Mapping Fixed Gas Detectors and Flame Detectors

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Early detection of gas leaks and flames can help prevent the escalation of dangerous incidents; therefore, safety engineers must design and implement the most effective detection system possible. Engineers pour over flame and gas detector spec sheets, and they consider safety manufacturer certifications. But high-quality detectors that are improperly placed might not meet detection goals.

Safety experts have long known that wise placement of the devices into a specific application leads to effective detection coverage, which in turn leads to the best scenario for successful mitigation. Yet UK Health and Safety Executive (HSE) statistics indicated that 40% of major gas releases in the North Sea offshore installations were not detected by gas detection methods.

To improve safety, more and more detector placement is being performed by experts using computer modeling. This computer-aided detector placement or "mapping" is the process of determining where detectors are to be placed for optimal response.

Mapping has come into more focus lately for several reasons.

- Rapid technology development and loss of expertise: In the past, gas and flame detection evolved at a comparatively slow rate while on-site personnel applied their experience to position gas and flame detection. Currently, however, detection technology is evolving at a rapid rate while experienced safety personnel are retiring. The "art" of detection placement now needs to be combined with and converted to a "quantifiable science" of mapping.
- Demands of local authorities: Determining the number of detection points necessary and determining fractional detector coverage (the fraction of an area that is covered by detectors) is a challenge. Health and Safety Engineers might recommend 200 of points of detection for a particular site. The EPC Contractor safety supplier might recommend 100. What is the appropriate quantity? Will the fire and gas detectors sense a leak in time for fire and gas system to mitigate the hazard? These are some of the questions asked by local authorities. Facility management and safety engineers must have quantifiable answers. Engineers need a structured process (mapping) in place to determine detector placement.
- Expectations of users on detection-device manufacturers: Historically manufacturers of gas and flame detectors have focused primarily on providing the most effective gas and flame detection products. Some manufactures, however, now are becoming more involved in the application of their products. Gas detection manufacturers have intimate knowledge of emerging technology, regulatory changes, detector limitations, knowledge of environmental challenges, and more.

Assessing Detection Technology

Assessing available flame detection and gas detection technology is an important aspect of placement. Emerging technologies are quickly overcoming limitations that hampered older detector placement (Figure 1).

For optical flame detection, technology choices include devices that detect radiation in the ultraviolet (UV), infrared (IR), or combined UV and IR spectral ranges. For many applications, sensing in multiple areas of the IR spectrum (Multi-IR) is the current state of the art. Because flames can be generated by a wide variety of sources, from methane to hydrogen, various flames emit energy in different areas of the optical spectrum. For example, if hydrogen fires are a possibility in an application, the engineer must verify that the flame detector can sense non-hydrocarbon "invisible" flames.

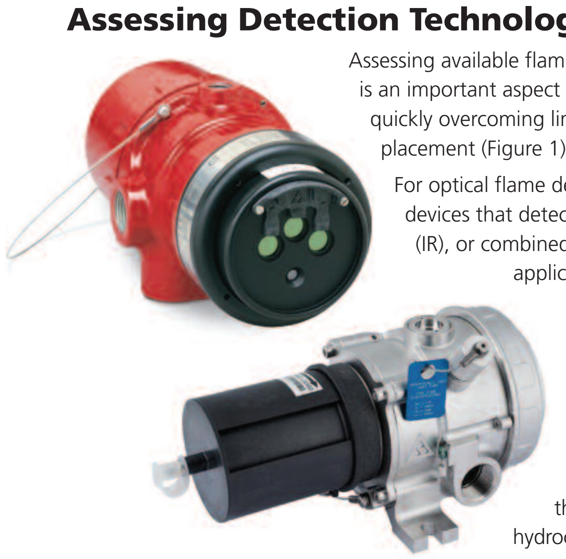

Figure 1. Technology assessment is critical to successful detector placement. Recent advances in algorithms and technology have improved flame and gas detection.

When selecting gas detectors, it is important to verify that the specified response times account for delays caused by environmental protection such as rain guards. Below is a list of most commonly available gas and leak detector technologies that are commonly mapped.

