

Fire & Gas Detection in Process Industry

Presentation Part - 2

Comparing QRA Results, Hazardous Area and F & G Layout

Emulsion Transfer Pumps

FWKO Tank

Ring Main Header

Total fire and explosi risk contour level:

- ≥ 0.0
- $\geq 1.00e-009$
- $\geq 1.00e-008$
- $\geq 1.00e-007$
- $\geq 1.00e-006$
- $\geq 1.00e-005$
- $\geq 1.00e-004$
- $\geq 1.00e-003$

EDUNDANT) PIT

STING ICE NEW FENCE (NOTE-3)

EVAPORATION POND (NO. 2 COMPARTMENT)

EVAPORATION POND (NO. 1 COMPARTMENT)

SWITCHGEAR & FIELD AUXILIARY ROOM

CONC. STAR E 636.375

CONC. STAR E 641.500

CONC. STAR E 666.375

CONC. STAR E 681.500

CONC. STAR E 686.375

CONC. STAR E 701.500

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CONC. STAR E 1981.500

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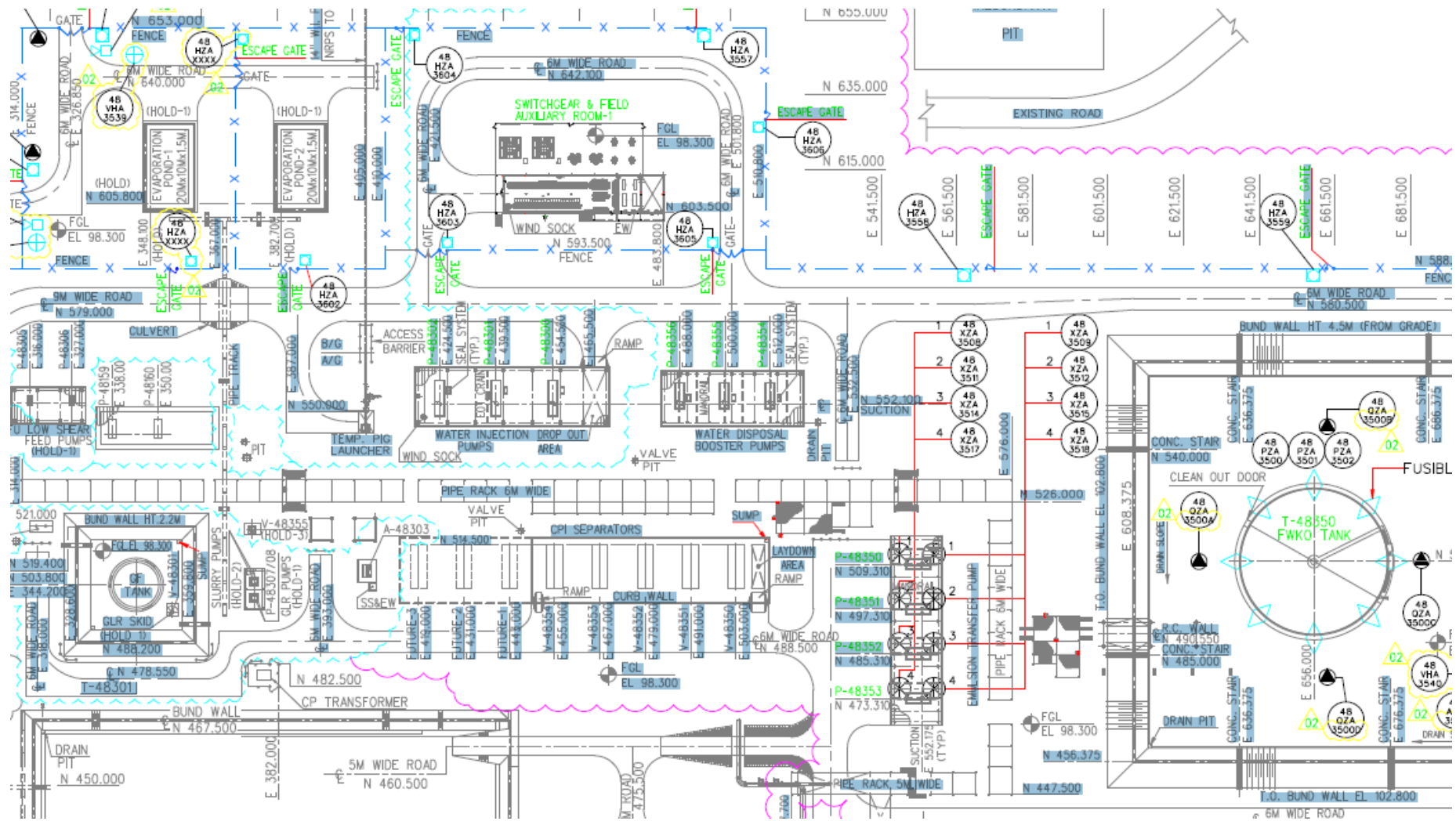
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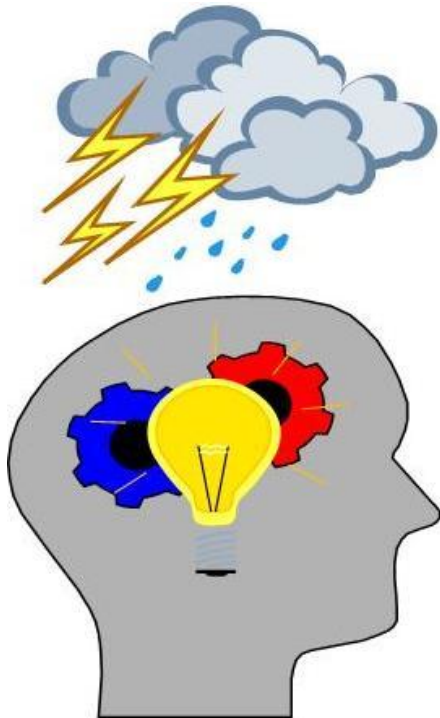
CONC.

F & G Layout (NRPS)

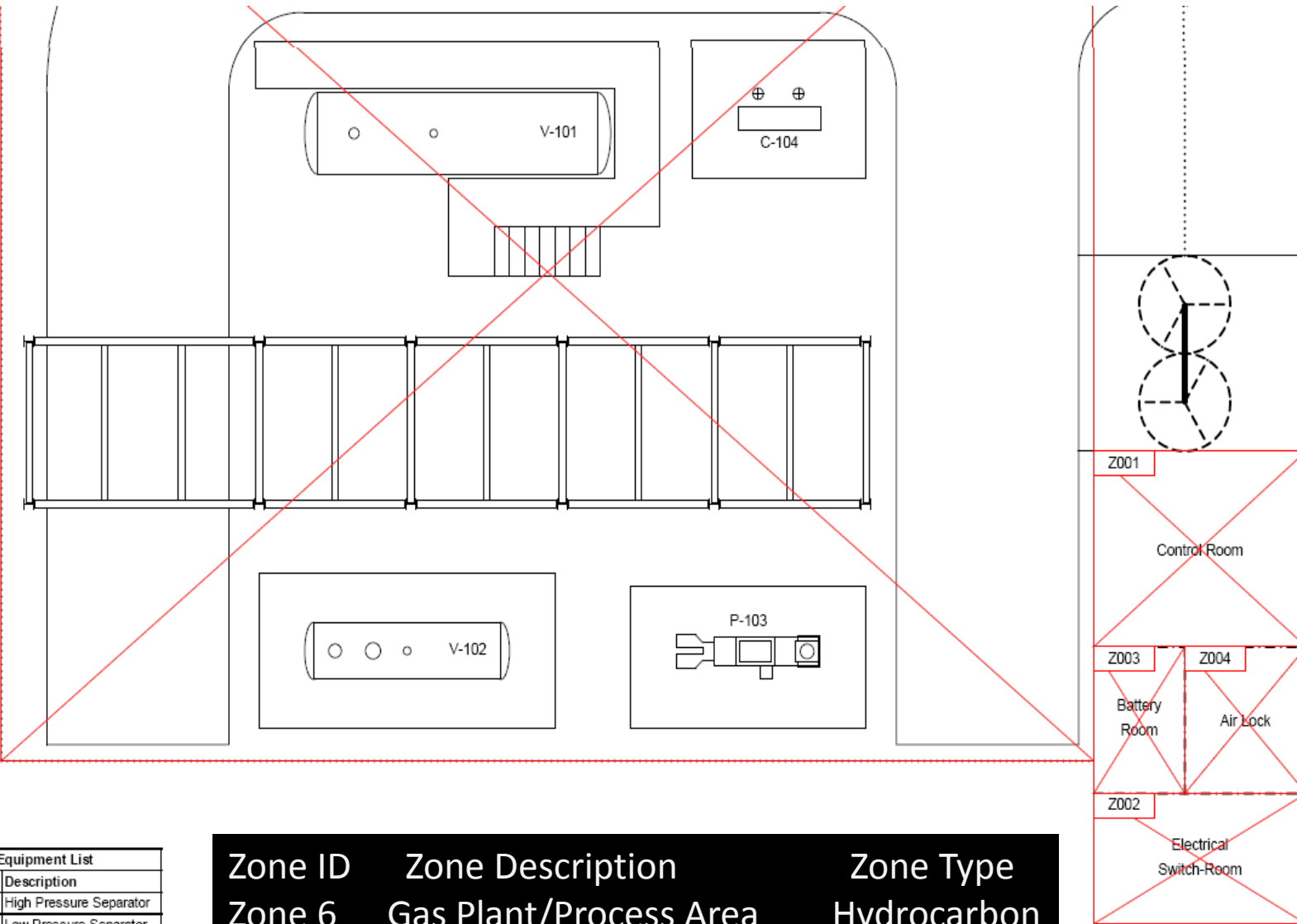


Sample Exercise

Placing F& G Detectors



SAMPLE LAYOUT for F & G



Equipment List	
Tag No.	Description
V-101	High Pressure Separator
V-102	Low Pressure Separator
P-103	Export Pump
C-104	Gas Compressor

Zone ID
Zone 6

Zone Description
Gas Plant/Process Area

Zone Type
Hydrocarbon

Proper Selection of Fire & Gas Detectors

- Optical Flame Detectors
- Smoke Detectors **x**
- Heat Detectors
- Hydrocarbon Gas Detectors

Proper placement of detectors is critical in the design of a fire and gas system to ensure that coverage is adequate to detect hazards at their incipient stage, before escalation

Selection of the improper detection technology can often lead to problems in the operation and maintenance of a fire and gas system. In many cases detectors are selected which are not suitable for the application, resulting in spurious alarms or ineffective detection of hazards.



