Fire detector coverage mapping for improving existing systems

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This article presents a case study of the analysis of an existing fire detector system in the Gulf of Mexico. The analysis demonstrated that better coverage could be obtained using fewer detectors, allowing the design to be changed which could result in significantly lowering maintenance costs while improving safety.

The objective of this article is to prove that a risk based Fire and Gas (F&G) System design will not only ensure that risk goals are being achieved but also carries financial incentives improving system reliability, increasing spurious trip avoidance and reducing the severity of hazardous events.

A principal objective of a fire and gas system design is to reliably detect, alarm, and, if necessary, take automatic action to mitigate a fire hazard, combustible gas hazard, or toxic hazard. The ability of the system to perform its intended safety actions in a demand condition is dependent on a number of factors associated with design, installation, site-specific operating conditions, and maintenance. Most failures of fire detection and suppression systems to function properly under a demand condition are related to one of two mechanisms:

- Inadequate coverage: Failure to detect a defined type and magnitude of hazard due to inadequate sensor type, number or location;
- Inadequate FGS availability: Failure of component hardware to function as intended.

Although applicable national standards (ie NFPA 72, EN 54, etc) address numerous aspects of good engineering design for F&G Systems, they do not prescribe in detail how to design a robust system to avoid the types of hardware failures and lack of coverage failures. In fact, it is difficult in practice to prescribe good engineering design for sensor placement and equipment reliability due to numerous site-specific factors that influence the overall ability of the system to perform adequately on a demand condition.

Another objective of fire and gas system design is not to interfere with normal process operations unless a hazardous condition is present. Fault conditions due to component hardware failures or site-specific operating conditions can result in spurious activation of the system. The ability of the system to meet this non-interference objective is also known as the 'spurious trip avoidance' of the system, and this goal tends to counterbalance the goal of achieving high availability on a demand. A robust fire and gas system design comes only through careful consideration of both safety objectives and spurious-trip-avoidance objectives.

Achieving optimum fire detector placement will ensure that adequate detector coverage is achieved to meet risk reduction goals while also ensuring avoidance of spurious trips.

Part 1: Procedure for FGS integrity analysis

The procedure for FGS integrity analysis can generally be described in seven steps:

Step 1: Definition of FGS zones

Fire and gas zones are defined by physical location. Operating areas should be segregated into discrete zones. Each zone will be assessed separately for FGS hazards: fire, flammable gas, and toxic gas. Performance targets will be established for each zone and FGS design will be to provide adequate protection within each zone for fire hazards and gas hazards. Zones should be defined based on location of processing equipment and the attendant hazards. Fire hazards within a zone should be similar. Gas hazards within each zone should be similar. Coverage within a zone typically implies that an automated safety action will be taken by the FGS when a fire or gas release has been detected within a zone. The result of this task is a list of zones, each with a definition of the potential fire hazard as well as the potential gas hazard.

Step 2: Define zone category

Each zone is assigned a category to determine general requirements for fire and gas detection.

Further, detailed analysis of performance requirement (including detector coverage mapping and safety availability analysis) is not required for all categories. The following table provides a list of zone categories:

Zone Category	Area Definition	Examples
H	Hydrocarbon possessing area, general fire / flammable gas, toxic gas hazard	Well bay, production separation, gas compression.
N	Non-hydrocarbon fire hazard	Combustible liquid storage, lubrication oil system.
D	General occupancy, no hydrocarbon fire hazard	Accommodation module control module
E	Non-hydrocarbon special equipment protection	Non-classified electrical equipment
T	Gas turbine or engine enclosures	Gas turbine and turbine enclosures
V	Combustion air intake / ventilation air intakes	Reboiler, combustion air blower

Table 1: Zone categories (designed for an earlier study).

The risk based analysis described in this paper is not necessary for many FGS zones. For example, category E, T and V zones in the above list do not require detector coverage mapping. FGS functions used in these applications are generally required to provide adequate segregation of non-process and process areas and therefore verification of general area coverage using detector mapping is meaningless. A category D zone in the above table would only be expected to comply with an industry standard level of performance. This includes designs to comply with requirements of the local fire detection standards (eg NFPA72 [1], EN 54 [2], or BSI BS 5839 Part 1 [3]).

