# Fire and gas detection mapping

## Computer aided design to increase safety and reduce cost

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## Introduction

Fire and gas detection systems should play a crucial role in loss prevention on many sites. Formal safety assessments such as quantified risk assessments often assume that fire and gas detection systems will reduce risks, yet their design is often a matter of "black art"; it is often difficult to quantify the parameters involved and there is little guidance to define required performance or to relate achieved performance to safety requirements.

Modern fire and gas detection designs tend to be towards hazard based approach featuring recognised and quantified hazards, for example ranging from highly sensitive items such as hydrocarbon gas compressors through to lower risk items such as produced water vessels.

Using highly developed assessment methods together with custom software the flame detection assessment, gas detection assessment and heat detection assessment packages are able to review and assess arrangements from initial designs through construction and onto existing installation. The assessments are used to optimise and validate designs and maybe used in formal safety studies.

## Methodology of fire and gas mapping

### Setting of performance targets

The key to achieving a performance based in fire and gas detection systems design is to start with defining the required system performance. This should be done for all types of fire and gas detection equipment. For example, in terms of fire detection of 'flaming fires' parameters such as flame size in radiant heat output (RHO) should be specified. For gas detection parameters such as gas cloud size and gas concentration should be specified. In both cases voting logic and response time must be clearly specified. The setting of such performance targets will usually require input, or agreement, from the client's operations personnel, normally the control engineer and personnel familiar with the process and safety risks.

Typical steps to applying grades in hydrocarbon risk volumes for flame detection are:

- Assign an 'average' grade of detection coverage throughout all hydrocarbon fire risk volumes (grade B).
- Identify any parts of grade B areas where better detection is required, and assign them (grade A).
- Review all remaining grade B areas for parts where cover is excessive and assign a lower performance (grade C).

**Grade A** is used for hydrocarbon risks, which are associated with particularly sensitive risks such as small hydrocarbon condensate pumps. Such risks will normally have well defined risk reduction measures (control actions), some of which may be active and need to be triggered by automatic fire detection. Grade A zones should extend a minimum of 1m from the plant to which it applies and segregated from grade C volumes by a further 2m of grade B.

**Grade B** is the 'normal' level of fire detection in hydrocarbon risk areas and is used wherever another Grade is not more appropriate. Typically grade B equipment will include items that are not sensitive to small fires such as oil separation vessels. Grade B zones should extend a minimum of 2m from any plant which is protected by it, or to the area boundaries if any are within 4m of the plant.

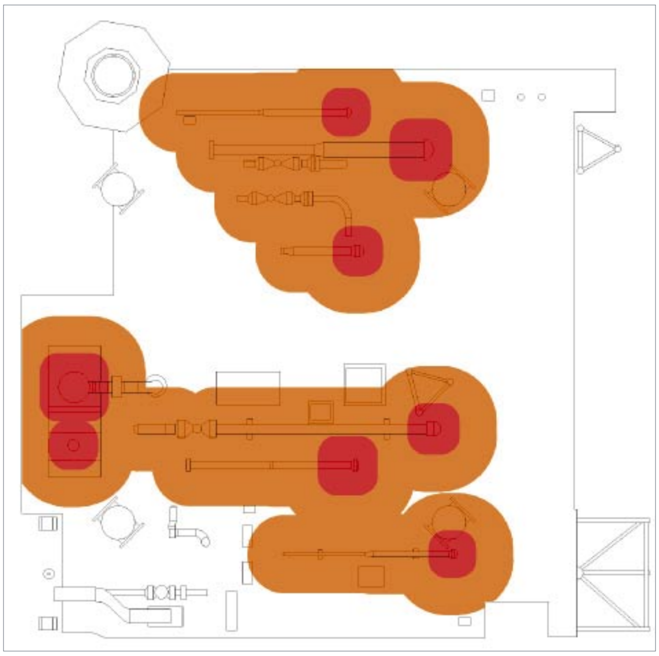
**Grade C** is used where the grade B level of detection is excessive, and so a reduced performance Grade is required. Typically grade C equipment will include items that have little or no flammable inventories such as produces water vessels. Grade C zones should not be within 2m of grade A volumes (i.e. there must be a grade B area between A and C), or hydrocarbon plant from which there is potential source of release, e.g. flanges or compression fittings (which will be grade A or B).

The gradings described above for flame detection coverage are based on targets used by many oil and gas production companies throughout the world.

