

DEP SPECIFICATION

FIRE, GAS AND SMOKE DETECTION SYSTEMS

DEP 32.30.20.11-Gen.

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DESIGN AND ENGINEERING PRACTICE

DEM1



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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE.....	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	10
1.5	SUMMARY OF MAIN CHANGES.....	10
1.6	COMMENTS ON THIS DEP	11
1.7	DUAL UNITS.....	11
2.	THE FIRE & GAS DETECTION SYSTEM	12
2.1	DETECT THE HAZARD.....	12
2.2	ALERT PEOPLE	12
2.3	INITIATE ACTION.....	12
3	DESIGN PROCESS.....	14
3.1	IDENTIFY HAZARDS RELATED TO FIRE, GAS AND SMOKE EVENTS	14
3.2	DEFINE SITE HAZARDOUS ZONES, FIRE ZONES	14
3.3	CLASSIFY THE LEVEL OF CRITICALITY OF IDENTIFIED HAZARDS	14
3.4	GENERATE FIRE AND GAS DESIGN REQUIREMENTS AND PHILOSOPHY	15
3.5	DETAILED DESIGN OF FGS, INCLUDING CONFIGURATION AND LAYOUT.....	15
3.6	CONSTRUCT AND COMMISSION	15
4	DETECTOR TYPE SELECTION, DEPLOYMENT AND LOCATION	16
4.1	GENERAL REQUIREMENTS FOR ALL DETECTORS	16
4.2	FIRE DETECTORS.....	20
4.3	FLAMMABLE GAS DETECTORS	24
4.4	OIL MIST DETECTORS	27
4.5	CCTV GAS DETECTION.....	27
4.6	TOXIC GAS DETECTOR TYPE SELECTION.....	27
4.7	SPECIAL AREA DETECTION REQUIREMENTS	29
4.8	MANUAL ALARM CALL.....	30
4.9	DETECTOR IDENTIFICATION.....	31
4.10	PORTABLE AND PERSONAL GAS MONITORS	31
5	DETECTOR SPECIFICATIONS AND CHARACTERISTICS	34
5.1	GENERAL REQUIREMENTS FOR ALL DETECTORS	34
5.2	FIRE DETECTORS.....	36
5.3	FLAMMABLE GAS DETECTORS	37
5.4	TOXIC GAS DETECTORS	39
5.5	MANUAL ALARM CALL POINT	39
6	DETECTOR LAYOUT PERFORMANCE, MAPPING, OPTIMISATION AND VOTING	40
6.1	LAYOUT OPTIMISATION.....	40
6.2	DETECTION PERFORMANCE CRITERIA	40
6.3	FIRE AND GAS DETECTION MAPPING	42
6.4	DETECTOR VOTING	42
7	ALARM LEVELS, DETECTOR SETTINGS.....	45
7.1	FIRE DETECTORS.....	45
7.2	ALARM FOR NARCOTIC EFFECTS.....	45
7.3	ACOUSTIC LEAK DETECTOR ALARM LEVELS	45
8	ALARMS, EXECUTIVE ACTIONS, ANNUNCIATION	46
8.1	GENERAL	46
8.2	ACTIONS	46
9	FIRE & GAS DETECTION SYSTEMS DESIGN	50
9.1	GENERAL	50
9.2	DIAGNOSTIC ALARMS.....	50
9.3	PANEL SYSTEMS	50

9.4	POWER SUPPLIES.....	51
9.5	HMI INTERFACE.....	51
9.6	SYSTEM INTERFACES	54
9.7	SEQUENCE OF EVENT RECORDING.....	56
9.8	UNATTENDED INSTALLATIONS	57
9.9	ELECTRO MAGNETIC COMPATIBILITY (EMC).....	57
9.10	FGS ENVIRONMENTAL CONDITIONS.....	57
9.11	STANDARD DOCUMENTATION	57
9.12	TRAINING.....	57
9.13	AFTER SALES SERVICE.....	57
9.14	SPARE PARTS.....	57
10	COMMISSIONING AND TESTING	58
10.1	GENERAL.....	58
10.2	FACTORY ACCEPTANCE TEST	58
10.3	SITE ACCEPTANCE TEST	58
11.	REFERENCES	60

APPENDICES

APPENDIX A	TYPICAL DETECTOR CROSS-SENSITIVITY CURVES	62
APPENDIX B	EXAMPLE OF FIRE & GAS SYSTEM ARCHITECTURE	63
APPENDIX C	TYPICAL CAUSE AND EFFECT PLUS ALARM MATRIX	64
APPENDIX D	TYPICAL CAUSE AND AFFECTS PLUS ALARMS - COMPRESSOR/TURBINE MACHINE ENCLOSURES.....	66
APPENDIX E	EXAMPLE CAUSE & EFFECT ACTIONS.....	68
APPENDIX F	EXAMPLE FIRE AND GAS SYSTEM PROJECT CHECKLIST	70
APPENDIX G	TYPICAL NITROGEN UNIT FOR FIRE/HEAT DETECTION	72
APPENDIX H	TYPICAL ELECTRICAL LINEAR HEAT DETECTION FOR FLOATING ROOF TANK	73

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for fire, gas and smoke detection systems, and includes sensor technology selection, specification, installation, calibration, and also associated audible and visual alarm systems and Executive Actions. Its scope includes detection of fire, flammable gas, oil-mist, narcotic and toxic gases in and around all Shell facilities.

The “occupational health” or environmental measurements of toxic substances or physical agents, which do not pose an immediate threat to employees, the public or the environment are outside the scope of this DEP. Further, measurements or equipment associated with the control of fire water pumps and deluge systems are also out of scope.

Fire and smoke detection systems inside normally occupied buildings (e.g. office buildings, accommodation buildings and control rooms) are outside the scope of this DEP. Exceptions to this are the gas (flammable and/or toxic) and smoke or CO detection at building entries (e.g. HVAC) which are covered by this DEP. Fire and smoke detection systems for inside normally occupied buildings shall be installed as per applicable “code” (see definition in 1.3).

The requirements of this DEP apply to new installations and replacement or upgrades of existing installations. For replacement or upgrades, the Principal may consider retaining a consistent design or operating philosophy for the whole site where ALARP can be demonstrated.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual DEM 1 – Application of Technical Standards.