Step 3: Assess F&G risk

For each FGS zone a risk assessment should be conducted to determine the associated hazard. Quantitative risk analysis is generally required to accomplish this.

The design intent of a FGS is not to prevent a hazardous condition from initially occurring, but rather to reduce (or mitigate) the consequences to a lower level after initially detected. A small fire is prevented from becoming a large fire that will escalate into a catastrophic consequence. A small gas release that already presents a toxic or fire hazard is prevented from becoming a large gas accumulation that could result in a large hazard. Therefore, the risk associated with successful F&G system function must also be considered in an overall determination of the tolerability of risk along with the probability of system failure leading to larger consequences. This issue of a 'mitigated consequence' is the reason that standard risk analysis techniques, such as Layer of Protection Analysis (LOPA), should not be used in the analysis of F&G systems. The use of a quantified risk assessment ensures that both 'mitigated' and 'unmitigated' consequences are properly addressed.

Quantified risk analysis also addresses the two-fold problem of analysing detector coverage and FGS safety availability. The objective is to analyse the risk of the hazard against which the FGS are intended to mitigate. Further, the model allows for analysis of risk in sufficient detail to make a 'tolerability of risk' decision and to specify performance parameters for the FGS design. An 'event tree' model can be used to accomplish this. The scenario begins with a hazardous event (eg fire, combustible gas release, etc) within an area of concern. In the following 'event tree', it is evident that by increasing the detector coverage (S1) and/or reducing the probability of failure of the FGS (F2), the a release resulting in a high consequence event is reduced.

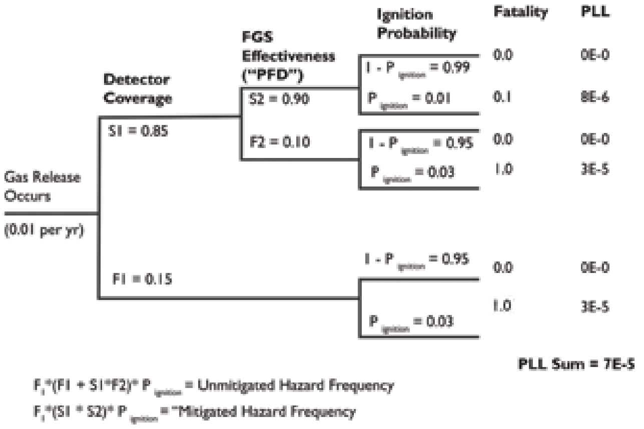

Figure 1: Event Tree Model.

Step 4: Determine FGS performance requirements

The performance target is a specification that defines the ability of the function to detect, alarm, and if necessary, mitigate the consequence of a fire or gas release upon a demand condition. In concept, a higher hazard installation should require higher levels of performance; while a lower hazard installation should allow for lower levels of performance, so that FGS resources can be more effectively allocated.

Flame detector performance targets

Design of fire detection system is predicated on the principle that sensing a turbulent diffusion fire should be early enough such that automatic control action can be taken, if required, during the incipient stages of the fire to maximise safety and limit commercial losses to a tolerable level. Incipient fire detection requires an adequate number of detectors that are strategically located in a manner to provide adequate coverage.

Combustible gas detector performance targets

Design of combustible gas detection is predicated on having the ability to sense a threshold volume of gas at an incipient stage where action can be taken to prevent significant loss from occurring were that volume of gas to ignite and result in a deflagration. Note that the goal is not to prevent any size flammable cloud from forming, igniting, or deflagrating. The goal is to limit flame front acceleration of such ignited gas clouds to a speed that has been demonstrated to be below the threshold of structural damage in typical offshore oil and gas installations. The degree of hazard and the damage from a combustible gas deflagration is related to the size of the cloud as well as other factors such as confinement, and the presence of turbulence inducing obstacles.

Combustible gas detection performance targets should be evaluated in locations where ignited gas clouds could cause damage from explosion overpressure. In these locations, the smallest gas cloud that has the potential to cause such damage should be used to define requirements for placing combustible gas detectors.