Use of F&G in Hydrocarbon Processing Facility

Assessment of the Hydrocarbon Processing Equipment

- 1.1 Amount and type of equipment in the zone
- 1.2 Potential credible sources of hydrocarbon in the zone
- 1.3 Ignition Sources
- 1.4 Concentrations of toxic gases in processing fluids

2. Assessment of Fire and Gas Consequences

- 2.1 Determine release scenarios which the system is intended to protect against
- 2.2 Consider commercial asset valuation and business consequences
- 2.3 Consider safety related consequences including personnel and public safety

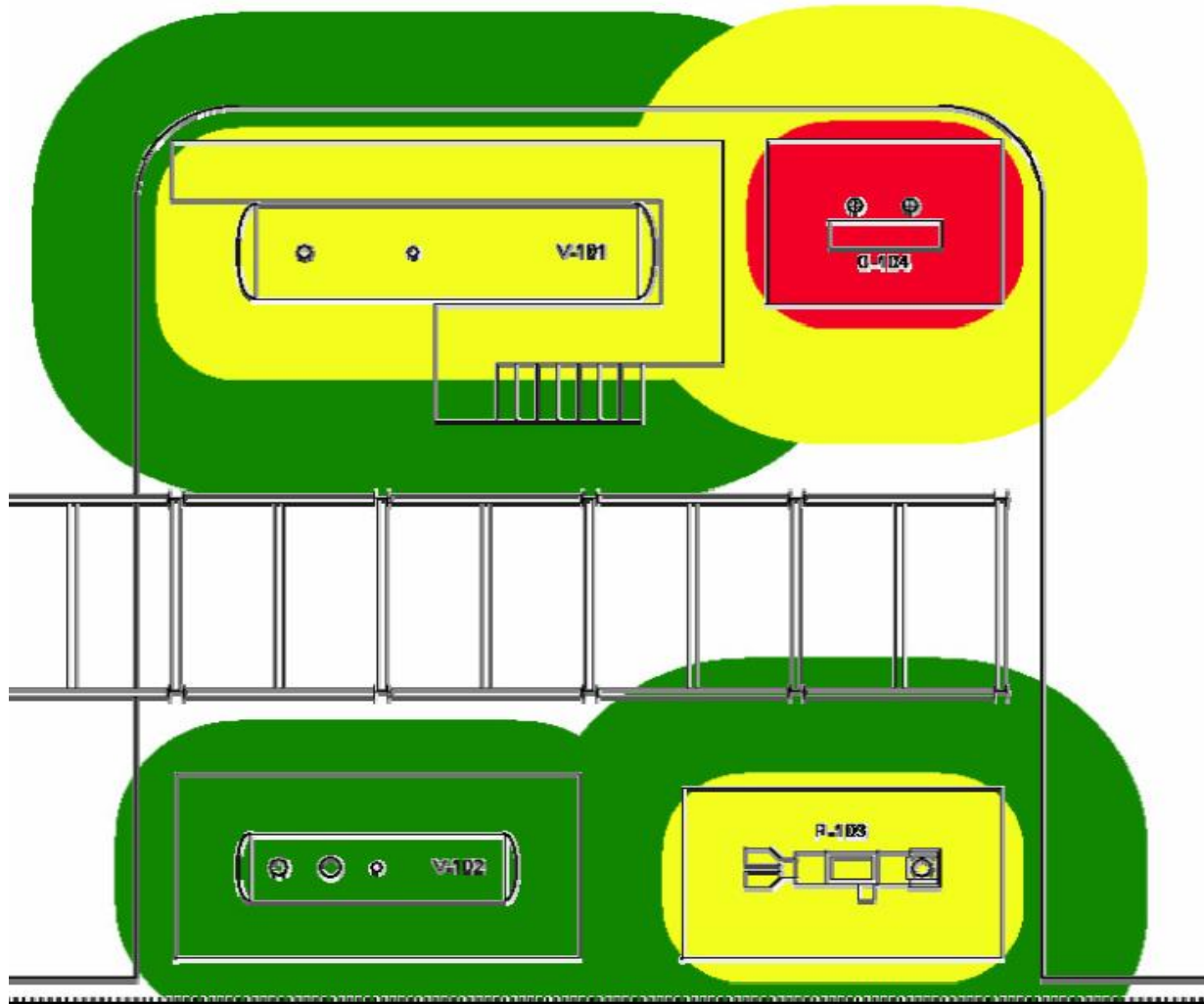
3 Determine opportunity for effective operator response action to prevent hazard escalation

4. Assessment of level of human occupancy.

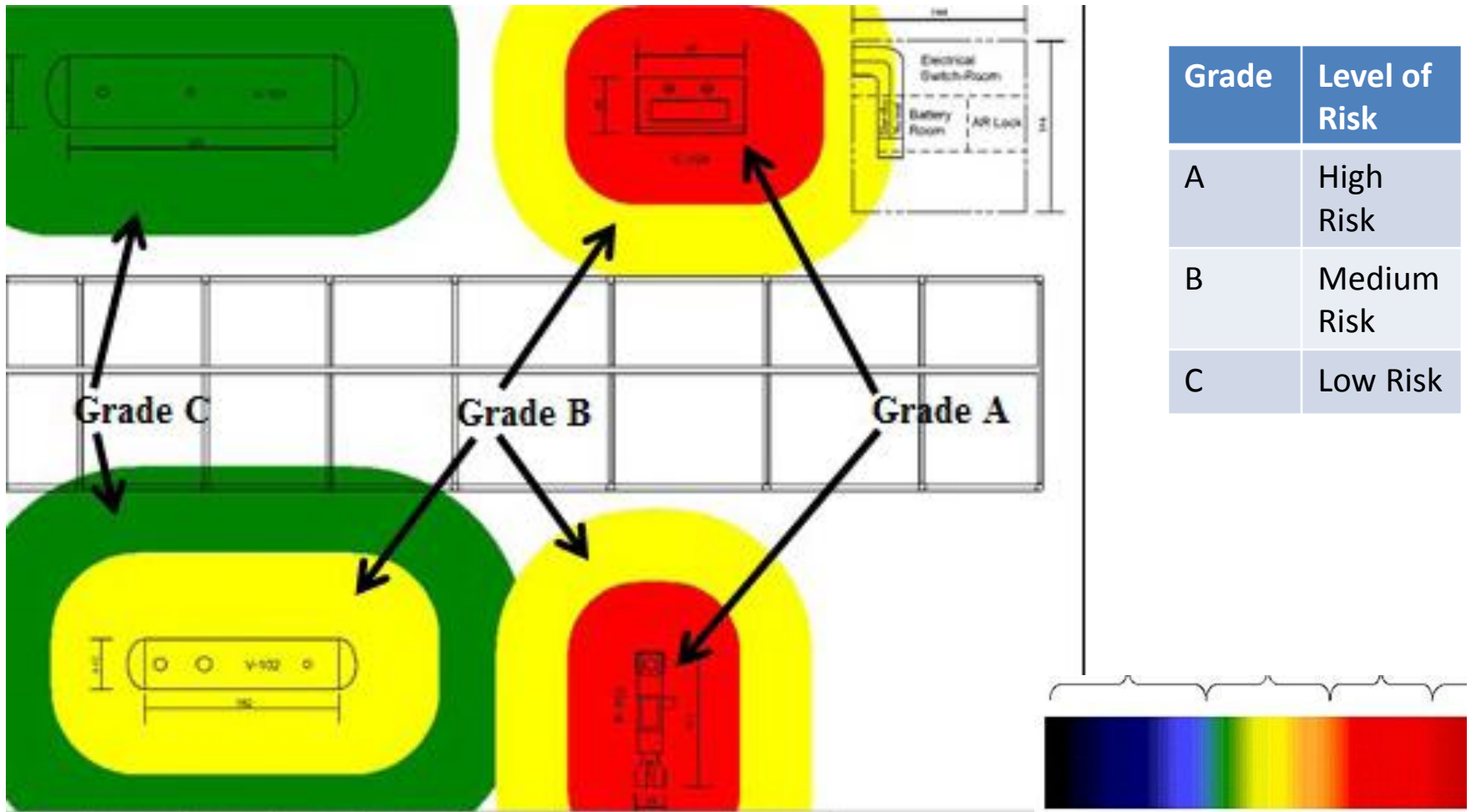
FGS Function & Performance Target List

Equipment List											Graded Areas
Equip Tag	Equip Type	Hazard Type	Leak Scenarios								
			Leak Description	Hole Size	Item Leak Frequency	HC HAZARD RANK					
						Consequence (Risk Matrix)			Rank Criteria		
						Severity - Safety	Severity - Asset	Severity - Environment	Hazard Rank (Release Rate)	Hazard Rank (Occupancy)	
C-104	1E-1	Comb. Gas	Small Leak of HP Gas from Export Gas Compressor	5 mm	9.2E-02/yr	3	3	3	<1 kg/sec	<=50%	A
			Large Leak of HP Gas from Export Gas Compressor	25 mm	8.0E-03/yr	4	3	3	1 to 50 kg/sec	<=50%	
P-103	WH	Liquid HC		5 mm	2.8E-03/yr	4	3	5	1 to 50 kg/sec	<=50%	B
			Leak of Stabalized Liquid From Export Pump	25 mm	2.4E-04/yr	5	4	6	>50 kg/sec	<=50%	
V-101	SV	Comb. Gas	Leak of HP Gas from High Pressure Separator	5 mm	9.2E-04/yr	4	4	2	1 to 50 kg/sec	<=50%	B
				25 mm	8.0E-05/yr	5	4	2	>50 kg/sec	<=100%	
V-102	SV	Comb. Gas	Leak of LP Gas from Low Pressure Separator								

Zone Grading Extents Drawing



Extent of Grading



Color indicates the frequency of a gas release (or a fire release) existing at that specific location. At any particular location, colors on the right side of the visible color spectrum indicate high likelihood of a gas release or fire