- Point gas detection, such as catalytic bead sensors or infrared (IR) sensors, relies on the gas diffusing to the sensor. Wind, structures, leak size, gas density, and gas pressure can impact gas dispersion. Diffusion of the gas cloud to the sensor is required to detect gases.
- Line Of Sight (LOS) or "open path" gas detection relies on the gas dispersing through the open-path beam that runs between the detector transmitter and receiver, which are placed a given distance (such as 5m to 100m) from each other. These sensors are often placed high enough so that foot or vehicle traffic does not block the path. A typical application for LOS detection is fence-line monitoring.
- Acoustic gas leak detection has emerged as a complementary technology to the two more conventional methods (point and LOS) because the gas leak does not have to diffuse to the sensor itself. The sound of the leak is more evenly dispersed around a leak, so positioning the detector directly in the gas cloud is not necessary.

Categorising Fire and Gas Zones

Most facilities are subdivided into smaller fire and gas zones. Mapping uses these zones within the larger facility and allows the fire and gas system to better identify where a hazard exists and determine what actions to take in that zone.

Zones are areas with common hazard and occupancy characteristics. These zones also have common alarm and control characteristics, and are categorised based on electrical area classification.

Detector Placement Methods Versus Detector Mapping Methods

Two commonly used forms of detector placement that traditionally have been used are sometimes referred to as Heuristic or Prescriptive.

- Heuristic Placement takes advantage of personal expertise rather than computer modeling and is based on previous experience in similar applications. A detection application expert visually determines how potential gas hazards may disperse and places detectors in the probable path of the dispersion area. No numeric modeling is used, and the technique does not determine fractional coverage of detector placement. This method sometimes falls short of the safety goals because it tends to put more emphasis on the location of a potential gas leak rather than on the location of total gas accumulation.
- Prescriptive Placement is the action of placing detectors in accordance with a strict predefined standard. Using this method, engineers place detectors into the application space based solely on previous experience or standards. This type of detector placement is frequently used in turbine areas, where a turbine manufacture has provided clear definitions as to where points of detection should be located.

Changing the outlook of detector placement and influencing the techniques, ISA TR84.00.07-2010 "Guidance on the Evaluation of Fire, Combustible Gas and Toxic Gas System Effectiveness" [ref.1] provides guidance about methods of determining fractional detector geographic coverage. Methods that calculate the fraction of an area covered by detectors assume that a hazard can exist anywhere within a hazardous area. Fractional coverage is used in risk assessment to determine the overall performance goals of a gas and flame system.

To meet the ISA guidance, consultants are beginning to subscribe to one (or a combination) of the following philosophies or approaches to determine where and how many flame and gas detectors are required.

Full Quantitative Mapping is a risk-based approach and individually calculates each hazard/risk to determine if risk is reduced to a level below Target Mitigated Event Likelihood (TMEL). These risks can be plotted using computer programs to determine where risk is highest and detector placement is necessary. This is the most thorough method, but is computationally intensive.

Semi-Quantitative Mapping is emerging as a more commonly used method to define coverage. It takes into account factors such as Types of Processing Equipment, Level of Occupancy, and Asset Protection Value to categorise each zone into grades of required coverage. The following section will describe in more detail the elements of semi-quantitative mapping.

Mapping Example: Semi-Quantitative Mapping

When performing semi-quantitative mapping for combustible gas and flame detection, each fire and gas zone is further broken down to determine the grade of coverage required. Grading involves determining what level of hazard exists within a zone based on these parameters:

- Process Equipment
- Process Pressures
- Open Area or Confined or Congested Area
- Occupancy
- Asset Protection
- On Shore or Off Shore

After zones and grades have been determined, a single zone's plot plan is loaded into the mapping application to be evaluated. To map the flame detection areas, the certified "cone of vision" ranges (provided in manufacturer's specifications) for optical flame detectors are loaded into the program to designate covered areas.

Combustible mapping programs use a rule of thumb created in 1993 by the UK HSE [ref. 2]. This UK HSE study determined that a 6m propane or methane combustible gas cloud could cause a damaging pressure wave on an offshore platform. The UK HSE determined that gas detectors spaced to detect 5m clouds would minimise damaging combustible gas levels. The semi-quantitative method assumes that a tolerable 5m spherical gas cloud, or "critical gas cloud," can exist anywhere within the defined hazard area. The programs typically used for detector mapping take into account the number of detectors, location of detectors, and zone parameters then calculate percent of geographical coverage.