The selection of F&G performance targets are generally tailored to a specific zone based on the specific level of risk in a FGS zone as well as the operating company's aversion to risk. Example performance targets for Fire and Gas zones are defined in the following table. These have been calibrated based on assessment of typical fire scenarios, typical consequences, typical likelihoods and target risk reduction based on typical risk tolerance guidelines. In the table below grade A performance is appropriate for areas with very high exposure to fire and/or gas hazards, while grade C is appropriate for areas with relatively low exposure.

Fire Grade	Fire Detection Coverage	FGS Safety Availability
A	0,90	0,97
B	0,85	0,90
C	0,60	0,90
Gas Grade	Gas Detection Coverage	FGS Safety Availability
A	0,90	0,97
B	0,85	0,90
C	0,60	0,90

Table 2: Example performance targets for F&G zones.

Step 5: Assess FGS detector coverage

The purpose of detector coverage assessment is to confirm that the selected detector layout can comply with the performance targets if the system is correctly installed, operated and maintained. The following guidelines should be followed to confirm detector coverage.

- The proposed layout and orientation of detectors should be assessed for the following:
  - To ensure the coverage footprint is sufficient to provide the required hazard alarms and control actions.
  - To ensure detector views are not impeded by pipework, cable trays, or other obstructions.
- The effective range of selected detectors should consider the expected environment, with the estimate based on test data.

The FGS Detector Coverage Assessment can take one of two forms. If there is an existing F&G system design an FGS converge assessment can be performed to verify that the existing design is adequate. For new facilities, or facilities without existing F&G systems the FGS Detector Coverage Assessment should be used conducted during the initial FGS design phase to avoid the need for costly changes to the design in later stages.

This step involves an assessment to determine how effective that proposed array of detectors with a given voting arrangement will be in detecting an incipient hazard at a level that will initiate a specified safety action. An assessment of detector coverage involves analysis of the potential sources of fire and gas within a given zone. There are (at least) two possible methods that can be used: geographic coverage assessment, and detector (scenario) coverage assessment. In either case, the analytical method to determine coverage could range from simple, look-up tables, to rigorous, computer modelling of physical phenomena.

Detector geographic coverage assessment

A geographic coverage assessment seeks to determine the degree of coverage of a monitored area, which contains a process with potential fire or gas hazards. The goal is to determine the fraction of geometric area within a monitored process area which, if a release were to occur in a given geographic location, it would be detected. Geographic coverage is a function of the release detection equipment in that monitored process area considering, obstacles that prevent or inhibit detection, and the defined voting arrangement for the safety action of interest. For example: an array of many flame detectors in a monitored area with few obstacles and a 1ooX voting arrangement would yield a higher geographic coverage than an array with only few flame detectors in an area congested with process equipment and a 2ooX voting arrangement. Detector geographic coverage does not require a specific risk scenario to determine coverage. The method assumes a hazard could occur anywhere within a monitored area and seeks to determine how well covered that area is. Detector geographic coverage does require general information about the magnitude of a fire or gas hazard that requires detection in a monitored area.

Criteria for Fire Assessment

In general, the system's ability to detect a fire of given intensity increases as the number of fire detectors in a monitored area increases. However, in any system there is a threshold fire intensity below which the system may not activate due to limitations on the sensitivity of flame detectors. Since an analysis of geographic coverage is not conducted on a scenario-by-scenario basis, a general criterion needs to be established to determine the fire intensity that requires detection at any location within a monitored area. This criterion determines the analytical endpoint for adding more detectors to obtain a given level of coverage.

Most optical flame detection methods are sensitive to thermal radiation at various wavelengths, and the radiated heat output (RHO) of a fire is an important parameter in determining the threshold for detection. Selecting a very low threshold RHO detection criterion (eg less than 10 kW) may be appropriate in some instances that are extremely vulnerable to small fire effects or present a severe potential for fire escalation; while in other situations this criterion may lead to excessive number of flame detectors because small fires cannot be sensed at moderate to large distances from a detector. On the other hand, selecting a very large threshold RHO criterion (eg greater than 300 kW) may be appropriate in some instances where only minimal coverage is required to annunciate a fire in a normally unoccupied process area; while in other situations may allow a fire to grow to an unacceptably large size beyond which automatic control actions (eg suppression) can be considered effective.