Locating Fixed Combustible & Toxic Gas Detectors

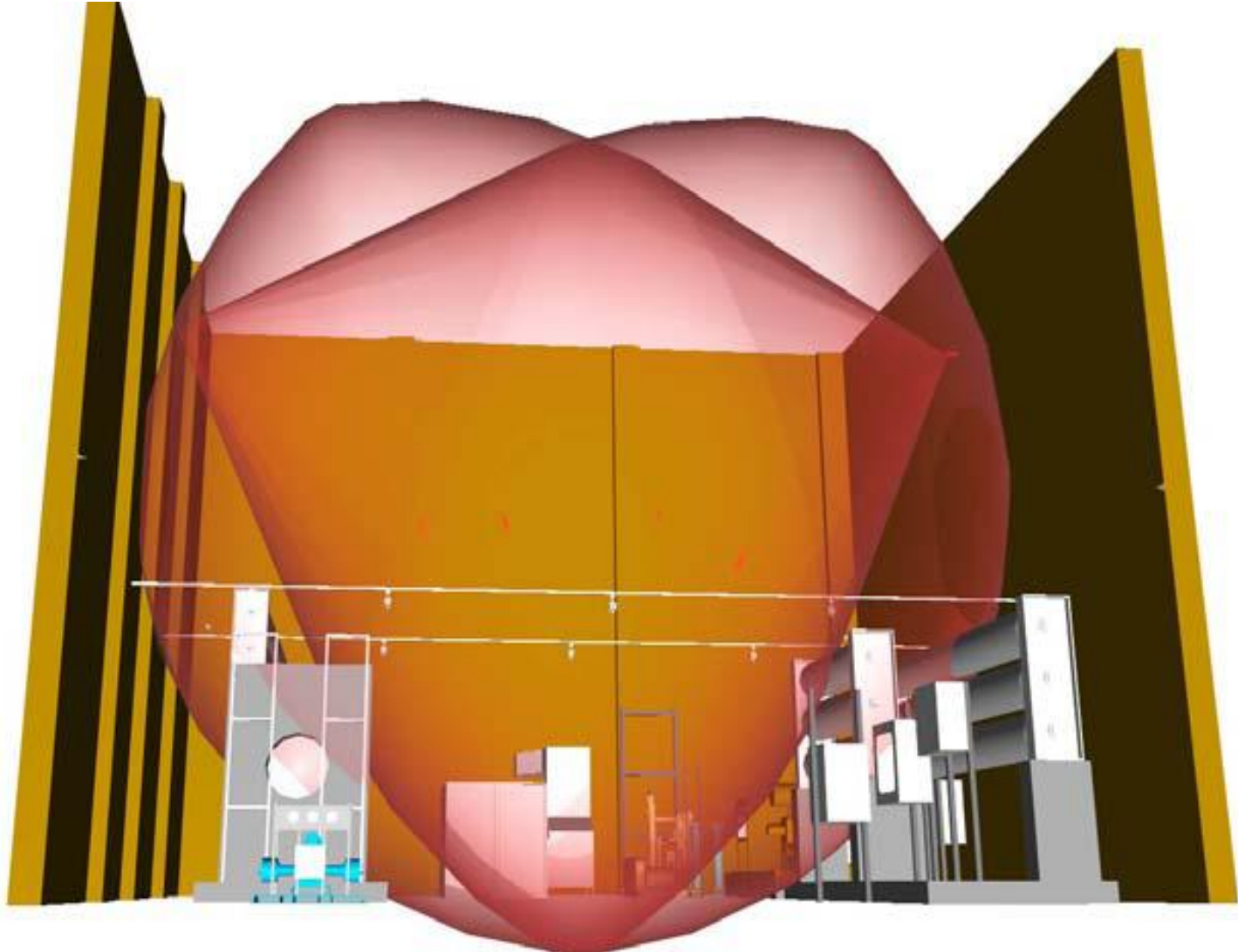
General considerations in positioning combustible and toxic gas detectors include the following:

- Elevations depending on relative density of air and any potential gas leakage.
- Installed in a grid pattern. At recommended spacing, or at reduced spacing for faster response.
- Possible flow direction of leaking gas and ventilation characteristics
- Proximity to potential hazards.
- Accessibility of detectors for calibration and maintenance.
- Manufacturer's recommendations.

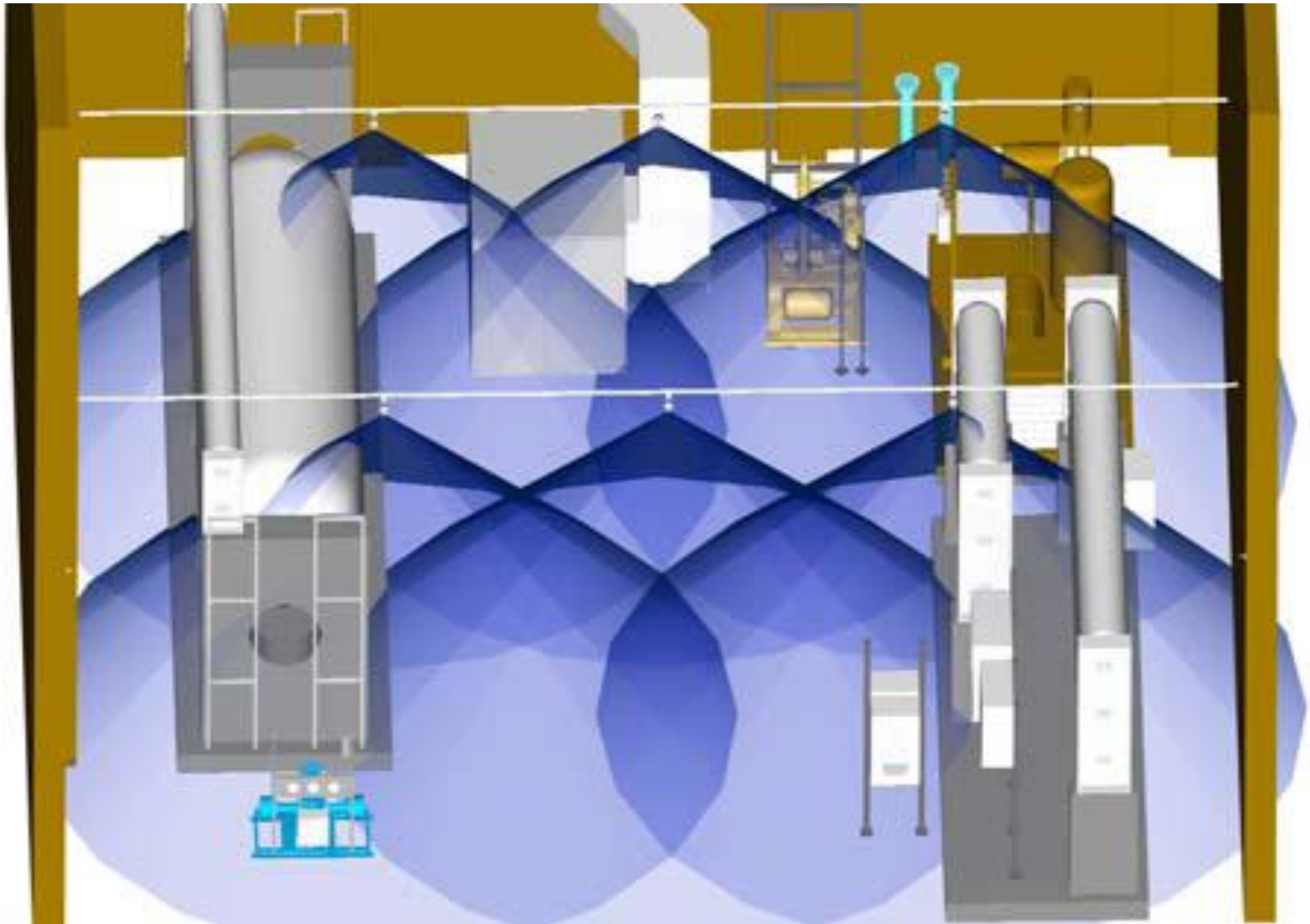
Green indicates coverage by two or more detectors, yellow indicates coverage by a single detector, and red indicates no coverage.

Visual fire detector map that is a color-coded representation of the areas covered and the % of coverage of each area.

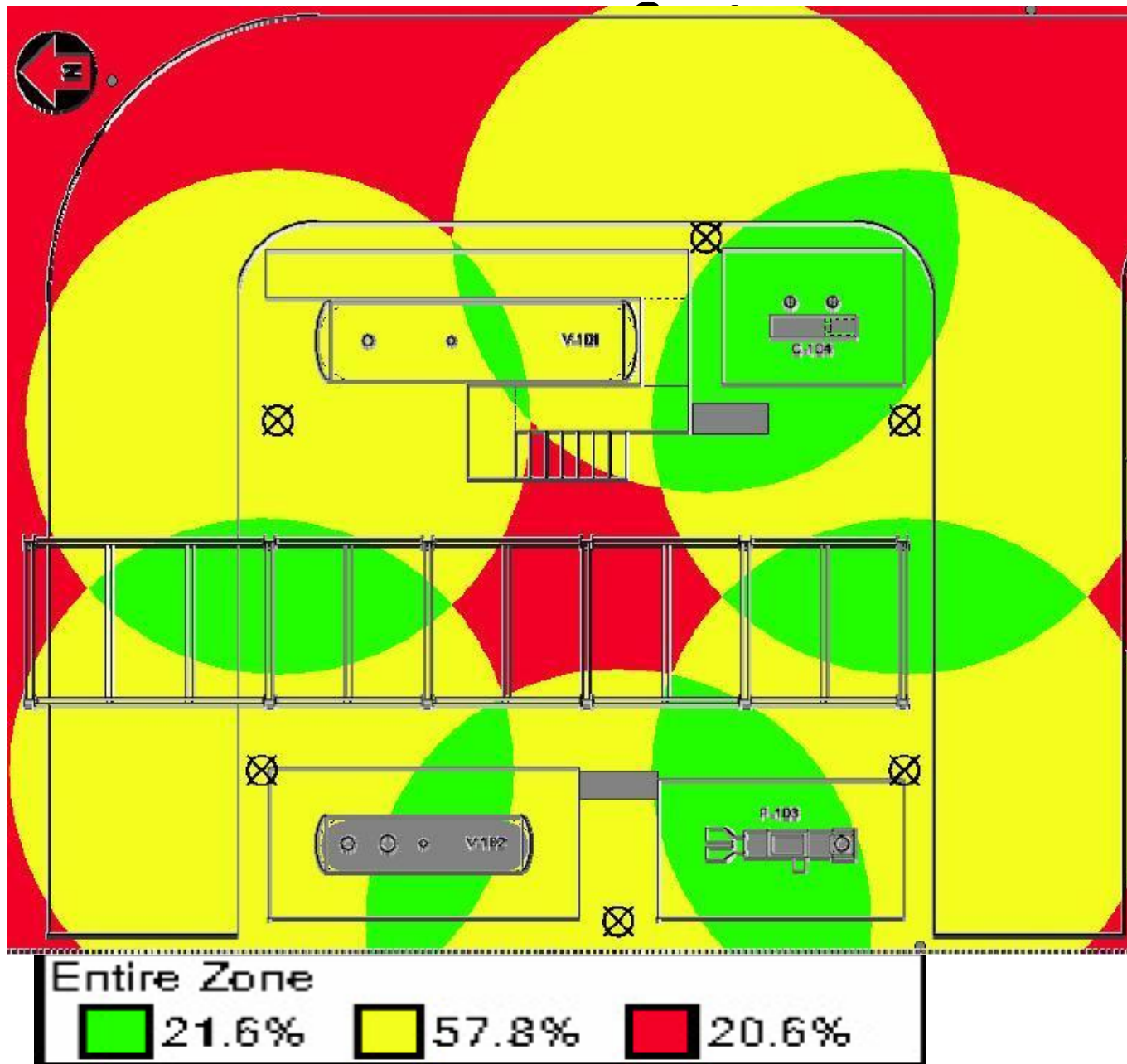
IR /UV Detector on walls - Scan footprint



