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Technical Note

The Case for the Target Gas Cloud Approach in Gas Detector Placement

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Since the inception of ISA TR84.00.07, debate has existed between which gas detection design methodology is optimal – scenario based or geographic gas detector placement. The application of scenario based techniques have been discussed for decades in the industry, but the technique is generally excluded due to a number of clear limitations. It's inclusion, however, in the 2010 ISA guidance provided a platform for the technique to be discussed within a wider audience, unfamiliar with F&G detection technology and design methods. The result has been great confusion and inconsistency in gas detection design with strands of interpretation causing fractures across facility types, global regions, and even within companies as to how to address the gas detection problem. The authors wish to robustly defend the use of the Target Gas Cloud approach, which is the generally accepted approach for industrial applications, and highlight the shortcomings of scenario based modelling for gas detection system design.

A recent technical perspective [1] presented an argument in favor of using a scenario based method for placing gas detectors within a section of an offshore gas production facility, supported by an analysis of 11,520 release scenarios. The technical perspective concluded that the scenario based approach provided superior coverage with 50% fewer detectors. However, this conclusion, as well as the analysis it's based on, appears flawed and evidences some common misunderstandings of the target gas cloud design methodology.

The example [1] begins by arranging point gas detectors throughout the space to be assessed with a 5-meter uniform spacing. This produces a 22-detector layout and the author of the referenced example concludes that this provides roughly 80% coverage using a target gas cloud size of 5 meters.

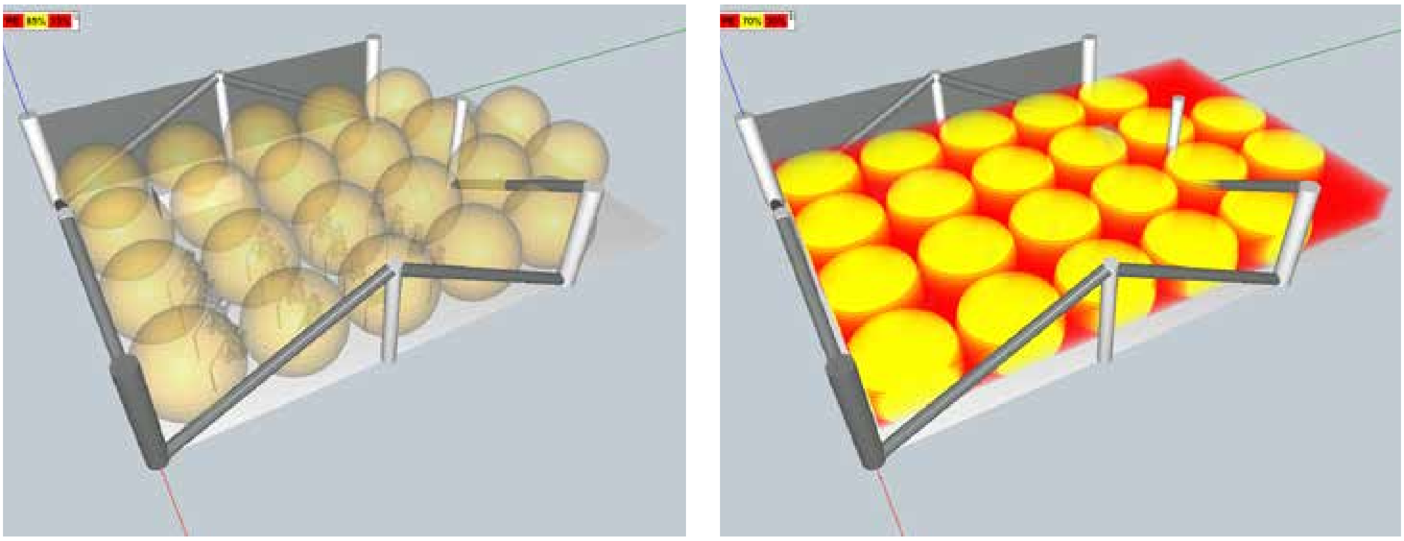

Figure 1: Graphical representation of the contrived 5 m grid layout and assessment restuls.