Criteria for Gas Assessment

The ability to detect a gas hazard at an incipient stage increases as the number of detectors increases. However, there are practical limits on the number and position of detectors that will imply the possibility of a small release going undetected as the gas disperses below its detectable concentration or situations where a small release remains

F&G– Fire and Gas
FGS – Fire & Gas System
GCA – Geographical Coverage Assessment
LOPA – Layer of Protection Analysis
RHD – Radiated Heat Output
SCA – Scenario Coverage Assessment

Abbreviations

undetected for a period of time until gas accumulation occurs in a semi-confined or confined area. Since an analysis of geographic coverage is not conducted on a scenario-by-scenario basis, a general criterion needs to be established to determine the size of gas release that requires detection anywhere within a monitored area. This criterion determines the analytical end-point for adding more detectors to obtain a given level of coverage. From a practical standpoint, the size and shape of a gas release that requires detection are required to perform a basis analysis of gas detector coverage. For flammable gas detection, factors such as the degree of confinement and presence of turbulence-inducing obstacles require consideration. The typical form of this criterion is a spherical gas cloud of given size (eg five metre diameter, etc); and the actual value can be based on analytical consequence modeling or study on the effects of flammable gas cloud size and the potential for damage blast effects from a deflagration. A smaller gas release criterion may be required in certain situations that are vulnerable to fire and explosion effects; while other situations a small criterion may lead to excessive number of detectors in an area that presents minimal hazard. A larger criterion may be appropriate in some situations; while in others it may allow an unacceptably large accumulation of combustible gas that presents a significant escalation hazard and beyond the capability of the mitigation system's effectiveness.

The advantages of Geographic Coverage Assessment (GCA) include an easy to understand graphical representation of results. There is no requirement to generate specific scenario-by-scenario coverage results. Computational requirements are high for this method (as well as scenario coverage).

The major disadvantage of the GCA method is that it is not sensitive to release frequency or hazard consequence severity.

For example, in a large area with few sources for a fire or gas hazard, use of the GCA can lead to a situation where detectors are added to cover portions of a monitored area that have a relatively low risk of and/or accumulation of gas. This limitation can also lead to a situation where a location with a high likelihood of a hazard is not covered adequately because that location is treated the same as any other location in the monitored area. It is possible to address these issues qualitatively but are better addressed in the second detector coverage mapping method, the Scenario Coverage Assessment (SCA).

Detector Scenario Coverage Assessment

A scenario coverage assessment, like that geographic coverage assessment, seeks to determine the degree of coverage of a monitored area, which contains a process with potential fire or gas hazards. However, that scenario coverage assessment differs from the geographic method in that it is sensitive to the risks present in the area being assessed.

To begin, specific risk scenarios need to be developed. This includes calculating the expected frequency of risk scenarios and determining that expected consequences.

Development of these scenarios generally requires detailed dispersion and consequence analysis, requiring specialised process hazard assessment software. The goal of the scenario coverage assessment is to determine the fraction of specific risk scenarios which are detectable by the F&G system. Computational requirements for the scenario coverage method are extremely high. This method is sensitive to the magnitude of hazard as well site specific information such as wind speed and direction.

Industry software is available for conducting the analysis of coverage. Most software is purpose-built on proprietary platforms. Examples include Kenexis Effigy computer-aided assessment software developed for the purpose FGS detector mapping.

Step 6: Assess FGS safety availability

Calculation of the FGS Safety Availability requires reliability analysis to be conducted. The purpose is to determine the probability of failure on demand of the FGS function, including the sensor, logic solver, and final control element(s) that are required to mitigate the hazard. Each FGS function should be subject to an analysis of FGS availability to verify it is capable of achieving the target availability established previously. The availability metric should be the average Probability of Failure on Demand, as an average over the functional test interval of the equipment. This is the summation of Sensor PFDavg + FGS Logic Solver PFDavg + Final Element PFDavg, where PFDavg is a function of the dangerous undetected failure rate, voting architecture of each device grouping, and functional test interval of the devices being considered. Quantification of FGS Safety Availability can be handled by typical probability math addressed in the ISA 84.01.02-2004 [4] technical report.

Step 7: Modify FGS Design

FGS design should be modified, as necessary, to achieve the performance targets for detector coverage and FGS safety availability. Typically the changes include: changing detector technology, relocating detectors, adding detectors, changing architecture and voting, and increasing functional test requirements.