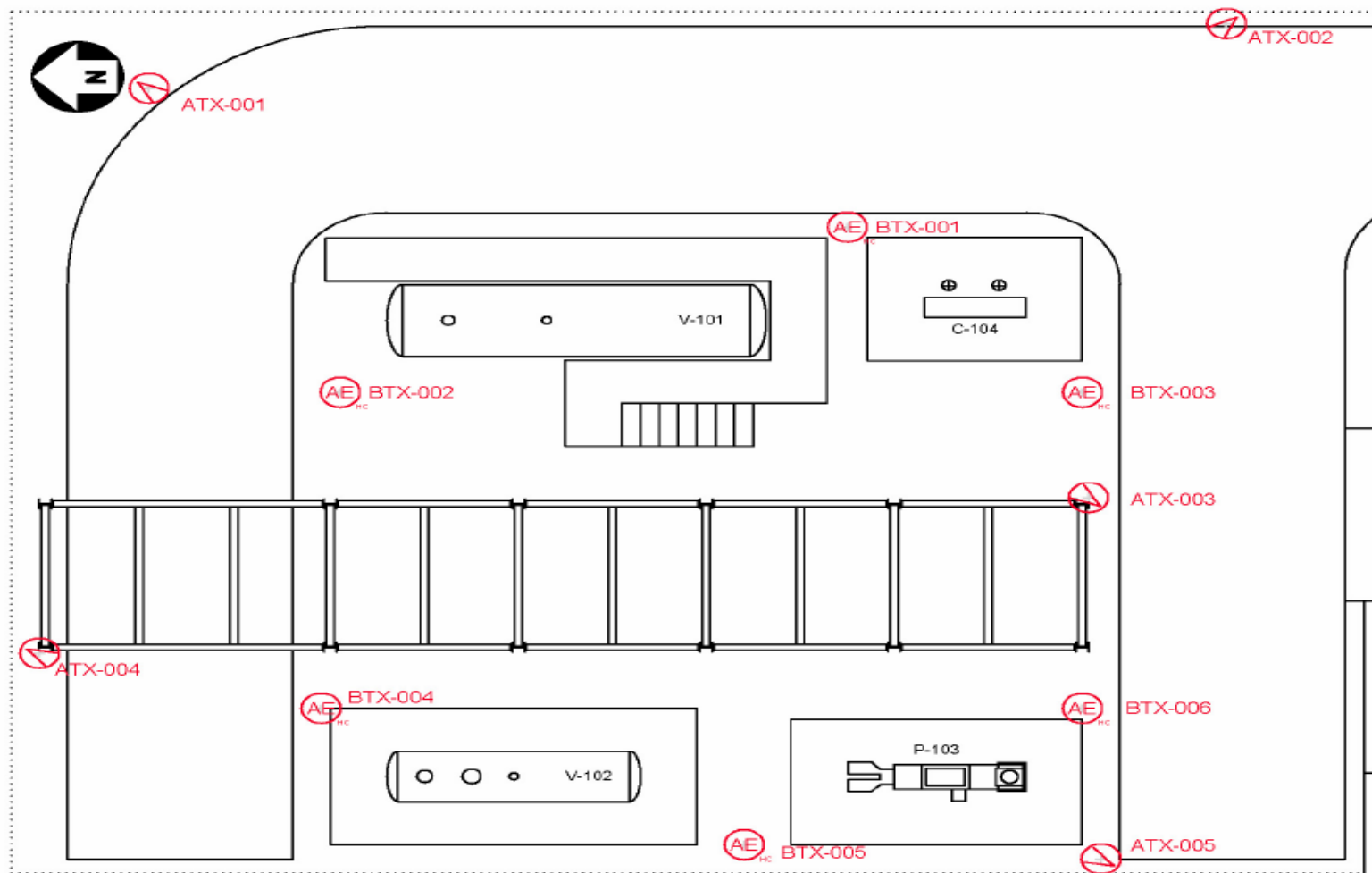
Gas detector on Ceiling - Scan footprint for Methane



Typical Gas Detector Layout–Gas Detection Coverage



Typical Fire and Gas Layout



Equipment List	
Tag No.	Description
V-101	High Pressure Separator
V-102	Low Pressure Separator
P-103	Export Pump
C-104	Gas Compressor

Considerations when placing F& G Detectors and Areas of Concerns

Consideration for F& G Detection

- Regulatory requirements;
- Hazardous area zoning, HEMP, QRA
- Limits of equipment congestion;
- Potential leak sources and areas where accumulation of gas may be likely or particularly hazardous;
- Type of detection approach to be provided – perimeter, area, or equipment specific;
- Detector voting logic to be deployed;
- Properties of process fluids (composition, volatility, phase, temperature, pressure, toxicity);
- Characteristics of potential releases (jet or flashing liquid, plume, buoyancy);
- Forced or natural draft ventilation patterns, wind speed and wind direction.

Current knowledge of Detection Effectiveness

Gas Detection

- Gas Detector head spacing is governed by the size and geometry of the area (confinement and congestion), **ventilation** and the nature of Hydrocarbon release.
- Typically the minimum spacing in congested areas is around 5 m based. Problems: Trapped volumes, / local confinement, Gas/vapour tends to slump, particularly in low air movement areas.
- Acoustic detectors. Location based on identifying the potential sources of leaks, e.g. all joining parts in high pressure gas installations. An ultrasound map of the background noise can be determined.

Current knowledge of detection effectiveness – Cont.

Fire and Smoke Detection

- Fire detection by heat rise or flame radiation. Unlike gas detectors these instrument are reliable and effective and independent of the ventilation regimes.
- For IR flame detectors range ~ 25 m. CAD used to optimise their coverage. Triple band IR systems are less prone to false alarms.
- Point Gas and Point smoke detectors depend on combustion products (particulates and gases) to the detector by convection. Smoke detectors are located at 7.5 m apart and are not appropriate for high ceilings (>10.5 m).

Areas of Uncertainty

- Guidelines for optimal combination of point, beam and acoustic detectors are dispersed in various documents and lack useable detail.
- Location of detectors for various types of flammable gas release: methane, propane and condensates are not defined.
- Response of instruments calibrated for methane to higher chain hydrocarbons are not well defined and awareness in the Industry is low (methane and C5-C8 hydrocarbons)

Current knowledge of detection effectiveness – Cont.

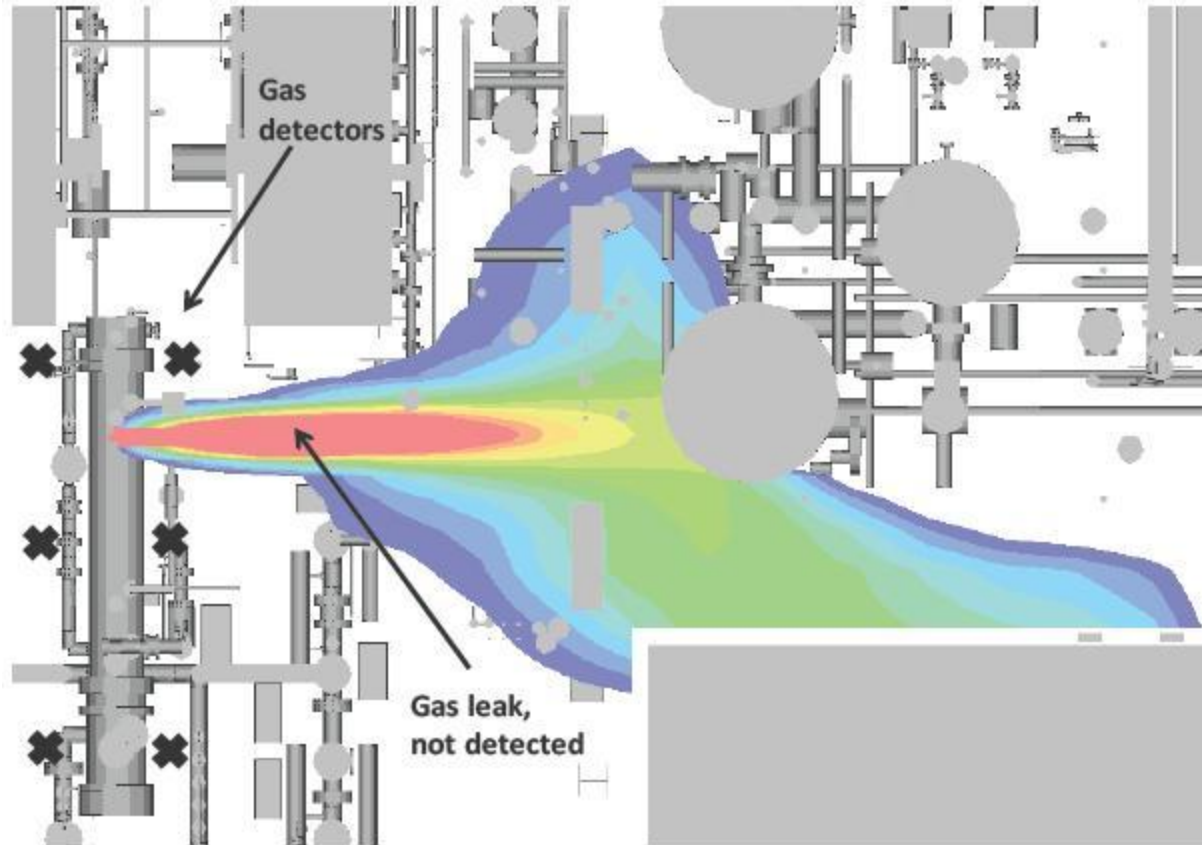
Areas of uncertainty – Cont.

Industry practice is based on the general guidance provided in company codes of practice (e.g. Shell, 1995 and BP, 1997). BS EN ISO 13702 contains high level advice on detection systems.