This is a revision of the DEP of the same number dated February 2011; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
1ooN	The detector voting logic "1 out of N" (1ooN) requires a single detector to trigger, (i.e. this is a non-voted configuration). "N" represents the number of detectors within the zone.
2ooN	The detector voting logic "2 out of N" (2ooN) requires two detectors in the same zone to trigger where "N" represents the number of detectors within the zone.
ALARP	As Low As Reasonably Practicable
AND	Logical operator, where all are required before satisfied.
Bump Test	This is a test where the transportable, portable monitor or personal monitor is subjected to test gases of known concentration so that the monitor's measurement performance and alarm points can be proven functional.
Code	Local and national regulations, or industry-wide standards and codes of practice for fire and gas systems (e.g. NFPA).
Confirmed Gas	Typically two or more detectors within a zone reporting gas, or single detector plus confirmation by Operations.
Confirmed Fire	Typically two or more detectors within a zone reporting fire, or single detector plus confirmation by Operations.
Congestion / Congested Area	An area containing objects such as equipment, pipes, structural supports. The density of objects (blockage) affecting gas dispersion and explosion overpressure. Note that a congested area can be unconfined (no side walls) or confined (enclosed by walls e.g. module or room)
Containment zone	Refers to any enclosed module which by design includes the use of physical barriers with the primary function to restrict or slow the spread of gas clouds (e.g. toxic) from un-ignited releases, or smoke, to other adjoining or connected enclosed spaces and to outside areas. Containment manages the "overlap" of the hazard (e.g. toxic) from one area to another and also affords segregation between hazardous (e.g. toxic) and non hazardous (e.g. non-toxic) areas.

Term	Definition
Conventional Gas Detection	Sensor technologies that directly detect the presence of a gas and are well established in the industry. This includes infrared (for flammable gas), catalytic, electrochemical, and semiconductor, but does not include acoustic detection.
Detector Mapping	A layout optimisation technique that uses 2D or 3D computer modelling to assess the coverage of detection systems against the identified hazardous scenarios. It provides an auditable assessment trail of the detection system's ability to meet the detection performance requirements.
Emergency Control Point	Safe area on site or installation from where emergency response is co-ordinated
Executive Action	In this DEP, Executive Action is a final action function to provide protection or mitigation of an event, such as: a) Tripping of process equipment (pumps, compressors, valves etc); b) Tripping or isolation of electrical equipment; c) Opening process valves, e.g. blowdown or depressuring valves; d) Tripping of ventilation systems (fans and dampers); e) Firing fire extinguishants, e.g. deluge or gaseous systems.
Fire and Gas System	The Fire and Gas System including components: a) Detectors (fire, smoke, flammable and toxic gas, acoustic leak); b) A logic solver; c) Panel(s); d) Human Machine Interface in a manned control centre, and where appropriate a second HMI at mustering point (where mustering point is in different location) or Emergency Response Centre if separate from control centre; e) Direct outputs, such as fire suppressants, audible and visible alarms; f) Interfaces to other systems, e.g. SIS, DCS; g) FGS Engineering Station.
Flammable Gas	For the purposes of this document, "flammable gas" refers to those flammable gases or vapours that can be ignited (i.e. hydrocarbons, hydrogen, etc).
HSSD	High Sensitivity Smoke Detection; typically aspirated with detection points based on modelling.
Narcotic effect	The impaired judgement or loss of ability to respond to commands caused by exposure to sufficiently high concentrations of narcotic products (e.g. hydrocarbon vapour).

Term	Definition
Occupied building	For the purposes of this document normally occupied buildings are buildings where personnel are present for periods of time to carry out normal operations; such as but not limited to office buildings, maintenance shops, control rooms and living accommodation buildings.
OR	Logical operator, a single requirement satisfies.
Personal Monitor	These are small compact devices that are attached to, and worn by the user whilst carrying out work activities. These personal gas alert devices do not give team or area protection.
Portable Monitor	Portable gas monitors are hand-held monitors used for leak seeking; verification of combustible or toxic gas-free areas; monitoring temporary work areas and safety checks. These are not personal gas alert devices as they can be located several meters away from where personnel are located.
Toxic Gas	For the purposes of this document, "Toxic gas" refers to those toxic gases that are hazardous to personnel (e.g. Hydrogen Sulphide).
Transportable Monitor	BS EN 50073 (BSI 1999) defines transportable apparatus as "apparatus which are not intended to be portable but which can be readily moved from one place to another. When required, they are positioned at a predetermined location to provide protection against hazardous events in that area. Transportable monitors should normally be used for monitoring temporary work areas ('hot-work') and in areas where fixed gas detectors are out of service."
Unoccupied building	For the purpose of this document normally unoccupied buildings are buildings where personnel visit infrequently and do not carry out regular lengthy routine activities during normal operation, and may be process buildings, analyzer shelters, metering buildings.

1.3.3 Abbreviations

AC	Alternating current
ALD	Acoustic Leak Detector
ASU	Alarm Summary Unit
ATEX	Atmospheres explosibles
BPCS	Basic Process Control System
CCTV	Closed Circuit television
°C	Celsius
CO	Carbon monoxide
CO ₂	Carbon dioxide
CSA	Canadian Standards Association
dB	Decibel
DC	Direct current

DCS	Distributed Control System
ESD	Emergency Shutdown
EDP	Emergency Depressurisation
EMC	Electro Magnetic Compatibility
EMI	Electromagnetic interference
FAR	Field Auxiliary Room
FAT	Factory acceptance test
FFSIS	Foundation Fieldbus™ Safety Instrument System
FGS	Fire and Gas System
FIREPRAN	Fire Protection Analysis
F&G	Fire and Gas
GOR	Gas to Oil Ratio
GTL	Gas to Liquid
HART	Highway Addressable Remote Transducer
HEMP	Hazards and Effect Management Process
HF	Hydrogen fluoride
HLG	High Level Gas Alarm
HMI	Human Machine Interface
HSE	Health Safety and Environment
HSSE	Health Security Safety and Environment
HVAC	Heating, Ventilation and Air Conditioning
H ₂ S	Hydrogen sulphide
Hz	Hertz
IPF	Instrumented Protective Function
IMS	Ion mobility
IP	Internet Protocol
IR	Infra-red
I/O	Input / output
Kg	Kilograms
kW	Kilowatt
LAV	Local Activation Valve.
LCC	Local Control Centre, Installation Control Centre or any control room
LED	Light emitting diode
LFL (or LEL)	Lower Flammable Limit. For the purposes of this document, the terms “lower flammable limit” and “lower explosive limit” (LEL) are deemed to be synonymous.
LLG	Low Level Gas Alarm
LNG	Liquefied Natural Gas
LOS	Line of Sight

LPG	Liquefied Petroleum Gas
mA	Milliamperes
NEMA	National Electrical Manufacturers Association
MTBF	Mean time between failures
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratories
PA	Public Address System
PES	Programmable Electronic System
PFD	Probability of Failure on Demand
PPE	Personal Protective Equipment
ppm	Parts per million
PTFE	Polytetrafluoroethylene
QRA	Quantified Risk Assessment
RFI	Radio Frequency Interference
RH	Relative humidity
S	Seconds
SAT	Site acceptance test
SER	Sequence of Events Recorder
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SME	Subject Matter Expert
SSSV	Sub Surface Safety Valve
STEL	Short term exposure limit
TSC	Toxic stream concentration
TSR	Temporary Safe Refuge (or Safe Refuge)
TWA	Time weighted average
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
UV	Ultra Violet
Vol	Volume
VDU	Visual Display Unit
2-D	2 dimensional
3-D	3 dimensional

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (11).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2011. The following are the main, non-editorial changes.