It is stated in [1] that this 5-meter gas cloud is the size of cloud that “could result in a vapor cloud explosion.” This is not true. A 6-meter cloud of stoichiometrically mixed gas was found to be able to produce damaging overpressures in a typical, semi-congested process area in a literature review by the HSE in 1993 - the OTO 93 002 report. Spacing detectors at 5-meter intervals was recommended for semi-congested process areas based on this.

The goal of the target gas cloud method is not to detect leaks or to minimize the mean time to detection (MTTD). Nor is the method attempting to always detect the same, fixed size of gas cloud, regardless of the area for which detection is to be provided. Rather, the approach attempts to detect accumulations of flammable gas in a given process area before they reach a size at which they will be damaging if ignited in that area. Because the overpressure of an explosion is dependent on flame acceleration, which is, in turn, dependent on the level of congestion and confinement in the area, the size of the target gas cloud to be detected will vary based on the nature of the area.

It can be assumed from the aforementioned analysis that a 5 m cloud is in fact the gas cloud of concern which will lead to explosion overpressures of >150 mBar. The dimensions of the wellbay can be inferred to be approximately 20 meters by 30 meters based on the layout and analysis. Based on this, Micropack generated a model and conducted our own analysis of the layout:

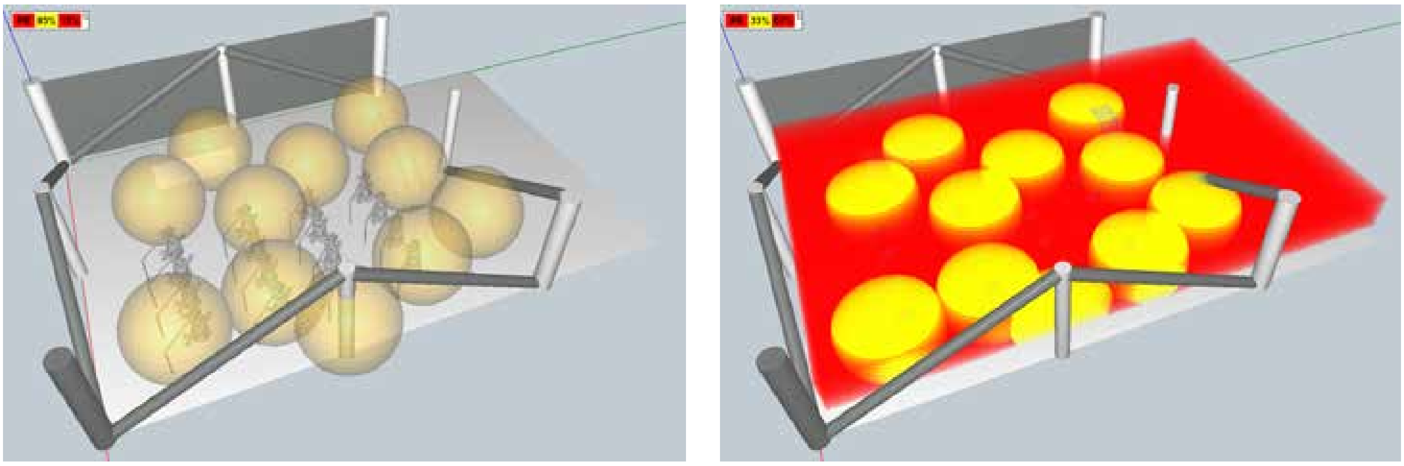

Figure 2: Graphical representation of the ‘optimised’ Scenario based layout and assessment restuls.

When this layout is assessed on a volumetric basis using a target gas cloud approach, it can be shown that this layout provides coverage for only 33% of the graded volume / area. This means the target gas cloud which would result in **unacceptable** explosion overpressure if ignited can exist **undetected** in 67% of the volume. This result shows that the coverage may provide coverage for 80% of the 11,520 selected release scenarios, but it dangerously fails to provide coverage capable of detecting the potentially damaging accumulations of flammable gas for fully two thirds of the process area.

Yes, the analysis includes over 11,000 leak scenarios - a feat which likely consumed many engineering hours, unless it omitted crucial information required to provide an accurate analysis of fluid flow through the volume (i.e. near field blockage etc.). Regardless, these 11,000 scenarios are but a tiny fraction of the nearly infinite number of leak scenarios that could occur in a process area like this when one accounts for variations in leak location, size, orientation, and weather conditions, not to mention temporary obstructions - like scaffolding - which completely invalidate the entire gas detection design. While many clouds are analyzed, the analysis does not, and cannot, fully capture all possible leak scenarios and it is therefore, in our opinion, misleading and potentially dangerous to claim "80% coverage" based on these results.