Finding of a of large scale experimental study :

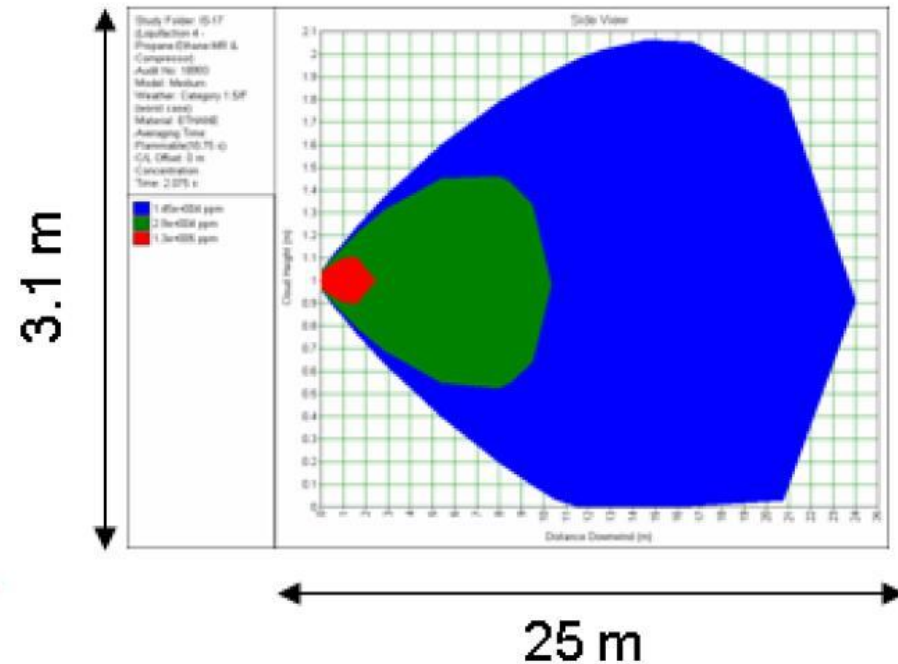
- 1) The use of a grid based on 5 m spacing for point detectors was successful in detecting releases where clouds formed within the module;
- 2) Having the spacing between detectors slightly reduced detection times but at the expense of a large increase in the number of detectors required. Doubling the detector spacing caused a large increase in detection times;
- 3) The IR point detectors performed better than the catalytic detectors, both in the number of releases detected and in the detection time;
- 4) Well-placed detectors can improve the performance of a detection system [with knowledge of dispersion, the processes undertaken in a module, equipment layout]

Pressurized Leak Dispersion Pattern



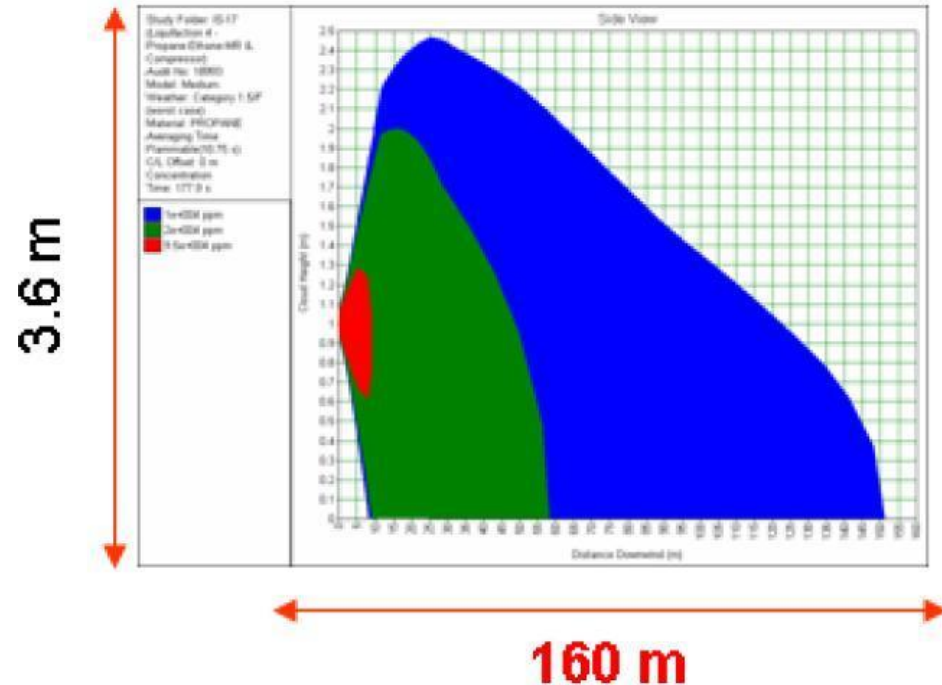
Pressurized gas leak flowing past detectors into an open area of the facility

Dispersion Pattern & Hydrocarbon Density



20mm release from Ethane circuit
 Tave= 2.3 C Pave= 22 bara

Ethane Dispersion

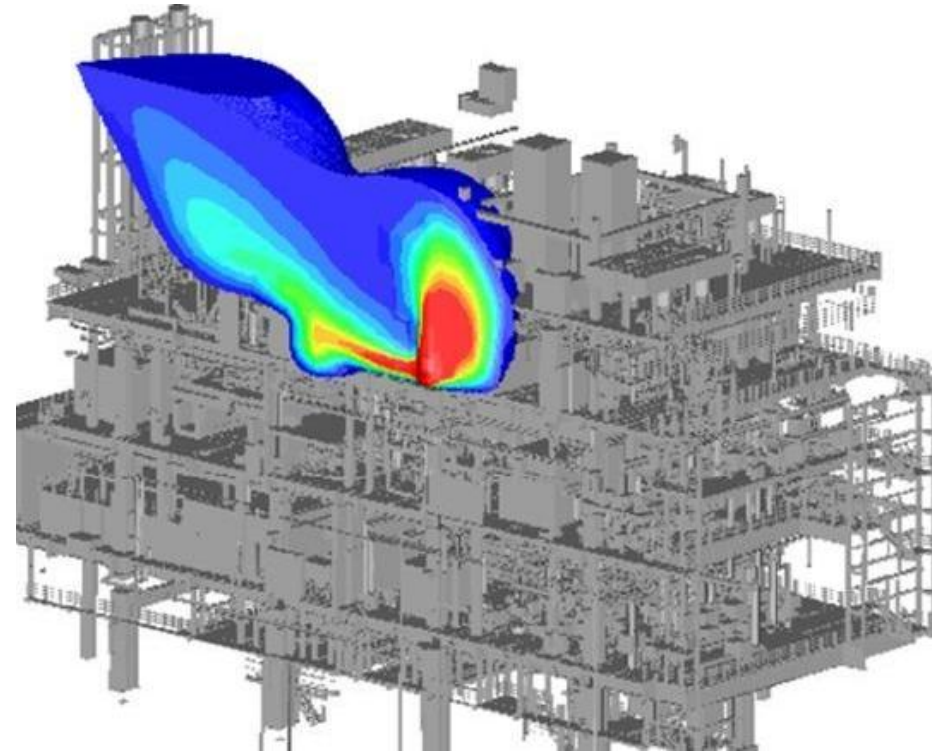


20mm release from Propane circuit
 Tave= 56 C Pave= 19.7 bara

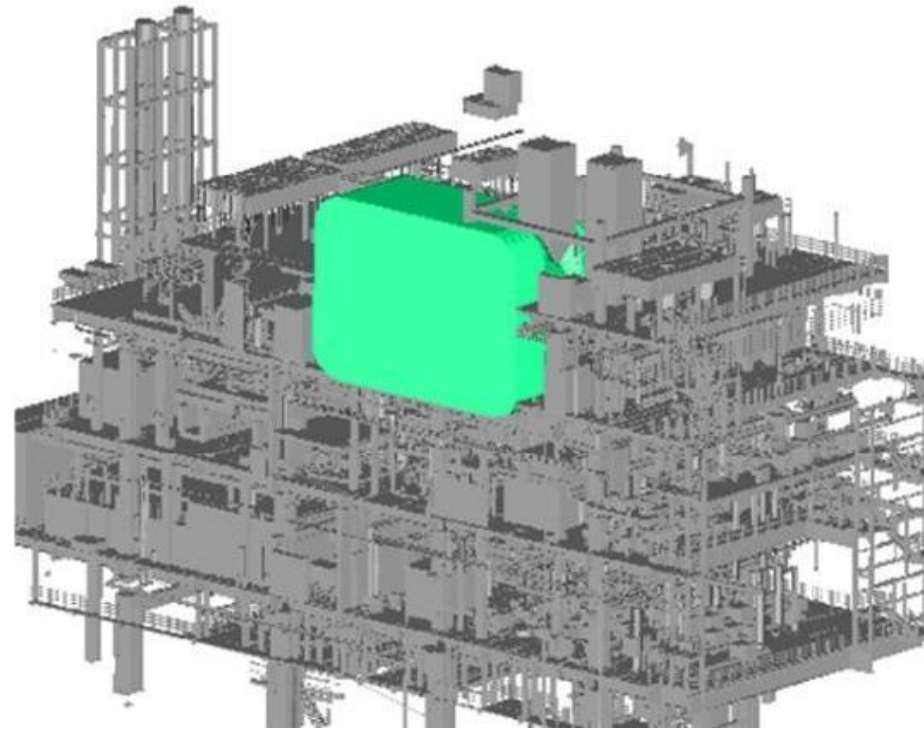
Propane Dispersion

Gas Cloud Dispersion -Assumption

In homogenous gas cloud from dispersion simulation



Dimensioning gas cloud used in assumption / layout



Equivalent Stoichiometric Cloud mapping of resulting inhomogeneous clouds determined from gas dispersions

Strategy Development Issues

Further, more specific guidance is needed on the most effective location of detectors in a system. This guidance should be based on experimental studies of (to overcome area of concerns):

1) - Methane releases;