Typical flame detection performance targets for offshore oil and gas production platforms, expressed in terms of RHO, are:

| Grade | Alarm | Control Action |
|---|---|---|
| A | 10kW | 10kW |
| B | 10kW | 50kW |
| C | 100kW | 100 kW |

**Figure 1: Typical fire detection grade map**

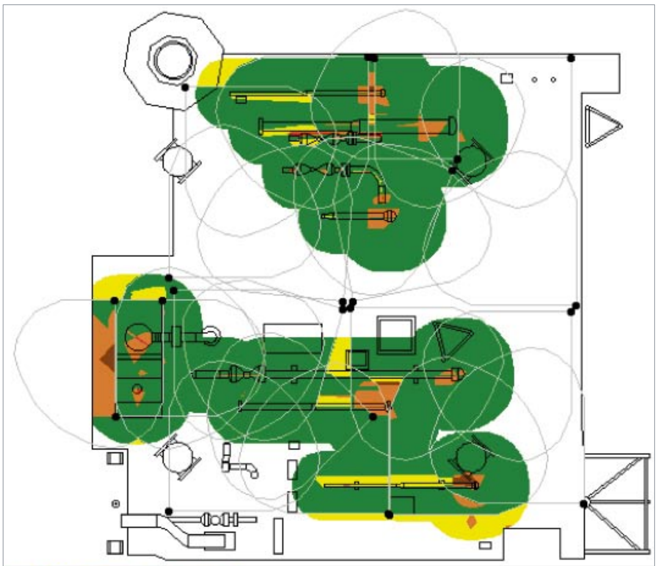


**Grade map key**
Grade A = Red
Grade B = Yellow
Grade C = Green

## Flame detection coverage assessment

Flame detection coverage can be assessed using software based mapping tool (“*FDA*”). The input requirements for this tool are performance targets, detector layouts and details of the detector types all obtained previously. The detectors are represented as 2 dimensional CAD files depicting each detector’s field of view. The performance targets for each area are set according to their local hazards and escalation risks. This information is stored in a ‘grade map’ file. A custom software system then ‘overlays’ each relevant detector’s footprint onto the grade map and, using a truth table, constructs a graphical image of the coverage afforded by the area’s detectors. The finished graphical file is known as the ‘assessment’ file and provides an objective estimate of that area’s flame detection coverage. This analysis shows the typical interaction of flame detector coverage physical obstruction and hazard grading, an interaction that is virtually impossible visualise without computer assistance.

In the example shown below the areas shown in green meet the flame detection coverage targets, those areas in orange and yellow meet restricted targets while those in red have poor coverage and may require revision.



| | | | | | |
|---|---|---|---|---|---|
| A | 74% | 0% | 23% | 3% | 0% |
| B | 89% | 8% | 3% | 0% | 0% |

**Figure 2: Typical fire detection assessment**

## Typical steps to applying grades in hydrocarbon risk volumes for gas detection are:

The target gas cloud sizes are selected for each area based on the area’s volume, confinement and degree of congestion. Typical gas cloud performance targets are:

- confined space(s), (E) inferring a 4 metre detection limit;
- partially enclosed (PE), inferring 5 metre detection limit; and
- open (O), inferring 10 metre detection limit.

## Geometry of accumulation

It is a basic assumption of the methodology used in gas detection assessment (in keeping with the philosophy of damaging explosion overpressures) that the gas cloud can be modelled as a nominal sphere. This assumption (which is conservative because the 'ideal' spherical geometry encourages higher overpressures than the more realistic plume) permits a rapid and reasonably accurate assessment of detector coverage.

The gas cloud sizes considered are specified as 4m, 5m and 10m diameter clouds having volumes of $33m^3$, $65m^3$ and $523m^3$ respectively.

Each area assessed is represented as a regular orthogonal volume specified in terms of its length, width and height (or, using conventional cartesian coordinates, X, Y and Z dimensions)