Old section	New section	Change
All		Dual units have been added throughout the DEP; see also (1.7).
6.4.1	6.4.1	Additional instruction on voting requirements for multiple detectors. Added exceptions to the requirement for a minimum of 3 detectors.
6.4.2	6.4.2	Changed requirement for voted executive action.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of “DEPs on the Web”, available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. THE FIRE & GAS DETECTION SYSTEM

Fire and gas detection systems are one of the (risk reducing) recovery controls used where there is potential for fire or loss of containment (release and / or gas accumulation) that would pose a risk to employees, the public, the environment or the business.

The Fire & Gas System shall enable mitigation of hazardous conditions such as fire or loss of containment by performing three basic functions:

- Detect the Hazard;
- Alert People;
- Initiate Action.

These are described in more detail in the sections below.

2.1 DETECT THE HAZARD

Fixed fire, gas and smoke detection equipment shall be selected to meet the requirements of this DEP and to provide, within practical limits, the earliest detection of emerging or significant hazards, specifically:

- The presence of a fire;
- The presence of smoke from smouldering or incipient fires;
- The presence of a hazardous release or accumulation of flammable gases due to loss of containment;
- The presence of a hazardous release or accumulations of a toxic or asphyxiating gas (including those with a narcotic effect) due to loss of containment.

2.2 ALERT PEOPLE

The fire and gas system SHALL [PS]:

- Alert the operator at a continuously manned control centre to any detected hazards, their approximate location and type of event;
- Alert personnel in the vicinity of the hazard to the detected hazard so that they are able to take appropriate and timely action and evacuate to a safe location;
- Provide data about the fire and gas event at the emergency control points to facilitate management of the incident.

Note: There may be the additional requirement to provide notification of emergency situations to local community services, e.g. fire brigades

2.3 INITIATE ACTION

The initiated action shall be automatic, except where human action has been assessed for the facility and hazard type, and it is demonstrated that human action is an effective part of the mitigation process.

The following actions shall to be implemented within a fire and gas system:

- To alert or warn off approaching manned transport (e.g. helicopters, boats) using audible and visual means;
- Isolate and minimise the inventory of hazardous materials (which may contribute to escalation) in the affected area;
- Minimise potential ignition sources by electrical isolation of non-essential equipment or equipment not suitable for use in the present hazard;
- Initiate active fire protection systems, where applicable, within the response time required;

- Minimise the ingress and spread of smoke within buildings or closed modules, where smoke may impair escape, refuge and evacuation;
- Provide HVAC operation that is required for the detected hazard, where applicable, e.g. maintain module air flow when gas is present in the module.
- Initiate restrictions of access, e.g. road blocks on and offsite.

3 DESIGN PROCESS

The typical sequence of design activities relevant to a Fire, Gas and Smoke Detection System is:

- Identify hazards related to fire, gas and smoke events;
- Define site hazardous zones, fire zones;
- Classify the level of criticality of the identified hazards;
- Generate fire & gas design requirements and philosophy;
- Detailed Design of FGS, including configuration and layout;
- Construct and commission;
- Operate and maintain.

It may be necessary to reiterate some steps to achieve the optimum result. The above steps also apply to modifications to Fire, Gas and Smoke Detection systems.

3.1 IDENTIFY HAZARDS RELATED TO FIRE, GAS AND SMOKE EVENTS

The Shell "HEMP" Hazards & Effect Management Process shall be applied.

The results of the FGS hazard analysis shall form the FGS system design objectives comprising:

- Zone definitions (Containment, Fire, Hazard)
- Detection requirements per zone
- FGS hardware robustness requirements
- FGS system cause & effects matrix

3.2 DEFINE SITE HAZARDOUS ZONES, FIRE ZONES

3.2.1 Zone Boundaries

Identification of Zone Boundaries shall consider features of the geography of firewalls, bundwall, decks and module levels, roadways, buildings, HVAC items, fire protection systems, and facility extremities.

3.3 CLASSIFY THE LEVEL OF CRITICALITY OF IDENTIFIED HAZARDS

The FGS are safety critical systems and shall be subjected to functional safety management as per DEP 32.80.10.10-Gen.

This DEP shall be read in conjunction with the IPF DEPs and except as noted in this DEP the design, sensor selection, logic solver, horns/beacons, installation and maintenance of the FGS shall be in compliance with the requirements of the Instrument Protective Function DEPS whether or not all aspects are addressed explicitly in this DEP.

The IPF SIL assessment process shall be carried out for F&G protective functions on air intakes to occupied buildings (control rooms), (Field) Auxiliary Rooms, Substations, or a "containment zone" that is within dispersion hazardous boundaries, and always for offshore platforms. All other F&G detection with Executive Action do not need SIL assessment.

Where a F&G detection function has not been SIL assessed a PFD better than 2% shall be achieved for:

- A single detector up to and including the detection input to the logic solver, and including the annunciated alarm when an operator action is required.

3.4 GENERATE FIRE AND GAS DESIGN REQUIREMENTS AND PHILOSOPHY

The Fire and Gas Design Requirements (and/or F&G Philosophy) document shall be written and maintained. The document includes:

- Statement of the concepts, assumptions, regulatory requirements and references to be used in developing the safety design and functional specification of the Fire and Gas detection systems. This includes the requirements from the HEMP process.
- Summary of the overall Fire and Gas detection system (e.g. system architecture), including diagnostic capabilities associated with F&G sensors.
- Description of the application of the philosophy to each unit, area or zone of the facility (e.g. perimeter, area coverage)
- Human-machine interface philosophy (including policy for integration with other alarm systems, alarm levels and expected operator response, alarm locations, etc)
- Maintained system performance
- Detection requirements for fire, flammable gas and toxic gas, by zone
- Detection technologies and suppliers to be used
- Deployment approach (e.g. coverage mapping, selective placement)
- Voting schemes, including how to respond to diagnosed faults
- Detection layout assessment and performance criteria e.g. "Detection Performance" for fire and gas detection mapping.
- Operator competence, knowledge and training requirements.
- Facility to capture sequence of events.

3.5 DETAILED DESIGN OF FGS, INCLUDING CONFIGURATION AND LAYOUT

Detection designs are for early detection of hazardous loss of containments. This may be from product accumulation or from leaks.

The detector layout design for accumulation events shall use modelling to assure that the detection meets the identified detection performance criteria (e.g. fire sizes, gas cloud sizes). The same study may assess the placement of horns/beacons to verify that the appropriate operator and staff awareness is achieved.

When selective placement of detectors for specific leak events, (e.g. detection or boundary / perimeter detection) the detection shall be placed such that so far as reasonably practicable the detection will provide early detection. To ensure early detection, selective placement shall consider release size, momentum and air movement (e.g. prevailing wind, HVAC).

3.6 CONSTRUCT AND COMMISSION

Factory and site acceptance tests and site commissioning processes shall be carried out as per DEP 62.10.08.11-Gen.