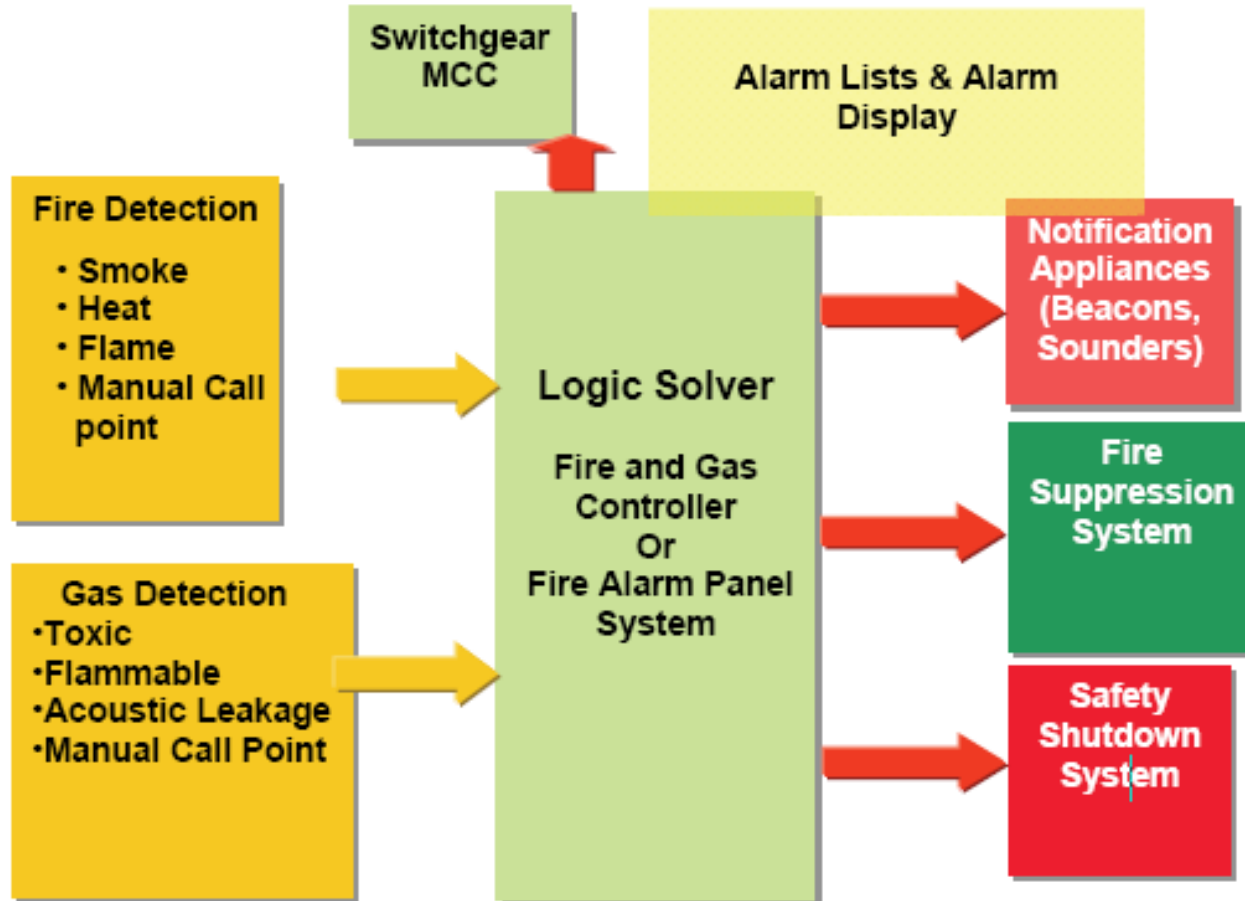
- Higher fraction, e.g. propane, releases; and
- Condensates (C5-C8 hydrocarbon) releases.

2) The response of sensors calibrated to one type of hydrocarbon when exposed to longer or shorter chain hydrocarbons specific to the well fluids should be investigated with the aim of improving overall detection performance.

3) Be aware of real time ventilation data, it is key element in installing an effective gas (and smoke) detector system.

Working of F & G Safety Systems

Working of F & G Safety System

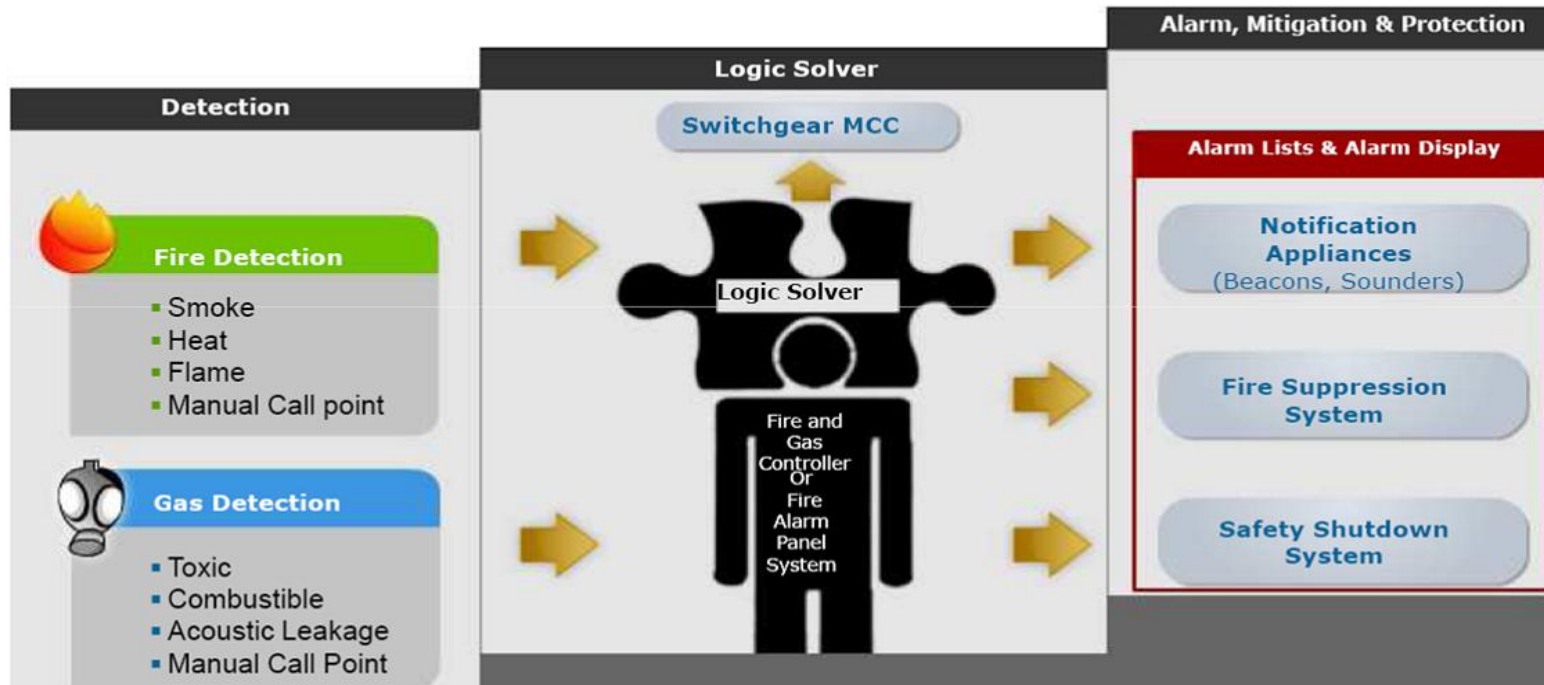


Typical F&G safety system comprises detection, logic control and alarm and mitigation functions. Logic solver is the central control unit of the overall F&G detection and control system. The controller receives alarm or analog signals from field monitoring fire and gas detectors. The controller handles the required actions to initiate alarms and mitigate the hazard.

