Multiple Safety Systems Operating at High Demand Rates

Luiz Fernando Oliveira and Luciana Chame (DNV GL)

There are many practical situations in the realization of risk analyses (in a LOPA, for instance) when the risk analyst must evaluate the frequency of hazardous events for process configurations comprising the action of multiple safety systems (mostly two but sometimes more) which are subject to high demand rates. Two of the most common situations are those found in 1) tanker truck filling stations and 2) liquid tank filling in a tank farm. In the first case, the order of filling operations may easily reach several a day and in the second that of several a week. As per IEC 61508, any safety system subject to more than one demand per year should be considered as running under the high demand mode (a questionable orientation, but anyway that is what is in the standard). Both above cited situations are clearly very high demand rates as they happen on the order of hundreds to thousands per year.

We identify four different ways to solve the above problem: 1st) construct a fault tree with three branches: one with the frequency of demands, the second with the evaluation of the PFD of 1st SIS, and the third with the evaluation of the PFD of 2nd SIS. 2nd) Use IEC 61508 high/continuous demand approximated equations and calculate the failure frequency of the combined two safety systems, 3rd) Use IEC 61508 high/continuous demand approximation to evaluate the failure frequency of the 1st SIS and multiply it by the PFD of the 2nd SIS, and 4th) Use a Markov model or a simulation model integrating the demand rate to solve the problem. The first model is commonly found in some risk analyses but it is clearly inappropriate for a high demand situation. The use of the second may be appropriate or not depending on the existence or not of an order of actuation of the two systems as further explained in the paper. The third one is also further explained in this paper and gives very good approximations for most practical situations. The fourth is the most precise one but it may be too complicated to be used in many practical situations. Results of this fourth model are shown for a couple of simplified examples and compared to the results from the other models.

Therefore, in this paper we address the possible solutions of the practical problems illustrated above and some additional ones (flare system of offshore platforms), and the implications of the use of the different methods to the classification of the required SIL for the safety systems. Some practical recommendations are also given on how to deal with the problem in practical risk analysis situations.