Toxic gas detector mapping can be performed based on uniform spheres surrounding the hazard, similar to combustible gas mapping. Although the 5m sphere size is a reasonable starting point for the mapping of toxic gases, safety engineers must be aware there is no general rule for toxic gas detector spacing. Each application must be carefully considered prior to mapping toxic gas detection.

Be aware that cloud size choice can fine tune the mapping program. Using a smaller cloud size in the mapping program reduces the anticipated hazard size and effectively improves system response and safety. Larger cloud size effectively increases response time in low-grade hazardous areas. Ultimately the safety engineer responsible for the site should carefully consider cloud size used in toxic and combustible mapping.

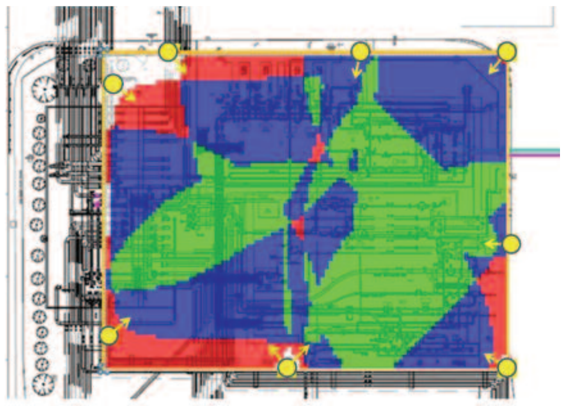

Figure 2. Example of a flame detection coverage map. Yellow circles are the modeled flame detectors with an arrow indicating their orientation.

The output of the mapping program for gas and flame detection designates the detected and undetected areas on the plot plan to provide a percentage of geographical coverage (Figure 2).

Voting's Impact on Detector Mapping and Fractional Coverage

Voting is a gas and flame detector design option in which more than one detector (for example, two out of three, 2oo3) must detect hazardous gas levels or flames before an alarm is activated. Voting is commonly applied to gas and flame systems to design in more fault tolerance and avoid emergency shut downs (ESD) caused by false alarms.

Voting causes changes in fractional coverage and response time because a gas cloud must grow to encompass multiple detectors.

A flame must be significant enough to be in the field of view of multiple flame detectors to initiate an executive action.

Many mapping programs do consider and calculate coverage for degrees of voting options. The programs recognise the tradeoffs presented by voting and, therefore, show the differences in coverage for varying degrees of voting.

A Walkthrough Improves Detector Placement

After the detector map is complete, it is important to verify that the detector map accurately meets safety needs. The installer and end user take the printed detector map and walk through the areas where detectors are to be placed. This activity requires application experience and knowledge about detector capabilities.

Although the primary concern in a walkthrough is to keep detectors as close to the mapped location as possible, a walkthrough might show that a given detector is obscured by piping that was not shown in early concept drawings (Figure 3).

Figure 3. Flame detector view is blocked by obstructions.

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During the walkthrough, consider that the combustible gas detectors will need to be cleaned and calibrated periodically to verify operation, therefore, make sure the detectors are accessible for efficient maintenance. Also consider the situation into which the detector is placed. For example, although locating a catalytic bead gas detector in a ditch around a tank farm will provide a quick response to a hazardous incident, if a flood occurs and the ditch fills with water the sensor will be ruined.

If the walkthrough indicates significant deviations from mapped locations, coverage should be reevaluated.

Conclusion

In summary, determining the position of gas and flame detection is a challenging opportunity. Following a systematic approach as described in ISA-TR84.00.07 and documenting each step will provide you with a FGS design philosophy. This documented design philosophy can be used to understand the performance goals of your system and act as an aid when changes are made to your processes.

References

1. ISA TR84.00.07 – 2010, "Guidance on the Evaluation of Fire, Combustible Gas and Toxic Gas System Effectiveness"; January 2010.

2. UK Health and Safety Executive; Offshore Technology Report OTO 93 02; "Offshore Gas Detection Siting Criterion Investigation of Detector Spacing"; Lloyds Register of Shipping, Lloyds Register House, 29 Wellesley Road, Croydon CR0 2AJ.