Example - Working of F & G Safety System



Fire & Gas Detection System Interfaces



**F&G Logic Solver
Safety Manager (SIL 3)**

**ESD
Safety
Manager**

**DCS
Experion PKS**



Fire & Gas detectors, Manual Call Points

Sounders, Beacons

**F&G Mimic
Panel**

Fire & Gas Detection System Control Interfaces

Measure

Control

Actions

**Fire/Smoke
Sensors**



**Temp
Safety Switches**



Gas Sensors



**Temp
Transmitters**



**Building Automation
Systems**



**Fire System
Panels**



**F & G Loop &
Logic Controllers**

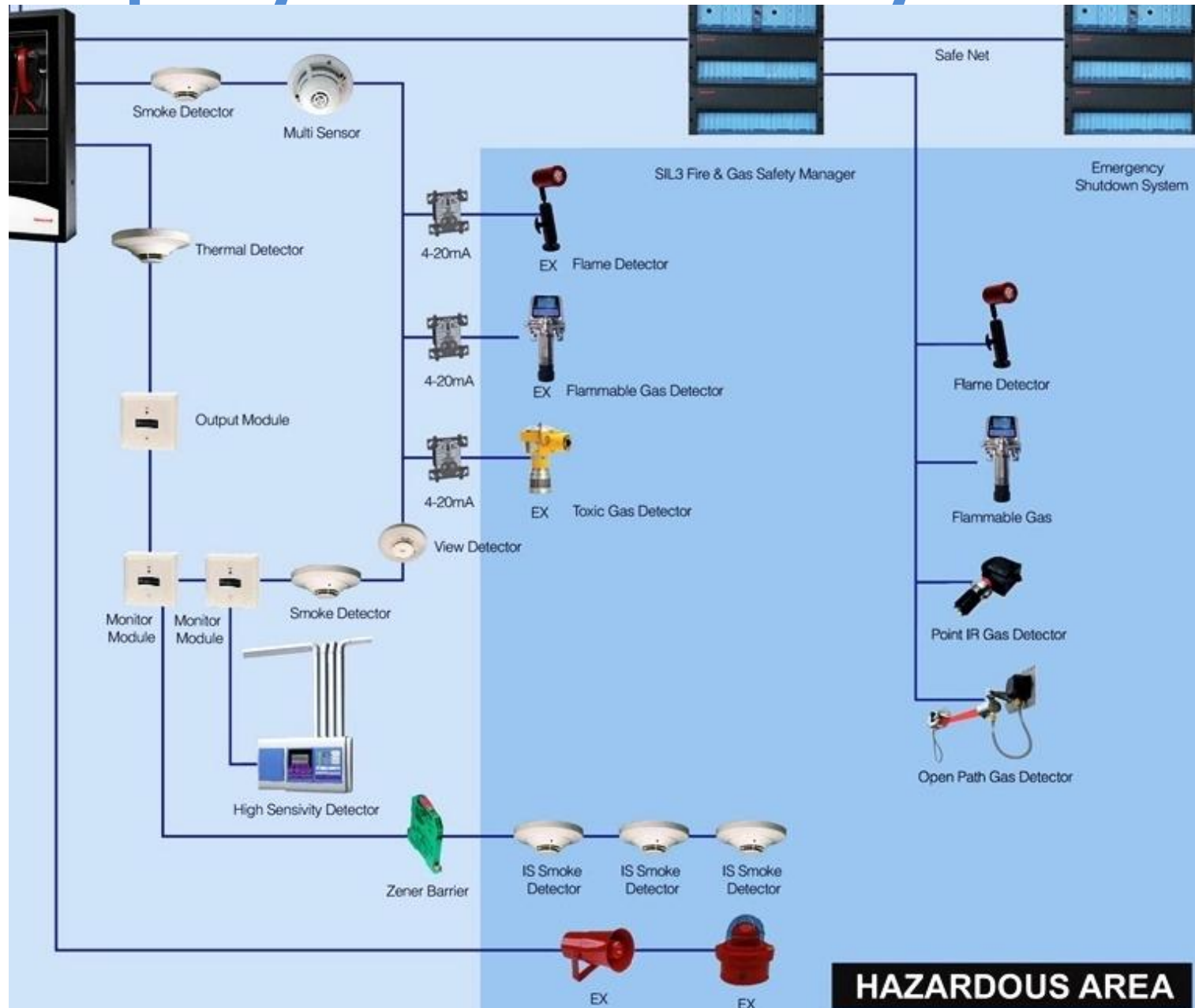


**Pneumatic
and Electric
Actuators**

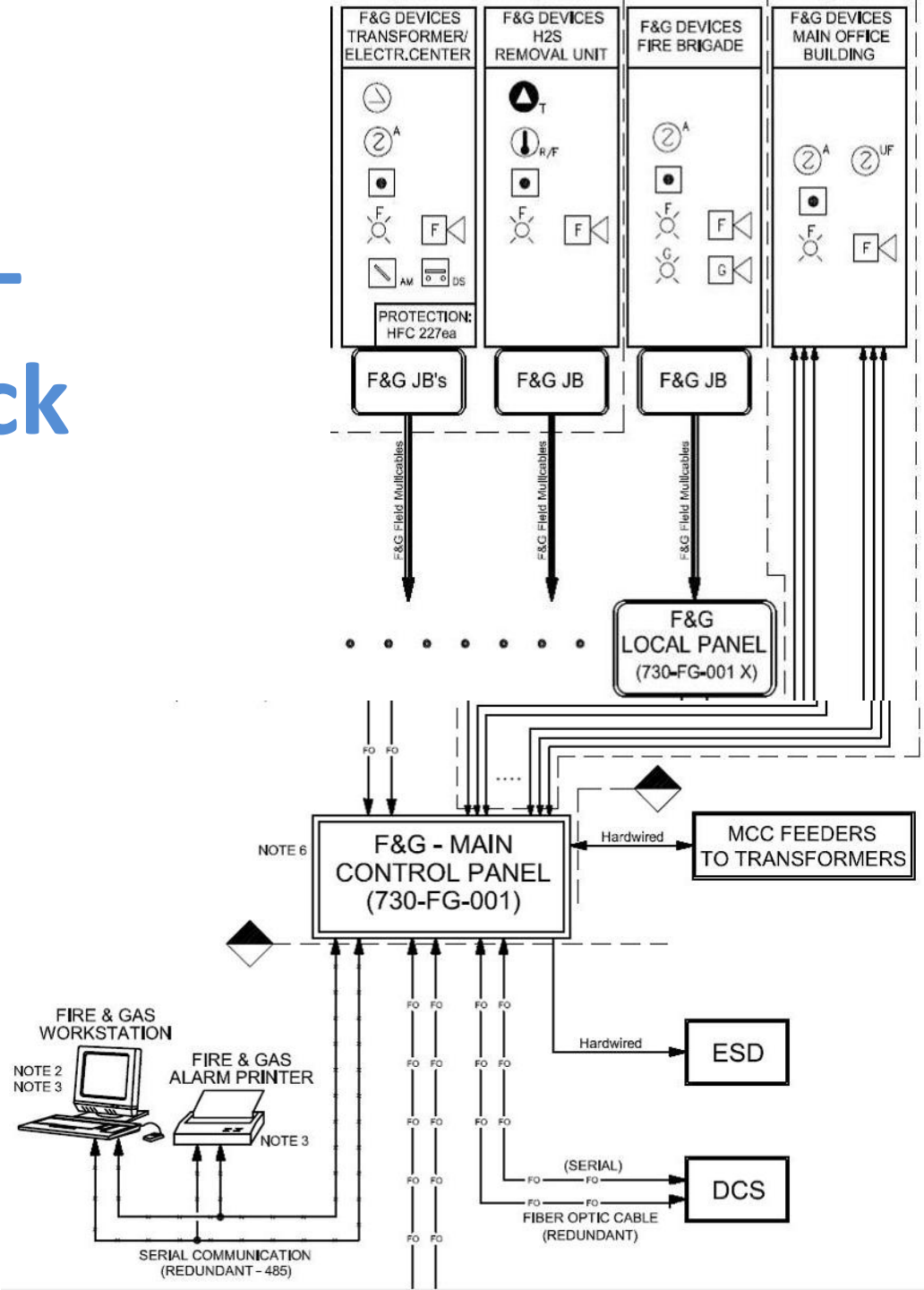


- DCS for graphic displays
- ESD system
- HVAC System
- Pneumatic Panel
- Process Unit Control Panels for package items (such as Gas Turbines / Compressors)
- Flashing Beacons & Sounders
- Extinguishant & Deluge panel
- Diesel and electric fire pumps

Loop Layout- Fire & Gas System



Sample – F & G Block Diagram



Fire, Smoke and Gas Detection Selection and Application Guide

Fire, Smoke and Gas Detection Process Area Application Guide

Facility Type	Flammable Gas		Toxic	Fire	Fire	Heat	
	<i>LOS</i>	<i>Point</i>		<i>(Optical)</i>	<i>(Smoke)</i>	<i>Linear</i>	<i>Spot *</i>
Onshore Well Site	Yes (4)	Yes (4, 5)	(1)	No	NO	Yes (4)	
Pump House	Yes (4)	Yes (4)	(1)	Yes	No	Yes (4)	Yes
Compressor / Turbine	Yes (4)	Yes (4, 5)	(1)	Yes	No	Yes (4)	No
Refinery / Chemical Plant	Yes	Yes (5)	(1)	Yes	(2)	(3, 4)	ER
Loading Gantry	Yes	Yes	(1)	Yes	(2)	(3, 4)	ER
LNG/ LPG storage & handling	Yes	Yes (5)	No	Yes (ER)	No	Yes (ER)	Yes
Pig /Slug Catcher	Yes	Yes (5)	(1)	ER	No	ER	ER
Floating Roof tank Rim Seal	Yes	Yes	(1)	Yes		Yes	

(1) If toxic gas is present and a hazard

(2) In non process buildings such as control rooms, electrical rooms

(3) Used as main detection or as secondary detection system

(4) Required depending upon control, hazard assessment

(5) Point detection + Acoustic Gas Leak Detector

ER - Subject to Engineering Review

(*) Use either pneumatic or electric linear heat detection or frangible quartzoid bulb detector.

Fire, Smoke and Gas Detection

Associated Areas Application Guide

MAJOR HAZARD AREAS	PRIMARY DETECTION
DIESEL GENERATOR ROOM	HEAT (SPRINKLER)
WORKSHOP / BATTERY ROOM/ SWITCHGEAR ROOM	SMOKE
CONTROL ROOM	SMOKE /HEAT
CABINS / CORRIDORS /PUBLIC ROOMS	SMOKE / HEAT + (SPRINKLER)
RADIO ROOMS	SMOKE
GALLEY / HOOD/ DUCT	HEAT

Typical F & G Detectors – PDO facilities

Hazard	Type of Detector	Equipment Type	Facility Type			
			Gath Station	Prod Station	Booster Station	Power Station
Fire	Both Heat & Flame	Crude oil/ condensate shipping pumps	X	X	X	N/A
		Compressors	X	X	N/A	N/A
		Turbine enclosures	X	X	X	X
	Flame	Fixed roof tanks	X	X	N/A	N/A
		Floating of tanks	N/A	X	N/A	N/A
		Diesel generator	N/A	N/A	X	X

Typical F & G Detectors – PDO facilities

Hazard	Type of Detector	Equipment Type	Facility Type			
			Gath Station	Prod Station	Booster Station	Power Station
Fire	Smoke	Control rooms	X	X	X	X
		Auxiliary rooms	X	X	X	X
		Electrical rooms	X	X	X	X
		Offices	X	X	X	X
Gas	Comb Gas	Turbine enclosure (air intake)	X	X	X	X
		Gas compressors	X	X	N/A	N/A
		Fuel gas skid	X	X	X	X

Typical Detection Actions - PDO facilities

Type of Detection	Alarm/Action	Facility Type			
		Gath Station	Prod Station	Booster Station	Power Station
Heat / Flame/ Smoke	GFS panel alarm	X	X	X	X
	Mimic panel alarm	X	X	X	X
	Area sirens/bells	X	X	X	X
	ESD associated equipment	X	X	X	X
	Station ESD	X	X Note 1	X	X Note 1
	Alarm to SCADA	X	X	X	X

Note 1 – ESD not required for Manned Stations

Typical Detection Actions - PDO facilities

Type of Detection	Alarm/Action	Facility Type			
		Gath Station	Prod Station	Booster Station	Power Station
Smoke	Isolate associated non essential power supplies	X	X	X	X
	Associated AC trip	X	X	X	X
Toxic (H2S) / Manual call Point	GFS panel alarm				
	Mimic panel alarm	X	X	X	X
	Area sirens/bells	X	X	X	X
Manual call Point	Station ESD	X	X	X	X
			Note 1		Note 1

Note 1 – ESD not required for Manned Stations

PDO Specific F &G Requirements

Wellheads

Heat detection fitted with actuated ESD valves and pumps shutdown

Production and Test Separators

- Generally no detection is required for crude oil separators, gas separators and compressor surge vessels.

Turbine Hoods / Turbine Driven Generation Sets (same as Gas Turbine Drivers)

Fire and gas detection and protection systems for turbine hoods shall include:

- Flammable gas detection on the combustion and ventilation air inlet.
- Heat + Flame detection.
- 3-Flammable gas release should be detected at the ventilation outlet airflow.
- 3-Heat detectors (bimetallic type) shall be installed over bearings. A minimum of four flame detectors.

Cone (Fixed) Roofed Tanks

Fusible plug fire detection

Shipping Pumps

- Crude oil vapour detection
- Heat switch for fire detection

PDO Specific F &G Requirements

Gas Processing Facilities

Fuel Gas Treatment Skids: Consideration shall be given to the installation of fixed gas detection

Compression Facilities

Generally, no detection is required for gas separators and compressor surge vessels.

a) Centrifugal Compressors

Heat detectors above each bearing with a seal or gland (intended to detect both gas fires and lube oil fires).

b) Reciprocating Compressors

As a minimum they shall be equipped with heat detectors above each bearing with a seal or gland as per centrifugal compressors.

