Accepted Manuscript

A risk-based methodology for the optimal placement of hazardous gas detectors

Kang Cen, Ting Yao, Qingsheng Wang, Shengyong Xiong

PII: S1004-9541(17)31108-4
DOI: https://doi.org/10.1016/j.cjche.2017.10.031
Reference: CJCHE 985

To appear in:

Received date: 28 August 2017
Revised date: 29 September 2017
Accepted date: 24 October 2017

Please cite this article as: Kang Cen, Ting Yao, Qingsheng Wang, Shengyong Xiong , A risk-based methodology for the optimal placement of hazardous gas detectors. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Cjche(2017), https://doi.org/10.1016/j.cjche.2017.10.031

Process Systems Engineering and Process Safety

A risk-based methodology for the optimal placement of hazardous gas detectors☆

Kang Cen[1,*], Ting Yao[1], Qingsheng Wang[2,*], Shengyong Xiong[3]

[1] *School of Civil Engineering and Architecture, Southwest Petroleum University, Chengdu 610500, China*

[2] *Department of Fire Protection & Safety and Department of Chemical Engineering, Oklahoma State University, Stillwater, OK 74078, USA*

[3] *Wanzhou Branch Plant of Chongqing General Natural Gas Purification Plant, Southwest Oil & Gasfield Company, PetroChina, Wanzhou, Chongqing 404001, China*

** Corresponding author: cenkangxt@126.com (K. Cen) ; qingsheng.wang@okstate.edu (S. Wang)*

☆Supported by the National Natural Science Foundation of China (51474184), and the Natural Science Foundation of the State Administration of Work Safety in China (2012-387, Sichuan-0021-2016AQ).

Abstract: Hazardous gas detection systems play an important role in preventing catastrophic gas-related accidents in process industries. Even though effective detection technology currently exists for hazardous gas releases and a majority of process installations have a large number of sensitive detectors in place, the actual operating performance of gas detection systems still does not meet the expected requirements. In this paper, a risk-based methodology is proposed to optimize the placement of hazardous gas detectors. The methodology includes three main steps, namely, the establishment of representative leak scenarios, computational fluid dynamics (CFD)-based gas dispersion modeling, and the establishment of an optimized solution. Based on the combination of gas leak probability and joint distribution probability of wind velocity and wind direction, a quantitative filtering approach is presented to select representative leak scenarios from all potential scenarios. The commercial code ANSYS-FLUENT is used to estimate the consequence of hazardous gas dispersions under various leak and environmental conditions. A stochastic mixed-integer linear programming formulation with the objective of minimizing the total leak risk across all representative leak scenarios is proposed, and the greedy dropping heuristic algorithm (GDHA) is used to solve the optimization model. Finally, a practical application of the methodology is performed to validate its effectiveness for the optimal design of a gas detector system in a high-sulfur natural gas purification plant in Chongqing, China. The results show that an appropriate number of gas