Part 2: Fire detector mapping case study

FGS detector coverage mapping is an effective method for the assessment of an FGS detector layout to validate that the performance target is achieved. Both FGS coverage and FGS availability are equally important to a well designed F&G system. However, the objective of this case study is to demonstrate how the use of detector coverage mapping can be used to improve overall system design. For this reason it will be assumed that the FGS system availability is high and failure of the system due random hardware failure were assumed to be low. Based on an actual FGS design implemented offshore in the Gulf of Mexico, the study will demonstrate that both safety and financial gains can be achieved using detector coverage mapping.

By optimising the type, location and number of detectors, system improvements can be realised. Using the detector coverage mapping method can reduce the total number of detectors while maintaining a high level of coverage. This will be shown to improve upon the system design in the following ways:

- Reduce overall operating cost.
- Reduce lost production costs due to unexpected spurious trips and/or system maintenance.
- Improve safety and reduce risk

A single F&G zone of an offshore production platform was analysed. The zone contains three production separator, one which is redundant and normally out-of-service. This zone has moderate exposure to hydrocarbon fire and gas hazards and is a typical application for the use of detector mapping. For the purpose of simplification only the fire detection system will be analysed. Both fire and gas hazards were considered, however it was assumed that no gas detection system will be in operation. The zone contains hydrocarbon fire hazards from two sources. The two large separator vessels contain both hydrocarbon liquid and vapour under pressure (approximately 40 psig). The following figure depicts the zone.

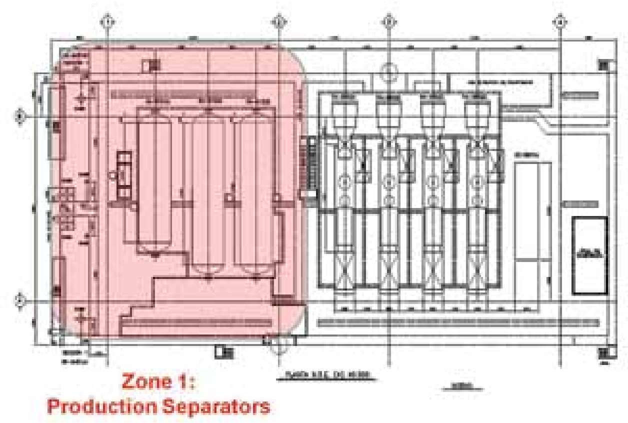

Figure 2: The single F&G zone of the offshore production platform.

Before the task of detector coverage mapping can be completed the requirements of the F&G system must be understood. This requires completion of steps 3 and 4 described earlier. The following paragraphs will describe these steps as they are critical to understanding the system requirements.

A loss of containment from a production separator has the potential to result in a variety of outcomes. Pool fires, jet fires and vapor cloud fires are all hazards of concern in this area. Based on historical industry data for offshore facilities the frequency of a release of process material from a production separator is approximately 6x10-3 events per year, or once in 166 year. Since two separators are in operation in this area the overall release frequency in this area is approximately once in 83 years. Again using historical industry data for the distribution of leak (rupture) sizes this frequency was distributed into three release size categories which were used to characterise a range of consequence severities. Releases from 5 mm, 25 mm and 75 mm (equivalent diameter) holes were considered.

As described there are three types hazardous outcomes; pool fire, vapour jet fire and vapour cloud fire. Considering that distribution of release sizes, a total of nine potential release scenarios were considered; a small (5 mm), medium (25 mm) and large (25 mm) case for the three types of hazards. The following tables present the expected outcomes for these nine hazards based on the results of details consequence and dispersion modelling.

Hole Size (equivalent hole diameter)	Release Rate	Personnel Impact	Asset Loss	Production Loss
5 mm	0,1 Kg/Sec	Serious Injury	$3 MM	10 Days
25 mm	3 Kg/Sec	Single Fatality	$30 MM	3 Months
75 mm	28,5 Kg/Sec	Multiple Fatality	$100 MM	6 Months

Table 3: Crude oil pool fire consequence analysis.