Control and Auxiliary Rooms

Conventional smoke detection:

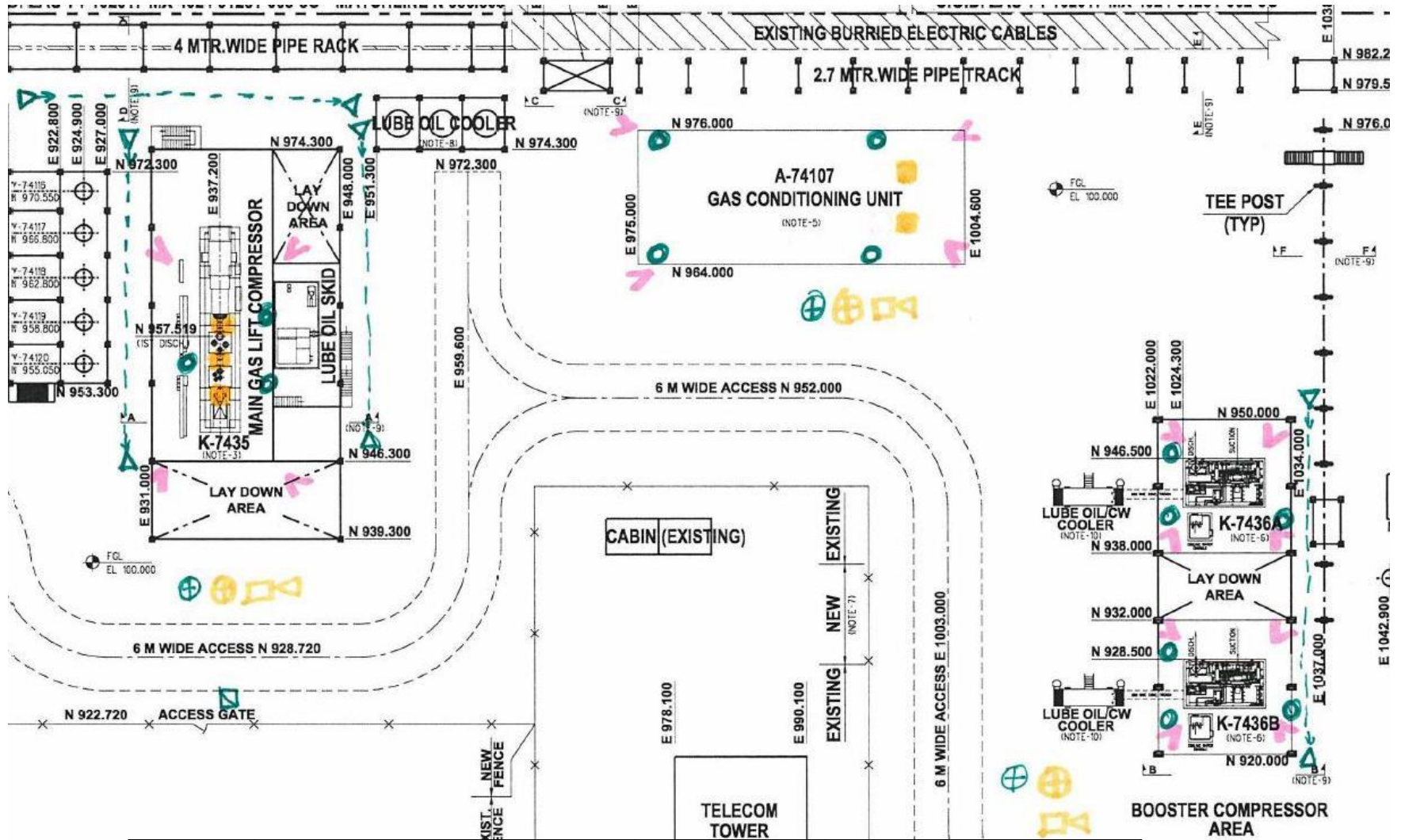
- Ceiling mounted & for cables located in voids. - Avoid Below the floor or above the ceiling.

VESDA (incipient smoke detection)

Critical control and switchgear rooms

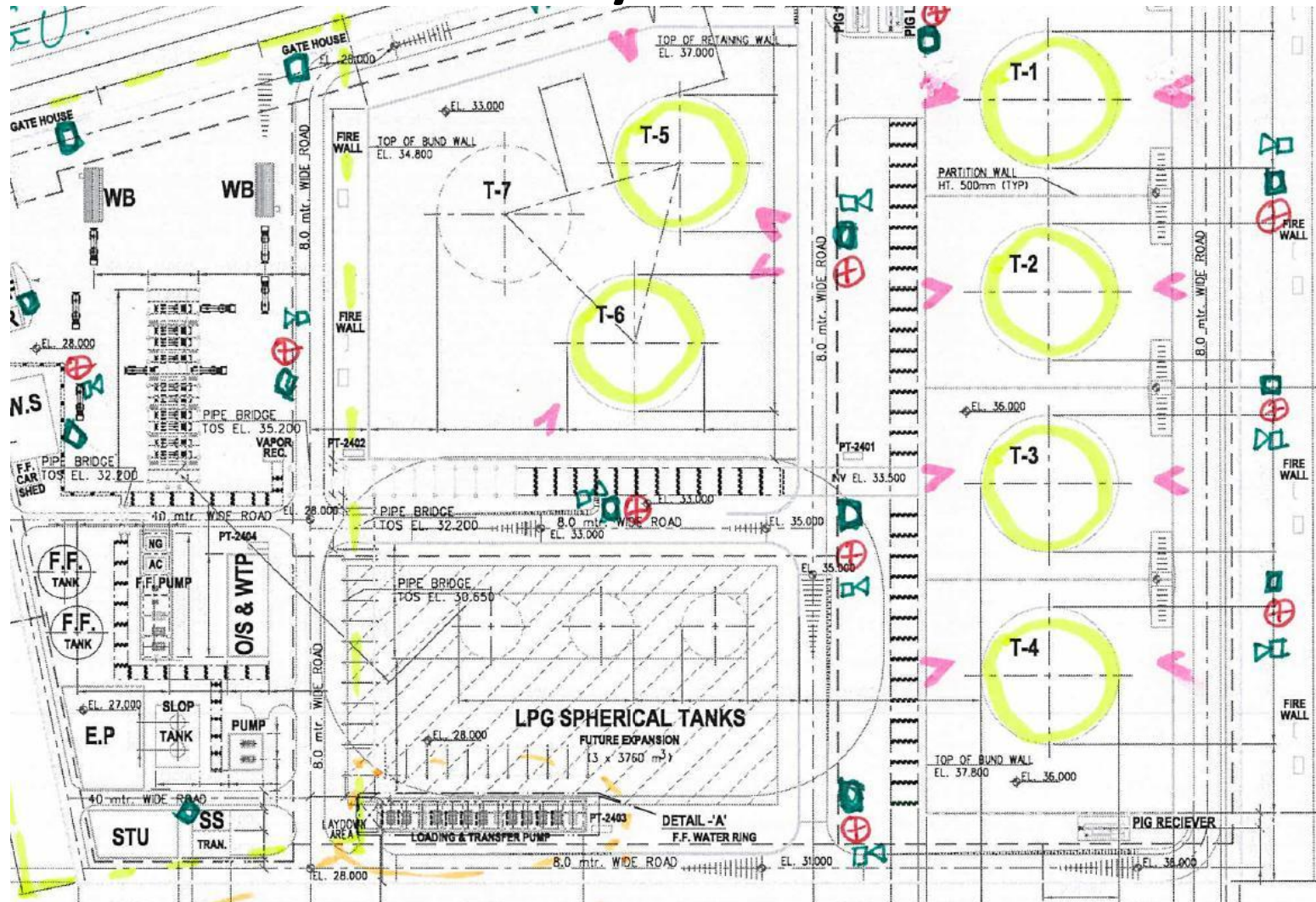
Sample Layouts of Fire, Smoke and Gas Detectors

Sample F & G layout-PDO Gas Project



	3-IR Flame Detector		Open Path / Line of Sight Hydrocarbon Detector
	Point Hydrocarbon Detector		Point Heat / Fire Detector

AOT F & G Layout Tank Farm

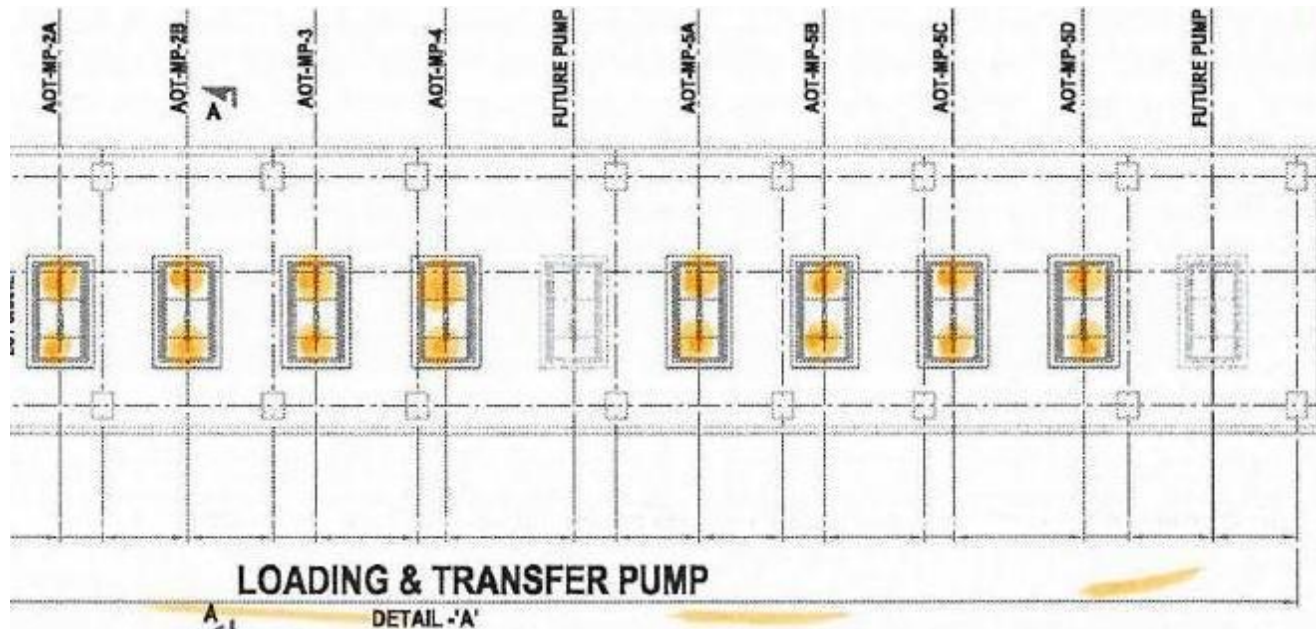


3-IR Flame Detector



Heat Sensing Line

AOT F & G Layout HC Pumps



AOT F & G Layout Office and Loading Area



Thank You
for your kind attention