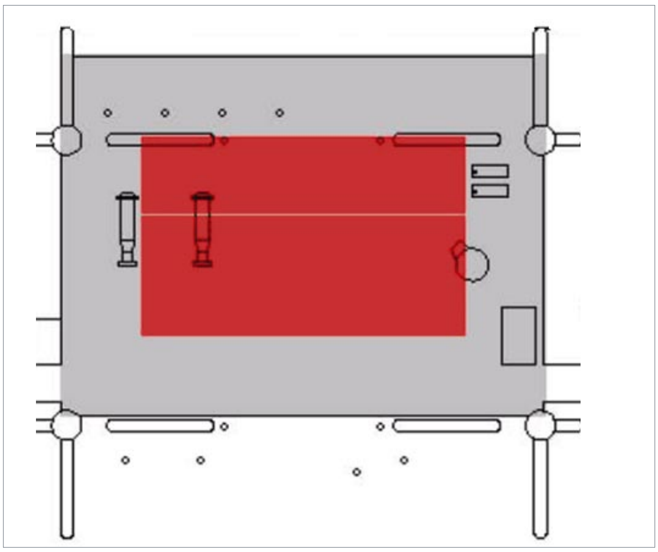
**Table 1: Definition of gas detection grade in terms of cloud size**

| Grade | High gas | Low gas |
|---|---|---|
| PE | 5 metre | 20 metre |
| O | 10 metre | 40 metre |
| E | 4 metre | 16 metre |

For the setting of both fire and gas performance targets a full list of existing detection equipment and detector location drawings are required.

Figure 3 shows an example of gas grade map, indicating the performance targets.

**Figure 3: Typical gas detection grade map**



## Gas detection coverage assessment

The gas detection coverage to the target gas cloud sizes can be assessed using gas detection assessment software assessment tool. The target gas cloud sizes will be proposed for each area based on the area's volume, confinement and degree of congestion as agreed previously.

The Fire and Gas plot plans are used to establish their proposed location on the installation, elevations will be required. These coordinates will be input into a software package, for analysis and assessment. This package objectively assesses the coverage of the existing gas detection system against the proposed performance target.

Gas Detection Assessment uses a number of simplifying assumptions in order to make it possible to assess sites. It is assumed that all gas detectors are either 'point' or 'open path' gas detectors, and that gas is detected if the accumulation envelopes a detector or intersects the track of an open path detector. Other types of inferential gas detector technologies including ultrasonic gas detection measures are not presently modelled, primarily because they effectively respond to release rates rather than gas concentrations.

**Grade map key**

**Grade PE**

HiGas Diam 5.00m
LoGas Diam 20.00m
H+L

**Grade PE**

HiGas Diam 10.00m
LoGas Diam 40.00m
H+L

**Grade PE**

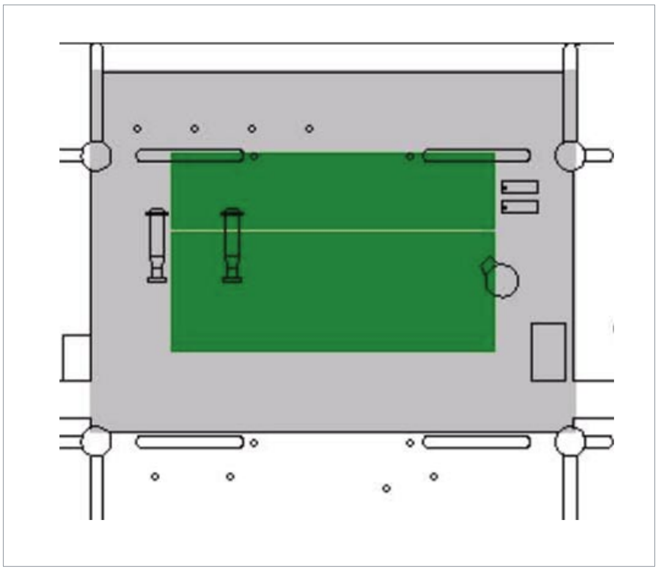
HiGas Diam 4.00m
LoGas Diam 16.00m
H+L

Each area assessed is represented as a regular orthogonal volume specified in terms of its length, width and height (or, using conventional cartesian coordinates, X, Y and Z dimensions).

The assessment result is, by definition a three dimensional structure which cannot easily be rendered on two dimensional paper, and the results of the assessment are available both as a numerical summary and as a series of horizontal 'slices' through the volume. These slices are available at various intervals and, for clarity; one representative slice for each area will be reproduced in the study.

In the example shown below the areas shown in green meet the gas detection coverage targets, while if any area was shown in red this area would have poor coverage and may require revision.

**Figure 4: Gas detection assessment**



The use of fire and gas mapping clearly defines the risk and the precautions taken to detect fires and gas releases. The methods used allow the designer to be optimised the design to achieve the best possible balance between safety and economy. This practice improves safety and reduces operating costs by insuring that the number of devices used is minimised yet still maintaining the levels of safety required. All responsible fire and gas detector manufactures should offer this service.

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