Hole Size (equivalent hole diameter)	Release Rate	Personnel Impact	Asset Loss	Production Loss
5 mm	N/A*	N/A*	N/A*	N/A*
25 mm	0,1 Kg/Sec	Serious Injury	$10 MM	4 Weeks
75 mm	0,9 Kg/Sec	Single Fatality	$30 MM	2 Months

** A small (5 mm) release of vapor from the production separators is not expected to discharge a sufficient amount of material with sufficient momentum to generate a jet fire.*

Table 4: Vapour jet fire consequence analysis.

Hole Size (equivalent hole diameter)	Release Rate	Personnel Impact	Asset Loss	Production Loss
5 mm	N/A*	N/A*	N/A*	N/A*
25 mm	0,1 Kg/Sec	Serious Injury	$10 MM	4 Weeks
75 mm	0,9 Kg/Sec	Single Fatality	$30 MM	2 Months

** A small (5 mm) release of vapour from the production separators is not expected to discharge a sufficient amount of material to result in accumulation of a vapour cloud with any measurable consequence if ignition were to occur.*

Table 5; Vapour cloud fire consequence analysis.

The consequences (personnel Impact, asset loss, production loss) in the above tables are generally developed in a workshop environment where engineers knowledgeable about the process provide input about the expected outcomes based on the results of the consequence analysis. These meetings should be similar in format to a PHA/LOPA workshop with personnel representing multiple disciplines (operations, process, control systems, etc.).

Using Probability math, the frequency of each of the nine outcomes list above was calculated. For example, in order to determine the frequency at which a small pool fire can be expected the following equation is applied:

$$i = {}_{Total} * P_{Liq} * P_{5mm} * P_{ign}$$

Where: = i frequency of a small pool fire

${}_{Total}$ = Total Frequency of a release

P_{Liq} = Probability that the release is from the liquid section of the vessel

P_{5mm} = The fraction of liquid releases that are small (5mm)

P_{ign} = The probability of ignition for a small liquid pool

Applying this sort of probability math to each of the nine outcomes yields the results in the following table. This table is a summary of the unmitigated risk in the area of the production separators. In other words, it is the risk without the benefit of the F&G system.

Release Frequency	1.2E-02	1 in 80 years
Serious Injury Frequency	1.4E-05	1 in 70 000 years
Single Fatality Frequency	1.6E-05	1 in 63 000 years
Multiple Fatality Frequency	1.4E-06	1 in 715 000 years
Annualised Financial Risk	$18,800	

Table 6: Summary of unmitigated risk.

Financial risk can also be reported graphically using an F-N curve, where the vertical axis is cumulative frequency and the horizontal axis is commercial loss.

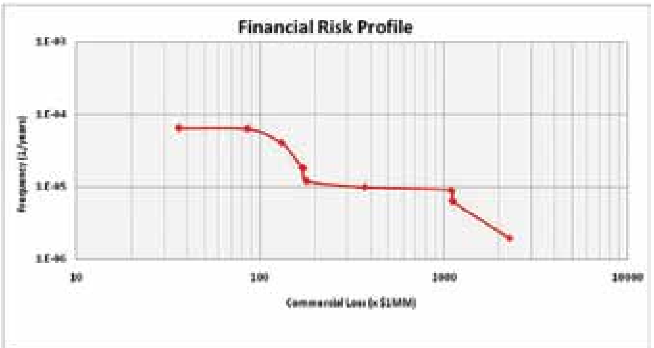

Figure 3: Financial risk profile.

Based on the corporate risk criteria of the owner/operator of this platform the above results require that a FGS fire grade performance target of "C" be applied to this zone. This means that the fire detection system should be capable of achieving at least 60% coverage in the area.

Verification that this target is being achieving requires modeling of the detector coverage. As stated earlier, to simplify the analysis the gas detection system was ignored. It was assumed that no gas detection system was operating and therefore all gas releases are undetectable (unless ignited). The following figure is the existing fire detector layout in the area of the production separators.

