Mathematical Modeling and Optimization of Safety Instrumented Systems, and Applications to Toxic Gas Facilities

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This research focuses on modeling and optimization of Safety Instrumented Systems (SIS) in compliance with the standards, including IEC 61508. For free of hazards, SIS are in charge of monitoring the operating conditions of various plants and toxic gas facilities be remaining under safe limits. We propose an optimization approach for SIS design minimizing the structure-dependant life-cycle costs and compare it against the leading works of Machleidt and Litz (2011) and Torres-Echeverria (2009). It provides a systematic procedure to determine the most optimal SIS configuration for the required functional safety. Thus, the approach, the mathematical programming formulation and the corresponding GAMS code determine and generate the optimal SIS architectures for sensor and final element subsystems, the optimal component sets (considering heterogeneous redundancies), and the optimal distribution of probability of failure on demand among the subsystems, by borrowing ideas on constraints from Machleidt and Litz (2011). The resulting SIS design would be later converted to the CAD format, for easier investigation. The proposed optimization approach is applied to practical case studies, including toxic gas storages.