The commissioning procedures shall ensure that devices (e.g. detectors, horns/beacons, etc) have been installed in the correct locations and orientations (with clear field of view of intended coverage area for optical devices), mounts are robust, interfaces and alarms are functioning.

4 DETECTOR TYPE SELECTION, DEPLOYMENT AND LOCATION

4.1 GENERAL REQUIREMENTS FOR ALL DETECTORS

Detectors selection SHALL [PS] take the following aspects into account to ensure detection of the hazards as they occur:

- Contaminants (e.g., dust, dirt, sand, silicones, oil, or sea water spray);
- Potential interferences (e.g., EMI / RFI, other gas constituents for gas detectors, welding arcs for fire detectors, sunshine for optical detectors);
- Output signal compatibility with interfaces;
- Local environmental conditions during normal and emergency situations (e.g. ambient temperature, vibration, background noise, effects of rain, snow, fog and wind).
- Site installed supplier/model equipment base (applicable to Brownfield upgrades);
- Technology robustness and proven reliability;
- Maintenance Philosophy,
- Manned / unmanned, accessibility, occupancy, etc
- Fire class as per table below

American	European/Australian	Fuel/Heat source
Class A	Class A	Ordinary combustibles
Class B	Class B	Flammable liquids
	Class C	Flammable gases
Class C	Unclassified / Class E	Electrical equipment
Class D	Class D	Combustible metals
Class K	Class F	Cooking oil or fat

Note: Electrical equipment fire class is Unclassified for Europe and Class E for Australia

The exact number and location of fire, gas and smoke detectors and their associated equipment (horns, beacons, etc.) shall be determined during detailed engineering. For guidance, a general overview of the typical FGS application is shown in (4.1.1). The number, type and location of detectors SHALL [PS] be determined by an assessment of selection criteria, including:

- Regulatory requirements;
- Hazardous area zoning, HEMP, QRA (Quantified Risk Assessment) results;
- 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.

Device installation and design specification (e.g. mounting) shall be in accordance with Manufacturer's installation instructions. Correct installation and orientation of detection equipment is critical to reliable performance.

The location and elevation of fire and gas sensors/detectors shall be such that:

- Access for testing and maintenance shall be considered during the design. Access wherever practical shall be from grade or platform without ladders, scaffolding, or lifting devices, or fall protection;
- Where point gas detectors are mounted at heights or inaccessible locations then test gas tubing up to the detectors may be used;
- Potential for damage during normal plant maintenance is minimal;
- Mounting arrangements shall ensure correct detection operation and shall be sufficiently rigid to ensure that vibration does not impact on performance. Structural steelwork used where practicable;
- Installed detectors always function within the environmental conditions, i.e. sand, dust, water spray, direct rain, snow or ice build up, salt spray;
- They allow for normal activities e.g. maintenance, scaffolding, lifts etc. which would block LOS type gas detectors or optical fire detectors.

FGS detectors located outdoors shall not be installed lower than 0.6 m (24 in) above grade or ground level. Where snow or other weather conditions may affect the detection capabilities, then the height shall be set taking these conditions into account.

When optical detectors, including reflector plates, are used, then anti-condensation heating shall be used when the environment can cause condensation.

Selection of certified electrical equipment for Fire and Gas systems SHALL [PS] follow:

- Zone1 (Class 1 Div 1) for all field mounted flammable gas and fire detectors irrespective of the actual electrical hazardous area classification.
- Zone1 (Class 1 Div 1) for flammable gas, toxic gas and/or smoke (if any) detectors at the inlet of unclassified buildings that are to be protected for gas/smoke ingress.
- Smoke, heat, emergency lighting, PA systems, control systems panels in unclassified building(s), that buildings are protected by gas detection at the inlets, may remain electrically energized if the equipment is certified for Zone 2 (Class 1 Div 2) or greater.

4.1.1 Overview Of Detector Requirements by Application

Table 4-1 and 4-2 provides common FGS detection options that may come from the hazard analysis. These are for guidance and may only be used if detailed review and hazard identification has not been carried out.

Table 4-1 Fire, Smoke and Gas Detection Process Area Application Guide

Facility Type	Flammable Gas		Toxic	Fire (Optical)	Fire (Smoke)	Heat	
	LOS	Point				Linear	Spot (a)
Offshore Platform (Process Areas)	Yes	Yes (5)	(1)	Yes	(2)	(3)	
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 Station	Yes (4)	Yes (4, 5)	(1)	Yes	No	Yes (4)	No
Onshore Gas, LNG, GTL Plant	Yes	Yes (5)	(1)	Yes	(2)	(3, 4)	ER
Onshore Refinery / Chemical Plant	Yes	Yes (5)	(1)	Yes	(2)	(3, 4)	ER
Road/Rail Gantry	(4)	(4)	Yes (1)	Yes (4)	No	(3)	ER
Analyser Shelter/House		Yes (4)	(1)	No	Yes (4)	No	
LNG/LPG/Storage/ Handling Areas (b)	Yes	Yes (5)	No	Yes (ER)	No	Yes (ER)	Yes (6)
Refrigerated LPG/LNG Tank	Yes	Yes (5)				Yes (4)	
Other hydrocarbons Storage/Handling Areas	ER	ER	(1)	ER	No	ER	
Slug Catchers	Yes	Yes (5)	(1)	ER		ER	ER
Floating roof tank rim seal area						Yes (4)	

(1) If toxic gas is present and a hazard

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

(3) May be used as main detection or as secondary detection system

(4) May be required depending upon control, hazard assessment

(5) Point detection may include Acoustic Gas Leak Detector

(6) Low temperature heat detector

ER Subject to Engineering Review

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

(b) LPG/LNG service requires early detection that is located close to potential leak sources.

Table 4-2 Fire, Smoke and Gas Detection Non-Process Area Application Guide

Facility Type	Flammable Gas		Toxic	Fire (Optical)	Fire (Smoke) (b)	Heat	
	LOS	Point				Linear	Spot (a)
Workshop – General					Yes (3)		Yes
Workshop – process analyzers		Yes (4)	(1)				Yes
Warehouse – general	Yes (4)	Yes (4)	(1)		Yes (8)		Yes
Dangerous Goods Store	Yes (4)	Yes (4)	(1)		Yes (8)		Yes (6)
Instrument auxiliary room, cabinets, floor cavity, cable routes					Yes (8)		Yes (6)
Electrical Switch Room/Substation					Yes (8)		Yes
Flammable gas storage yard	Yes	Yes		Yes (2)			
Administration buildings					Yes (9)		
Canteen					Yes (9)		Yes
Kitchen				Yes (2)	Yes (9)		Yes
Training centre					Yes (9)		Yes
Fire station				Yes (2)	Yes (9)		
Garage				Yes (2)	Yes (9)		
Control Rooms		Yes (5)	Yes (5)		Yes (9)		
Laboratories (main/Plant)		Yes (4)			Yes (9)		Yes
Battery Rooms		Yes (7)					
Computer rooms					Yes (8, 9)		Yes

(1) If it is possible for toxic gas to be present and in hazardous concentrations

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

(3) May be used as main detection or as secondary detection system

(4) May be required depending on control, hazard assessment

(5) Located at the air intake

(6) Rate of rise heat detector

(7) If Hydrogen gas is possible during charging

(8) High Sensitivity Smoke Detection (HSSD)

(9) To the relevant country building code

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

(b) Unless otherwise indicated, spot smoke detectors should be the integral heat detector type.