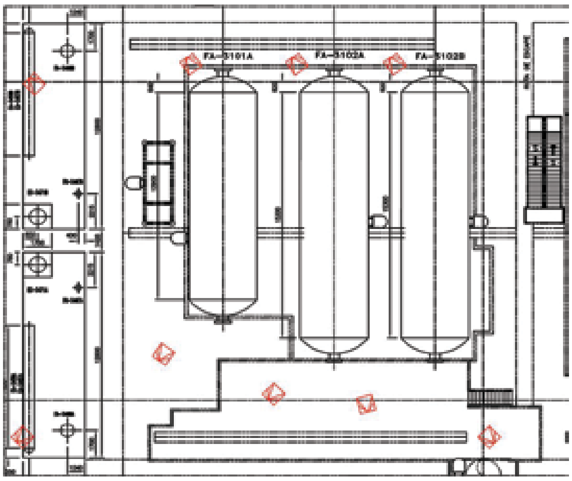

Figure 4: Existing fire detector layout in the area of the production separators.

There is a total of nine fire detectors in the existing system. Detectors are IR type and due to the marine environment are angled down sharply from the horizontal to avoid spurious activation due to incident IR radiation. It has been well documented that optical fire detectors are vulnerable to spurious activation in offshore environments due to reflection of the suns radiation off the surface of the water. Increasing the declination angle of the detectors is a common way to avoid spurious trips from reflection off the water, however it also required that the detectors be mounted closer to the area being monitored as the viewing angle is reduced. Voting in the system is 1ooN to alarm and 2ooN to take automated action.

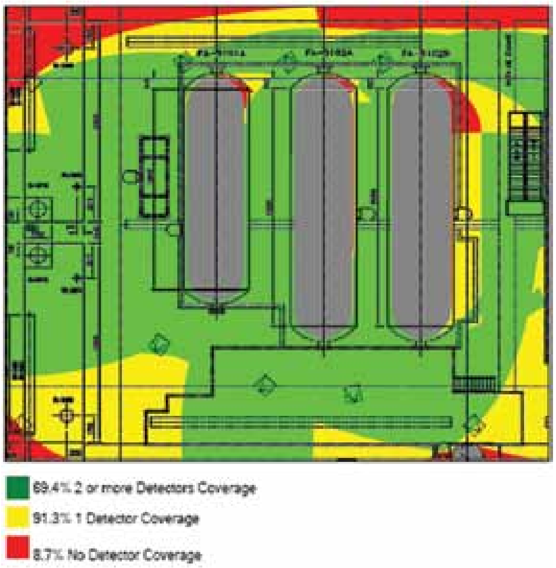

Figure 5: This figure has been generated to show the results graphically.

Using a purpose build software modeling tool the fire detector coverage of the existing system was calculated. It was determined that the existing detector array was capable of achieving 91% coverage for alarm (1ooN) and 69% coverage for automated action (2ooN). The following figure has been generated to show the results graphically.

In general, fire coverage in this area is high. However, the operator of this facility has had a history of false trips of the F&G system resulting in nuisance alarms and in some cases lost production due to spurious activation.

The operator wishes to maintain a high degree of coverage while improving the system resistant to spurious activation and reduce maintenance costs and downtime. A project was approved to replace the existing system with an improved system which would meet these criteria.

Before calculation of the detector coverage an appropriate detector technology must be selected. The existing system was commissioned several decades ago when IR type fire detectors were the technology of choice for offshore applications. In more recent years UV/IR or multi-spectral IR technologies have become available. These technologies have been proven to reduce spurious trips by filtering ‘noise’ and analysing and boarder spectrum of light. Because the rate of spurious trips had become an unacceptable problem a complete change in detector technology was being considered. The preferred technology for this application was multi-spectrum IR detectors, which have been proven to provide high spurious trip resistance offshore.

Although there is significant upfront cost involved with replacement of detectors, reduction in system maintenance would justify the cost. The change in detector technology also allowed for detectors to be placed further from the process due to the increased sensitivity of multi-spectrum IR detectors to hydrocarbon fires.

Given the new system parameters, multiple detector layouts were considered and modeled to determine coverage. The following layout was chosen because it was proven to provide high coverage with a minimal number of detectors.

