A Quantitative Assessment of the Placement Practices of Gas Detectors in the Process Industries

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Abstract

Several difficulties make the problem of gas detector placement in the process industry challenging. Dispersion scenario source locations, size, and duration are generally unknown. The gas leak development and transport depend on fluid properties and dispersion characteristics, environmental factors, and facility geometry. Finally, assessing the risk of a given dispersion scenario is a complicated task. In particular, explosion consequences need to be assessed. This must include considerations like ignition probabilities, personnel location patterns, human response, and layers of protection. As a result, the risk of a scenario is hard to predict.

A key shortfall of the gas detector placement approaches to date is their inability to handle this rich ensemble of data in a truly quantitative way. The overwhelming amount of information and uncertainties to consider, in conjunction with the huge amount of placement possibilities, present a challenging problem. This difficulty is often circumvented by the usage of simplified qualitative and semi-quantitative approaches. Regulations, standards, and operator-specific practices propose the use of prescriptive approaches supported mostly by qualitative considerations and rules of thumb. Surrogate metrics are used instead of quantitative risk metrics. These approaches are far from optimal.

This paper compares results from methods based on existing practice with modern quantitative numerical optimization techniques in order to answer the following questions: Are current investments in detector systems effective at reducing risk? Which approaches and surrogate metrics are closer to a real optimal answer? What is the risk reduction achieved from obtaining and processing the data via computational means? Common surrogate metrics and simplified approaches are compared against a mathematical programming formulation previously developed by the authors. The formulation (SP-RV) optimally places gas detectors in order to minimize the risk posed by a set of scenarios while considering unavailability and voting. Results were generated using four independent data sets of CFD generated data including the full geometric features of an offshore facility.