4.2 FIRE DETECTORS

Detection equipment SHALL [PS] be capable of detecting fires of the fuel-types that may be present in the coverage area.

Fire detection shall be optical flame detection except where it can be demonstrated that these may not be capable of detecting, for example due to high levels of congestion, interference from flaring activities or environmental conditions. The alternative detection system may be from other technologies e.g. pneumatic detection systems.

4.2.1 Optical Flame Detectors

Multi-wavelength (triple band) infra-red fire detection is the selected detection technology for detection of hydrocarbon gas and liquid fires, hydrogen fires and alcohol fires.

For special fuel applications, such as sulphur, consult the Principal for the selection of the detection technology for the application.

Single or dual wavelength IR (infra-red) detectors shall not be used.

UV (ultraviolet) detectors shall not be used in open modules. With the approval of the Principal they may be used in enclosed supplier packages.

The Principal's approval shall be required before UV/IR flame detectors are used as a detection method.

Optical type fire detectors are "field of view" devices. The following points shall be considered when positioning detectors:

- The detector's field of view covers the potential fire locations which are required to be monitored;
- The maximum distance from detector to the item or area requiring coverage shall be set after considering the fire size and fuel types, any desensitising effects from local conditions (e.g., steam plumes) and the detector's response to that fuel type of fire at that distance.

Flame detectors shall be oriented at an angle of pitch between 5 and 40 degrees below horizontal, so as to promote natural drainage of any condensed water or rain and to reduce accumulation of dust, ice, snow or debris.

4.2.2 Closed Circuit Television (CCTV) Based Flame Detectors

The Principal's approval shall be required before CCTV optical flame detectors are used as a detection method.

If CCTV systems are used, then the lenses shall either be self-cleaning, or be easily accessed for cleaning.

4.2.3 Heat Detectors

4.2.3.1 General

Heat detection is divided into two technology categories; point detection or linear detection.

Heat detection may be used as a second detection technology in conjunction with optical detection. When used as a second detection technology the heat detection systems shall comply with the requirements in section (4.2.3).

Heat detection may be used under any of the following conditions:

- The other forms of fire detection are not suited to detection of the hazards (e.g. highly congested area where optical detection cannot provide coverage due to equipment blocking the field of view(e.g. high equipment density));
- The other forms of fire detection would have unacceptable false alarm rates;
- To supplement the primary flame detection;

- Local regulations require it.

Heat detection when considered as an alternative technology may be located in (but not limited to) the following type of areas:

- Flammable liquid handling and storage area.
- Storage tanks rims
- Risers and wellheads
- Congested modules / areas
- Around pumps
- Compressor Drive End and Non Drive End bearing housings
- Inside machine hoods (compressors, generators)
- Non-hydrocarbon storage areas
- Under false floors in Control Rooms, Computer and Auxiliary rooms
- Areas where gas remains under pressure, e.g. fuel gas system.
- Selective placement of detection such as at pumps seals.

When used as an alternative the heat detection system shall detect the fires identified in the HSE documentation within sufficient time to initiate appropriate actions, and if relevant, activate the deluge firewater valve directly and independently from the FGS system. The heat detection system shall also be connected to the FGS and activate any alarms and other cause and effect identified actions upon initiation.

In open, naturally ventilated areas point heat detectors may be sited with a density in the order of one detector per 10 m² (1,050 ft²) and at a maximum spacing of 5 m (16 ft) apart. The maximum distance from a bulkhead to be no further than 2.5 m (8 ft).

Response times of heat detectors however depend on the amount of heat transferred from the fire to the detector. The actual quantity and placement of detectors will be determined by following the requirements of the detector manufacturers and applicable codes and standards taking into account factors such as:

- Height of ceiling and depth to which the detector projects below the ceiling
- Proximity to the source of fire or equipment to be protected (without blocking access for operation and maintenance)
- Ventilation flow patterns in the building
- Size of area to be protected
- Objects possibly blocking the heat flow to the detector, e.g. system cabinets, cable trays etc.

In enclosed, mechanically ventilated modules point heat detectors are installed at a density of at least one per 25 m² (6,700 ft²), and at a maximum spacing of 7 m (23 ft) apart. The maximum distance from a bulkhead to be no further than 3.5 m (12 ft).

Heat detectors shall not be applied in areas where ceiling heights are above 8 m (26 ft).

The use of smoke modelling software may be employed to assist in siting point heat detectors.

The sensing element shall be located between 25 mm (1 in) and 150 mm (6 in) below the ceiling level, and mounted away from effects that could cause false alarms.

4.2.3.2 Pneumatic (Linear and point)

Pneumatic tube, frangible (quartzoid) bulb, and fusible plug systems may be used when direct control of firewater deluge valves is required. These systems shall be connected to the FGS and provide alarm and other cause and effect identified actions when activated.

When pneumatic detection technology is required for fire detection, pneumatic tubing shall be used. At approval of the Principal, frangible bulb or fusible plugs may be used.

In case of Well head areas, facilities SHALL [PS] be provided to allow collective closure of all wells sub surface safety valve (SSSV) automatically upon confirmed fire in the wellhead area as detected by pneumatic fusible plugs or frangible bulbs. For offshore installations, this fire detection system shall also initiate a full platform shutdown.

Where pneumatic systems are used in hydrocarbon areas then the detection shall be installed locally to the expected fire sources, and at the required spacing for detection of the identified fire sizes.

When used as a heat detection system it shall detect the fires within sufficient time to initiate appropriate actions, and if relevant, activate the deluge firewater valve directly and independently from the FGS system.

The polyethylene tubing ("polytube") fire detection system shall be installed with a minimum number of connections by continuously looping it around the fire hazard area in accordance with Standard Drawings S 88.020 and S 88.021.

These systems shall be configured so that instrument air is supplied through a filter regulator and a restriction orifice (e.g. 1 mm (0.04 in)), such that on fire detection the tube ruptures and the pressure falls rapidly causing the pressure alarm to be raised. They shall also have a means to lock the air in the fire detection loop on loss of air supply to the individual detection loop.

Polytube shall be protected from accidental damage in such a manner so as to not affect its detection capability.

Stainless steel tubing shall be used between the detector station and the Polytube at the fire hazard area.

All joints in the system shall be taped or coated with insulating varnish.

A vent valve (for system testing and manual actuation) shall be installed at the end of the polytube system remote from the detector station and located in a clearly marked box at grade level within 15 m (50 ft) from the protected equipment.

