

TOXIC AND FLAMMABLE GAS CLOUD DETECTORS LAYOUT OPTIMIZATION USING CFD

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► Introduction to the case

Gas detectors are commonly installed in process facilities to automatically alarm and trigger safety measures in response to hazardous leaks. Without effective leak detection, installations can be susceptible to two main hazards: (1) **accumulation of toxic gases** to levels that exceed given exposure threshold limits, and (2) **accumulation of flammable gases** to levels that can cause fires or explosions. The quantity and positioning of hydrocarbon (HC) gas and toxic gas detectors (e.g. for detecting H₂S) is a crucial factor for the effectiveness of the detection process. However, the total number and placement of detectors that can be used is limited and should be optimized for maximum effectiveness.

► What is the set-up of the case?

The approach presented here is in line with that outlined in the **NORSOK S001** standard regarding criteria for detection. The proposed approach pertains to detection of HC leaks in semi-confined naturally ventilated areas. All dangerous clouds must be detected; and the gas detection system will be optimized based on clouds resulting from small, more frequently occurring leaks (typically 0.1 kg/s leaks). Therefore a typical study is divided into “**dangerous**” cloud detection, which involves the analysis of larger leak rates, and “**typical**” cloud detection, which involves the analysis of small more frequently occurring leaks.

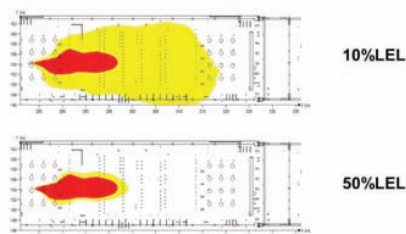


Figure 1: Variation in detectable volume of gas as the gas detector set point is changed from 10% LEL (top) to 50% LEL (bottom)

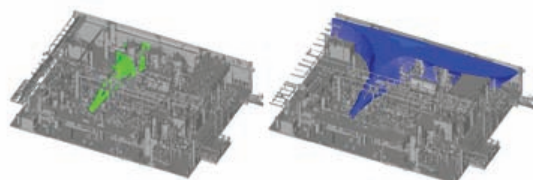


Figure 2: Variation in detectable volume of gas as the gas detector set point is changed from 30% LEL (left) to 20% LEL (right)

► Goals, objectives, expected results

The principal motivation behind using CFD to evaluate the performance of a gas detection system is the possibility of a direct assessment of the gas detection system’s ability to detect gas clouds generated by a series of simulated realistic gas leaks. CFD allows **the effect of geometry, ventilation and leak characteristics to be taken into account.**

► Industry, previous work

- Miranga-Taquipe – Compressor Stations (2013 - Petrobras - Brazil)
- Terranova - FPSO (2012 – Suncor - Canada)
- Gullfaks platforms (A, B, C)– BOP-decks (2011 - Akersolutions/Statoil - Norway)
- Statfjord C platform (2009 – Statoil - Norway)

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► Modelling with simplified tools

Limitations:

- Low wind velocity (below 1m/s), from external wind conditions or within under-ventilated areas in complex geometry, can not be accounted for
- Geometry effect not accounted for in the dispersion phase (ventilation, momentum of the release, turbulence generation,...)

Studies by the UK HSE (2001-2008) reported:

- Surveyed detection systems detected only 63% of major leaks and 31% of significant leaks

What would they mean for the project ?

Traditional detectors layout design guidelines are based on detector distribution density and leak probability:

- Result is frequently oversized and ineffective systems
- Excessive cost of installation and maintenance
- High incidence of false alarms → higher operational costs
- Inadequate sense of security

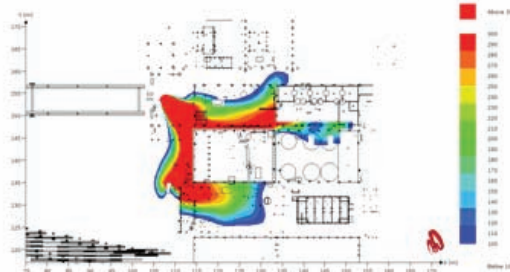


Figure 1: Flammable gas concentrations illustrating the complex shape of the cloud formed in the event of an impinging jet release on a process area. (FLACS Simulation)

