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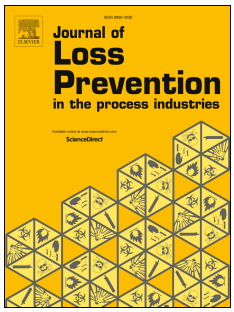

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Optimum Placement of Gas Detectors Considering Voting Strategy with Different Detection Set Points

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Abstract

Voting logic or *k* out of *p* redundancy is widely used in safety systems to meet two key objectives: enhancing reliability and reducing spurious performance. Even so, in designing gas detector systems especially of flammable gas type, it is a common engineering practice to consider at least two different detection levels in addition to normal voting. Under such circumstances, the presence of gas is confirmed if sensed by two detectors at two different concentrations: one at a low level and another one in the same voting network at a high level. Existing formulations for optimal placement of gas detectors do not consider this type of voting. In this study, first the general form of multi-level voting arrangement (mlv) with arbitrary levels of detection is defined. Then, two extended integer linear programming (ILP) formulations are proposed to address mlv in optimal gas detector placement. The first one called MCLPm maximizes coverage, and the second one called SP-Vm seeks to minimize an expected damage parameter such as detection time against a set of pre-defined leak scenarios. In a simple test case, the proposed formulations are examined, verified and compared with the original (non-extended) formulations. The results confirm the necessity and importance of using the extended formulations when *mlv* has been applied as the desired type of voting.

Key Words: Gas Detector, Sensor Placement, Optimization, Voting, F&G Mapping, Process Safety, Redundancy

1. Introduction

Although not as reliable as an independent protection layer, gas detectors whether of toxic or flammable type, could reduce the risk of leak events in process industries by activating mitigative and preventive measures such as alarm system, emergency shutdown (ESD) and ignition source isolation (NORSOK, 2008). It should be noted that, detectors do not directly prevent occurrence of the leaks or specify the required response actions. They are only used to activate safety systems such as the ones mentioned above if a specified concentration of gas or vapor is exceeded (HSE, 2011).