At approval of the Principal a fire loop may use nitrogen as the medium, and a typical installation example is in Appendix G.

4.2.3.3 Electrical or Optical Fibre (Linear)

Linear wire shall only be used at the approval of the Principal.

Linear heat detection may be used to supplement other forms of fire detection in difficult areas (for example, Tank rims, heavily congested plant areas or where flare radiation may cause false alarms using optical detectors).

Appendix H provides details of linear heat detection for a floating roof.

4.2.4 Smoke Detectors

4.2.4.1 General

Smoke detectors in general shall only be used in areas with potential for non-hydrocarbon fires.

In hydrocarbon processing plants, smoke detectors may be used in normally unoccupied buildings. The use in such applications is determined by the principal from hazard assessment.

The application of smoke detectors in normally occupied buildings is covered by "code".

When required in process areas, the smoke detection technology shall be optical. Ionisation detectors may be used at the discretion of the Principal (due to possible false alarms caused by dust or steam).

Optical detectors technology shall be photoelectric, open path infrared beam, or laser-based aspirating.

Combined devices (e.g. combined smoke and heat) shall be used unless the hazard is a low-heat-output smouldering fire.

Heat and smoke stratification shall be considered when siting detectors that are to be used in areas where the fire has potentially low heat output (e.g. electrical equipment rooms.). The use of aspirated detection systems may be used in areas where 8 or more point smoke detectors would be required.

Smoke detection SHALL [PS] be installed in HVAC air intakes to areas that need to remain manned during an emergency.

In open or forced ventilated areas, smoke detectors shall be sited considering the effects of stratification and how local air currents may influence smoke movement. For these areas, smoke generator tests or computer-based smoke release modelling shall be used to check that the detection is capable of detection during the ventilation air movements.

4.2.4.2 Point optical smoke detectors

Point type smoke detectors may be combined with other detection techniques for high risk areas such as the protection of sleeping personnel.

4.2.4.3 Open path smoke detectors

Open path detectors (gas, oil mist, smoke) require a clear and open path.

Open path smoke detectors shall not be installed in open areas where rain, steam or fog may be present. Open path smoke detectors shall be mounted in locations where people are unlikely to obscure the beam. The optical path length (the distance between the transceiver and the reflector) shall be restricted to 30 m (100 ft), unless analysis of detection systems has been carried out and demonstrate operation at longer path lengths.

Open path smoke detectors may be used in any of the following applications:

- Large open areas where point detectors would be difficult or provide inefficient coverage.
- Air intakes that require incoming air to be monitored for the protection of personnel within the protected area.
- Areas where the expected fire is likely to produce low heat output.

Open path systems shall have a transmitter and a receiver. Systems with a reflector may be used at approval of the Principal.

4.2.4.4 Aspirating systems

High-sensitivity (aspirating) smoke detectors are used in areas associated with essential specialist equipment, e.g. computer rooms, auxiliary rooms.

These systems shall be designed to provide sufficient detection with and without the HVAC system running.

Aspirated smoke detection may be considered where there are high ventilation rates, high congestion, high ceilings or the use of "low smoke" materials.

Flow and dispersion modelling may be used to determine the locations of sampling points.

4.2.4.5 Smoke Detection on intake ducts

Smoke detectors in ventilation ductwork shall be sited on a straight length of ductwork, at a distance of at least three times the width of the duct from the nearest corner. Also, in ducts that have air speeds above 5 m/s (16 ft/s), windshields shall be provided. Provision of windshields shall ensure dead spots are avoided.

NOTE Open path smoke detectors may be mounted outside the duct and monitor the duct air through 'windows'. This avoids any problems due to air speed and dirt accumulation and allows access for maintenance.

4.2.5 Carbon Monoxide for Fire Detection

Carbon monoxide (CO) detectors shall only be used by exception as fire detectors and then only with the approval of the principal.

Applications where CO detectors may be considered are:

- Fires are likely to be smouldering in nature and the use of smoke detectors may result in unwanted alarms, e.g. environments where steam or dust may be present.
- Products of incomplete combustion are likely to accumulate at equipment and enclosed spaces.

4.3 FLAMMABLE GAS DETECTORS

Detection equipment SHALL [PS] be capable of detecting the gases or vapours that may be present in the area covered by the detectors.

The method for gas detection shall be optical except where this is not capable of detecting the hazardous products (e.g. hydrogen, acetylene applications), or other methods provide rapid detection of release events (e.g. acoustic), or other methods are required by regulation.

Open path (also known as "Line of Sight" or LOS) infra-red detector technology provides greater coverage than a point detector for detection of gases (flammable and toxic) and shall be used wherever practicable. Consideration shall be given to:

- The background environment e.g. open path may not detect the hazard where excessive / persistent levels of steam are present in the area where the detection is required.
- The effects of any single open path gas detector going into fault that prevent detection, and the affect of this on detection coverage.

Point IR shall be used to detect accumulations of gas in highly congested areas where open path detection cannot be used due to no or restricted detection path.

Acoustic leak detection may be used for detection of high pressure gas releases as the prime detection technology or in combination with conventional detection (open path / point).

Where hydrogen is present in the process stream, the detection placement shall consider the hazard (size of event, flammability limits) and the overall ability to detect the release (i.e. which detector type / technology will respond earliest).

When siting gas detectors as release source detection, then the following shall be assessed to ensure that detection is effective:

- Product composition phase (liquid / vapour)
- Product pressure
- Location of release sources
- Congestion
- Air flows (e.g., wind, HVAC, thermal)
- Potential for accumulation
- Topography
- Detection distance away from the potential release source.

Note Detectors close to release sources may not be as effective as detectors placed at a distance away.

For evaporating liquid releases, detector siting elevation shall take account of the resulting vapour plume density and air flow patterns; if the vapour is heavier-than-air then detectors may be located at low elevations (minimum 0.6 to 1.0 m (2 to 3 ft) above grade out of doors, 0.3 m (12 in) above grade indoors).

Modelling to determine detector placement shall include all fin fan coolers, unless it is demonstrated that placing LOS detectors above them provides the correct level of coverage.

Unless otherwise specified:

- oxygen deficiency sensors located 1.5 m (60 in) to 2 m (80 in) above grade (i.e. close to head height).
- CO₂ sensors located at 1 m (3 ft) above grade
- the elevation of line of sight devices between 2.2 m (7.2 ft) to 4 m (13 ft) above grade or walkways, determined by detection coverage and installed equipment in the area.

Perimeter detection may be used at the discretion of the Principal. Where used, the following shall be considered:

- The dispersion takes place in an area of no or low congestion.
- Adequate accumulation protection within the zone area is also included, or deemed to be not required
- The assessed hazard is limited to the migration of gas to / from other areas.
- Where access and egress cannot affect the detection capability

Where it is not practical to provide access from grade or platform, point gas sensors shall be provided with calibration points via tubing to an accessible point, such as grade or elevated permanent platform accessible by stairs. The material shall be suitable for the test gas (e.g. stainless steel is not suitable for Chlorine (Cl₂) and H₂S).