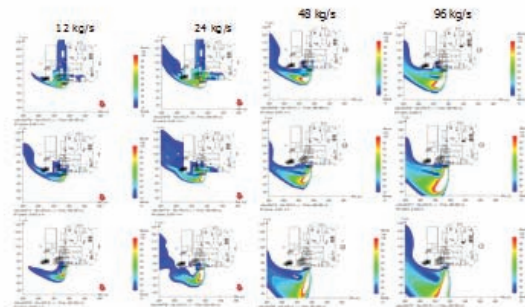


Figure 2: Flammable gas concentrations illustrating the complex shape of the cloud formed in the event of an external jet release on a process area. (FLACS Simulations)

► Modelling with FLACS/CFD

Advantages: modelling of releases impinging on a structure killing the momentum of the release, air entrainment and subsequent dispersion are completely different compared to the case where the geometry effects are not present or neglected causing the release to remain as a high momentum jet, which continues a significant distance in the direction of the release before being diluted by the wind.

Scenarios considered: The key to the CFD study is determining what scenarios should be taken into account. If the scenarios result only in large gas clouds, any detector layout will be acceptable and the study will not yield any useful information. Conversely, if all the simulated gas clouds are too small, the study will yield an unrealistic number of detectors.

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► Conservatism? Reduced with CFD or a need for more?

- Simulation work has shown that CFD simulations would account for complex gas clouds shapes and sizes and would induce a higher conservatism compared to simpler models.

► Solution given from FLACS & Added values for the project

- Assures that analyse becomes a tailor made test for the area in question and a proper gas detection system test
- **Assess different detector configurations and strategies**
 - Combination of detector types: Point, LOS, Senscient
 - Voting system: 1ooN, 2ooN....., separate or combined zones
 - Low and high alarm: %LEL, ppm
 - Detector response time
- **Performance data readily available:**
 - Explosive cloud location, size and detection time
 - Toxic gas & smoke cloud concentration, size and detection time
 - Assessment of different layouts and detector types (Point, LOS, Senscient) including 3D geometry effects.
 - Substantial cost savings in installation, maintenance and operation

► Others related cases ?

- Detection of external flammable gas cloud formation at turbine and Living Quarter air intakes
- Toxic gas detection system – High H₂S content in produced gas
- Frequent gas detections due to tank vents. Managing risk of major accidents (2010 - TOTAL - Paris, France) -

► References, from existing clients

“ Detection analysis for an offshore facility demonstrated that changing the detection criteria from 1*60%LEL to 2*20%LEL before shutting down the process had no effect in performance safety. Resulted in estimated yearly savings of up to 8 million US dollars ”

“ A study using traditional prescriptive methodology recommended installing over 50 detectors in an onshore gas compression plant. A study performed by Gexcon demonstrated that installing 18 detectors would meet all the required specifications ”

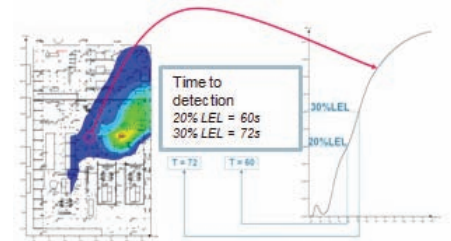


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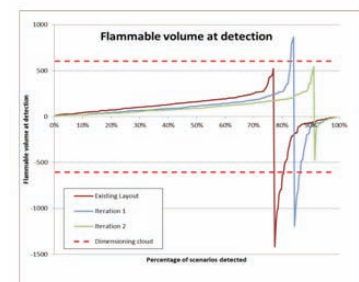


Figure 2: Flammable gas cloud volume at detection. Negative volume indicates undetected clouds



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