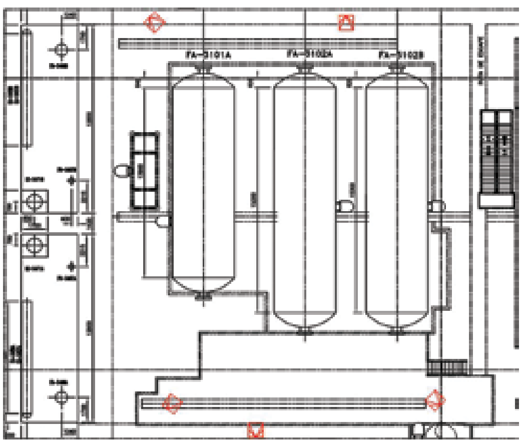

Figure 6: Layout selected because it provided high coverage with a minimal number of detectors.

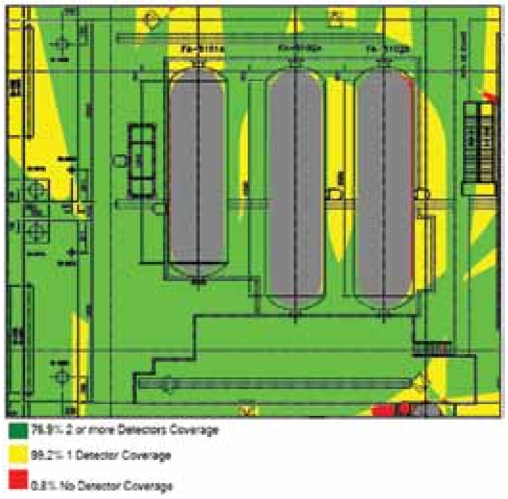

Figure 7: Detector coverage mapping revealed that this design not only reduced the total number of detectors but also improved detector coverage.

Quantitative risk analysis revealed that the new system was capable of reducing risks significantly. Both financial and personnel risks were reduced by approximately 50%. The following table and figure depict these results.

	Unmitigated		Mitigated	
Release Frequency	1.2E-02	1 in 80 years	1.2E-02	1 in 80 years
Serious Injury Frequency	1.4E-05	1 in 70 000 years	2.3E-05	1 in 45 000 years
Single Fatality Frequency	1.6E-05	1 in 63 000 years	9.5E-06	1 in 106 000 years
Multiple Fatality Frequency	1.4E-06	1 in 715 000 years	4.9E-07	1 in 2MM years
Annualised Financial Risk	$18,800	(US Dollars)	$9 300	(US Dollars)

Table 7: Summary of FGS effectiveness.

Figure 8 shows that financial risk was able to be reduce by mitigating the severity of a release, reducing the costs associated with both asset and production losses. The results revealed a reduction in overall financial risk of $ 9 500 per year in the area of the production separators. However, when the results are extrapolated to include all areas of the production platform, including fuel gas turbines, gas treatment and transfer pumps, the overall annualised reduction in financial risk was $ 87 000 per year.

Figure 8: Financial risk was able to be reduce by mitigating the severity of a release, reducing the costs associated with both asset and production losses.

	Unmitigated		Mitigated	
Release Frequency	1.1E-01	1 in 9 years	1.1E-01	1 in 9 years
Serious Injury Frequency	1.3E-04	1 in 7,600 years	2.1E-04	1 in 4 733 years
Single Fatality Frequency	1.5E-04	1 in 6,846 years	8.7E-05	1 in 11 518 years
Multiple Fatality Frequency	1.3E-05	1 in 77,750 years	4.5E-6	1 in 221 000 years
Annualised Financial Risk	$ 172 000	(US Dollars)	$ 85 000	(USD)

Table 8: Summary of FGS effectiveness.

In addition to the reduction in risk, the new system was able to significantly reduce maintenance cost due to the selection of appropriate detector technology as well as an overall reduction in the number of detectors requiring maintenance. Maintenance costs of the system were reduced by an estimated 22%.

Conclusion

By employing the methods of risk based F&G system analysis, specifically detector coverage mapping, the overall design of this system was improved significantly. Risks were able to be reduced in regards to both personnel protection as well as financially. The frequency of false alarms signals from the FGS was also significantly reduce by selecting appropriate detector technology and optimisation of the detector layout, reducing the overall number of detector while maintaining high levels of coverage. Although the methods of risk based F&G system analysis are relatively new to the process industry it is likely that future F&G system designs will make use of these techniques to improve system design and reduce system costs.

References

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