Siting distance for open path detectors is up to 60 m (200 ft) for onshore facilities and 30 m (100 ft) for offshore facilities. With the approval of the Principal, longer path-lengths may be deployed.

Open path detectors require a clear and open (i.e., unobstructed) path approximately 0.3 m (12 in) in diameter and therefore shall be applied with caution in congested areas. To prevent temporary obstruction it is advised that floor markings be applied to show the location of optical paths.

For high pressure gas detection (> 4 Bara (60 psia)) IR or acoustic detection technology shall be used, unless the IR technology cannot detect the gas species (e.g. hydrogen). For low pressure gas detection ($\leq$ 4 Bara (60 psia)) only IR technology shall be used, unless the IR technology cannot detect the gas. In the case that IR cannot detect, an alternative technology may be used (e.g. catalytic bead for hydrogen gas).

For detection using catalytic bead sensors (e.g. hydrogen) the effects on oxygen depletion shall be considered for detector positioning such that detection will not be impaired at the start of the release event (flooding of the sensor by released gas may deplete oxygen levels and prevent the sensor from detecting the gas release).

For enclosed modules with flammable or toxic products that use ventilation to maintain air quality, the ventilation extract systems shall have appropriate gas detection installed (e.g. flammable or toxic gas detection).

4.3.1 Inferred Gas Detection

Inferred detection does not provide the operator with a concentration level or the species for the inferred gas. The action upon alarm operating shall be the same for both the detected gas and the inferred gas. As such inferred detection shall not be used as a substitute for the second gas (e.g. toxic gas) detection where there is a different action required for detection of each species.

Inferred detection may only be applied if approved by the Principal, and it is demonstrated by calculations that:

- The second gas is directly inferred from the concentration of the gas being detected; AND
- This is always the case for all process stream contents in the area for the detection; AND
- The alarm level for the detected gas is activated before the second gas concentration reaches a hazard alarm level; AND
- The composition of the process fluids is predictable throughout the life of the installation.

Inferred detection for point detection and LOS detection shall not be intermixed.

Calculations shall be carried out for each zone that inferred detection is to be used, and this shall demonstrate that the inferred detection method is always capable of detecting the second gas from the primary gas.

4.3.2 Point Infrared Gas Detectors

Point infrared gas detector may be applied where:

- Space or congestion prohibits the use of open path gas detectors (e.g. uninterrupted beam path cannot be achieved, equipments located inside a pit / below grade level);
- Where open path can't be used due to environmental conditions;
- For small enclosures / rooms (e.g. Analyser House except where hydrogen is used as a carrier gas, detection gas or is contained in concentrations greater than 1% in the process fluid);
- HVAC systems.

4.3.3 Catalytic Bead Detectors

Catalytic bead gas detectors shall not be deployed for general use. They may be used only in applications where other technologies do not detect the identified gas species. For example, Catalytic bead gas devices detect hydrogen.

For non-hydrogen and volatile hydrocarbon applications, the use of catalytic gas detectors requires approval from the Principal. Where catalytic combustion type detectors are selected, these shall be poison resistant.

4.3.4 Pellistor- (Catalytic Bead) Replacement Infra Red Detectors

These devices shall not be used for new greenfield projects or projects that upgrade the Fire & Gas panel systems.

4.3.5 Acoustic Leak Detectors

Acoustic detectors shall not be used for detection of liquid releases.

Acoustic Leak detection may be considered for areas where the following requirements are met:

- The pressure driving the release results in sonic flow release velocity (typically greater than 4 Bara (60 psia) process pressure. Refer to manufacturer for applicable process pressures).
- In ventilated areas where accumulations of gas may not form.
- In situations where high pressure gas releases are difficult to detect with conventional gas detection (e.g. releases from elevated sources).
- Interfering ultrasonic noise from equipment in the area is masked out and does not give spurious detection or prevent detection.

Acoustic Leak detectors shall be installed above or adjacent to potential leak sources (typically within 3 m (12 ft)). Acoustic leak detectors require a clear field of view in an unobstructed cone around the detector. Refer to Manufacturer for guidance.

A detailed review of the noise profile for normal mode of operations shall be carried out to determine the effect on detection of operational noise sources, which include:

- Choke valves and control valves that are operating at high flow rates and high differential pressure
- Pneumatic tools operating off instrument air
- Depressurisation, blow down and relief valves
- Control valves with noise reducing trim (i.e., noise is shifted from audible to ultrasonic frequencies)
- Turbo Machinery

4.4 OIL MIST DETECTORS

Oil Mist Detection shall be considered in enclosed areas where aerosol mists of suspended droplets may be present.

The design and installation of Oil Mist Detectors require the following to be assessed:

- Any prevailing air flows;
- Environmental conditions such as humidity (steam, fog);
- Pockets of high smoke / oil concentration, and
- Obstacles to the flow of the particles.

4.5 CCTV GAS DETECTION

These detectors shall only be installed following approval by the Principal.

4.6 TOXIC GAS DETECTOR TYPE SELECTION

Toxic Gas detection equipment shall be capable of detecting the specific toxic gases or vapours that may be present in the area covered by the detectors.

The method for toxic gas detection shall be electrochemical, except as noted in (4.6.4).

Electrochemical sensor heads have a finite shelf life in the unpowered state (ca. 6 months from date of manufacturer). Therefore sensors for electrochemical detectors shall not be installed until immediately prior to commissioning. For the sake of functional loop testing, a "sacrificial" head may be used to verify that the transmitter is responding to test gas (i.e. move a single head from location to location).

Acoustic detectors shall be considered for detecting loss of containment of pressurised toxic gas where the release is into an open area and including elevated equipment, and where rapid response to loss of containment of pressurised gas is required.

Metal Oxide Semiconductor detectors are prone to desensitising over time if not exposed to the gas of interest. Hence, these shall only be considered where other detection technology cannot detect, and then only with the approval of the Principal.

Open path toxic detectors or NanoTechnology MOS (NTMOS) shall only be installed following approval by the Principal.

4.6.1 Hydrogen Sulphide (H₂S) Detectors

Fixed H₂S detection shall be installed in any building with limited ventilation and equipment containing H₂S.

For normally ventilated buildings or open process areas, refer to Table 4-3.

