex explains that for low demand mode, one of the assumptions for probabilistic calculations is that the expected interval between demands is at least an order of magnitude greater than the proof test interval.

*So are you taking this into consideration in your calculations?*

**Discussion Point # 2:**

IEC 61511-1 edition 2: 2016 advises deeper analysis when selecting a target failure measure. IEC 61511-1 Table 4 specifies that the PFD<sub>avg</sub> measure can be used for a SIF working in ‘demand mode’(see Figure 2).

**Table 4 – Safety integrity requirements: PFD<sub>avg</sub>**

DEMAND MODE OF OPERATION		
Safety integrity level (SIL)	PFD <sub>avg</sub>	Required risk reduction
4	$\geq 10^{-5}$ to $< 10^{-4}$	> 10 000 to $\leq 100\ 000$
3	$\geq 10^{-4}$ to $< 10^{-3}$	> 1 000 to $\leq 10\ 000$
2	$\geq 10^{-3}$ to $< 10^{-2}$	> 100 to $\leq 1\ 000$
1	$\geq 10^{-2}$ to $< 10^{-1}$	> 10 to $\leq 100$

*Figure 2 IEC 61511-1 Table 4 showing the PFD<sub>avg</sub> measure can be used for a SIF working in ‘demand mode’*

Please note that in this standard’s edition, the term ‘demand mode’ stands for both low and high demand SIFs. This yields the conclusion that the 2nd edition sometimes accepts that PFD<sub>avg</sub> might be used for high demand mode SIF’s as well.

So is this change a good approach?

Consider the following example: SIF A is classified as high demand mode with a demand rate of one per 10 months and the proof test interval is 1 month. Can the target failure measure for this example be expressed as PFD<sub>avg</sub>? Yes, when the proof test interval is lesser than the demand rate credit can be taken for proof testing activity. In this example credit can be given to the proof test activity because the SIF A failure is likely to be detected by a proof test and not by a real process demand.

**Table 5 – Safety integrity requirements: average frequency of dangerous failures of the SIF**

CONTINUOUS MODE OR DEMAND MODE OF OPERATION	
Safety integrity level (SIL)	Average frequency of dangerous failures (failures per hour)
4	$\geq 10^{-9}$ to $< 10^{-8}$
3	$\geq 10^{-8}$ to $< 10^{-7}$
2	$\geq 10^{-7}$ to $< 10^{-6}$
1	$\geq 10^{-6}$ to $< 10^{-5}$

*Figure 3 IEC 61511-1 Table 5 seems to provide a wider view on PFH applicability.*

PFH can be used for a SIF working in demand mode or ‘continuous mode’. i.e. low demand, high demand and continuous mode! This means the standard assumes it might be justifiable to use PFH for a SIF, which by definition, is classified as low demand mode. Consider the following example: SIF B is classified as low demand mode with a demand rate of one per year and proof test interval of 2 years. Can the target failure measure for this example be expressed as PFD<sub>avg</sub>? No, since the proof test interval is greater

than the demand rate, credit cannot be taken for proof testing activity. The credit cannot be given to the proof test because the SIF failure is likely to be revealed by a real process demand rather than by the proof test. Therefore, PFH may be appropriate.

### **Discussion Point # 3**

For any SIF mode both  $PFD_{avg}$  and PFH can be calculated. From probability math, there is no barrier to use PFH for low demand mode. The question we should ask ourselves is: *Is the calculated measure relevant from a safety point of view?* In fact, a better safety indicator for industry incidents would be the 'average dangerous event frequency' which for low demand can be calculated as  $PFD_{avg} \times$  demand frequency. For high demand, a complex formula shall be used; and for continuous mode, average dangerous event frequency equals to PFH. Unfortunately, the IEC 61508 approach is different. ISO/TR 12489 addresses reliability modelling and calculation of safety systems much better than IEC 61508 and may therefore constitute a more focused source of information.

In concluding the above, we should remember that PFD and PFH equations as derived in IEC 61508 are 'approximation formulas' and their use must be justified for each SIF to achieve a meaningful safety indicator. The selection process between  $PFD_{avg}$  and PFH for a specific SIF shall include consideration if a credit for the proof test or diagnostic can be given to a certain SIF and if all assumptions for calculation validity are fulfilled.

So please ask yourself, 'What is the basis for  $PFD_{avg}$  PFH selection in your project?' Do you consider all the conditions from IEC 61508-6 Annex B, or are you using one of the non-approximated methods for calculation of your target failure measure?

For further information please email me at [Rafal Selega](mailto:Rafal.Selega) or see [Functional Safety Lifecycle services](#)