All of this is not said in defense of the 22-detector grid. As the example [1] correctly points out, this approach is inefficient, results in a prohibitively large number of detectors and is not consistent with modern approaches to performance-based gas detector layout design. The problem is not the geographic methodology, but rather the representation of it.

Rather than using infrared point gas detectors (IRPGDs), experienced designers would typically recommend a design using four open path gas detectors (OPGDs) that run the length of the 30-meter side of the wellbay. The example analysis [1] does not use or mention OPGDs, in keeping with other literature which promotes the use of a scenario based approach [1,2,3,4,5,6]. OPGDs are widely regarded as a reliable and generally accepted flammable gas detection technology and have been for some time. A four OPGD layout would provide coverage for 85% of the wellbay, as can be seen in the assessment result below.

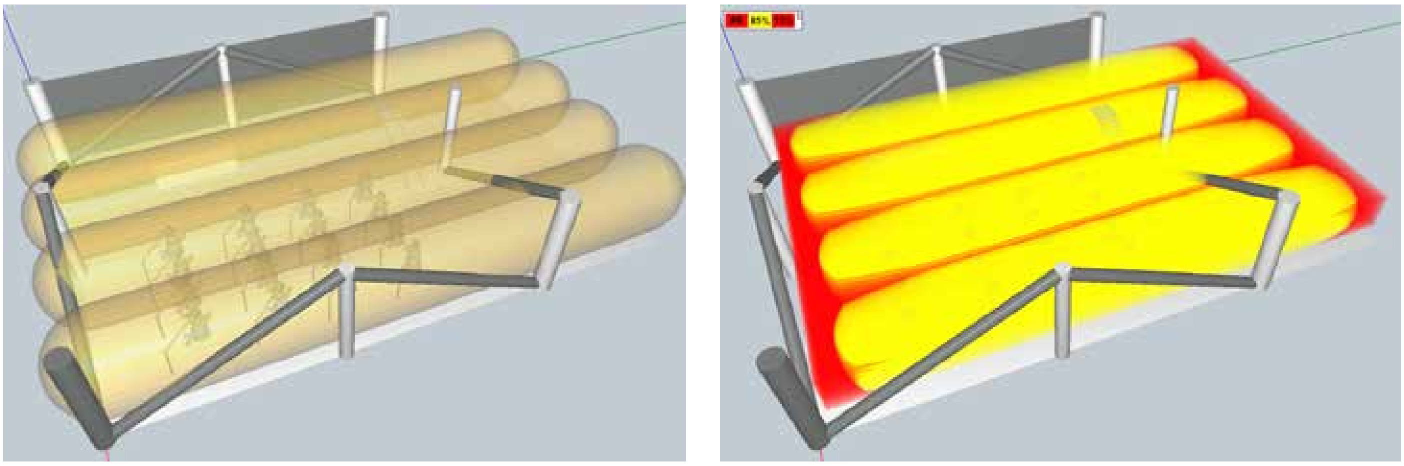

Figure 3: Graphical representation of the OPGD layout and assessment results.

With only 4 detectors (a significant reduction over the scenario based layout's 11 detectors), over 80% of the entire process area is covered - not just a sampling of scenarios - and an accumulation of flammable gas that could produce damaging overpressures if ignited is not likely to be able to "hide" from the detectors. This is modern, performance-based, gas detector layout design.

In conclusion, the case study [1] evidences severe but common misunderstandings of the target gas cloud design approach and the design intent of a gas detection system. Much of the work promoting scenario based modelling products also ignore an important truth of scenario based analysis - that it cannot capture all possible outcomes, or even an acceptable representative sample of scenarios. Additionally, these analyses often ignore current practice and advances that have been made in gas detection technology. As a result, scenario based layouts are proposed which leave dangerous gaps in coverage by basing the design on a potentially flawed and incomplete sampling of leak scenarios. Scenario / leak analysis and modeling is a valuable tool that has a place in the "toolbox" of a fire protection engineer. However, scenario based gas detector layout design can sometimes be a contrived and expensive and/ or time consuming undertaking.

References:

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