Table 4-3 Requirement for H₂S Fixed Detection by Process Stream Concentration

Likelihood of presence of H₂S within area	H₂S concentration in process stream	Fixed Detection Required?	Comment
Impossible or <10 ppm in air under all circumstances	<10 ppm	No	"H ₂ S – free" area
Possible in case of system malfunction	<0.1 % (1,000 ppm)	No if gas is flammable, and flammable gas detectors are installed. Yes if gas is not flammable or release is in the liquid phase.	Detection of a release may be provided by flammable gas detectors, and personal monitors.
	0.1 % to 1 % (1,000 to 10,000 ppm)	Yes, particular attention for areas where dispersion may be hindered.	Detection of a release shall be provided by fixed toxic gas detectors and personal monitors.
	>1 % (10,000 ppm) "High H ₂ S Area"	Yes	Detection of a release shall be provided by fixed toxic gas detectors and personal monitors.
Possible or expected in normal operations	Any	No	Risks managed through other HSE processes

Note The "concentration in process stream" refers to the stream with the highest H₂S concentration in a zone, and is specific to the zone in question.

4.6.2 Inferred Gas Detection

See 4.3.1.

4.6.3 Acoustic Leak Detectors

Read this section in conjunction with (4.3.5).

Acoustic detection shall be considered for use where rapid response to high pressure toxic gas release is a requirement and background noise interferences from other (process) equipment in the area does not impair detection.

Acoustic sensors detect high pressure gas release events. Where there is a toxic gas in the process stream then toxic gas may be inferred upon release detection.

Where there may be sour or sweet service in the same area and acoustic is used as a detection method then any release event shall be treated as flammable and toxic.

4.6.4 Detector Selection for Specific Toxic Species

4.6.4.1 Carbon monoxide (CO)

CO detectors shall be installed in areas where incomplete combustion products may be at toxic levels, e.g. from machinery exhaust fumes, or where CO may be present in significant concentration in process streams and loss of containment would cause a hazard.

Electrochemical CO sensors shall not be used in process areas where hydrogen is treated, manufactured or transported. For such applications open path IR and aspirating systems, utilising IR or Gas Chromatography as the detector, may be considered.

CO gas detectors shall be installed in HVAC systems where there is a risk of incomplete combustion from fuelled engines in the vicinity e.g. offshore accommodation office blocks

4.6.4.2 Carbon dioxide (CO₂)

CO₂ detectors shall be installed in areas where CO₂ could form a hazard. e.g. CO₂ injection, enhanced oil recovery and CO₂ sequestration.

4.6.4.3 Hydrogen fluoride (HF)

There are several HF detection technologies available: Electrochemical cell; laser LOS; ion mobility (IMS).

A combination of detection technologies shall be used to confirm detection.

Etched glass technology is only effective for specific applications where a release would be localised and highly concentrated e.g. below a liquid vessel. Etched glass detectors shall not be used for general detection of HF vapour releases, and shall only be deployed following the approval of the Principal.

HFA detection deployment shall use Gas Detection Modelling software and by assessing HFA releases on two levels, those being:

1) developing detection layouts in the immediate vicinity of specific areas of concern. The objective of this assessment is to alarm to HF accumulations that would present a hazard to personnel working on, or in the vicinity of these areas including perimeter detectors.

2) The second objective is to develop detection layouts to mitigate significant or major HF releases. Releases where acid concentrations are high and are mitigated by transferring the acid inventory to a purpose built vessel via the rapid acid-dump facility. This transfer may be initiated automatically by the sensors.

Robustness against "false dumps" is built into the detection layouts through a combination of point detectors within the unit voted in a 2ooN architecture AND voted with a Laser perimeter system to provide "confirmed" HF detection.

Approval from the Principal is required before implementing automatic executive action upon confirmed detection of HF and the 'dump' of the acid inventory.

4.7 SPECIAL AREA DETECTION REQUIREMENTS

4.7.1 Turbine engines / enclosures

Flammable gas detection shall be installed at the forced ventilation inlets (combustion and enclosed chambers) and at the enclosure outlet adjacent to the enclosed chamber.

When air movement stagnation may occur in the enclosure, then gas detection shall be fitted in the enclosure.

Where environmental conditions (temperature) in the enclosure and ventilation outlet are outside the temperature range of the detection equipment, then aspirated systems may be deployed.

4.7.2 Ventilation air intakes

Ventilation air intake for normally occupied buildings located within the gas dispersion area shall have gas detectors (flammable and / or toxic), and smoke detectors if smoke ingress is an identified hazard.

Where a building or its ventilation intake is inside or adjacent to a hazardous zone and the equipment in the building is not rated for the hazardous zone, gas detection (toxic and or flammable) shall be provided at the ventilation inlet to shutdown the building ventilation air intake.

Where the buildings ventilation outlet is within a hazardous zone there shall also be gas detection in the ventilation outlet to detect gas in the event of ventilation failure. Where toxic gas is a hazard, toxic detection shall also be installed at the ventilation outlet.

Where the air ducting has an area greater than 1.0 m² (10 ft²) there shall be minimum of 3 gas detectors installed. A less than 3 detectors may be used where the ducting area is less than 1.0 m² (10 ft²), and it is demonstrated that air flow is not stratified or may impair the ability to detect gas.

Stratification of the flow in the air ducting shall be considered and accounted for before siting detectors at the ventilation intake or outlet.

4.7.3 Unattended Installations

The Fire & Gas systems requirement for unattended installations will, in general, depend on their complexity and whether the installation is offshore or onshore.

The Fire & Gas systems shall be designed and installed using the assessment process as described for a normally manned installation.

4.7.4 COLD TEMPERATURE DETECTORS FOR LNG / REFRIGERATION PRODUCTS

Temperature detectors such as Linear wire or point heat detectors may be used for the detection of low temperature from liquefied gas releases, and only used at the approval of the Principal.

4.8 MANUAL ALARM CALL

Manual alarm call, personal radio link (not subject of this DEP), and direct telephone links (not subject of this DEP) may provide a means to alert others and the control centre.

If other means of communication between the field and control centre are available to all persons accessing the plant, then it may at the approval of the Principal be decided not to install manual call points within the plant area.

4.8.1 Location

This section applies when Manual Alarm Call points are required

They shall be located at places identified by the hazard assessment.

For example:

- Along roads in the plant area at intervals not exceeding 100 m (300 ft), located near to lamp posts;
- Along roads in storage / tank areas not exceeding intervals of 200 m (600 ft);
- Near or at locations having a higher risk such as remote pump floors, oil catchers, manifolds, motor control centres, jetty heads;
- On offshore locations, at escape routes (entrance to bridges and staircases);
- Inside process buildings;

- Inside process plant areas and positioned:
 - o Outside power station(s);
 - o Outside analyser house(s);
 - o Outside control room(s);
 - o Outside utility buildings;
 - o Outside hazardous enclosed areas;
 - o Along logical escape routes.
 - o Above grade locations where egress is difficult
 - o Entry and exit points of a pump house

Where no hazard assessment has been conducted, they shall be installed inside process plant areas, where the maximum distance to any alarm call point shall not exceed 30 m (100 ft). In congested areas where there is no direct egress from all points, the distance shall not to exceed 20 m (65 ft).

Manual alarm call point stations shall be fixed at an accessible height; between 1.0 m (3 ft) and 1.5 metre (5 ft) above grade or deck level. The height is based on anthropomorphic data for the target population of operators.

Manual alarm call point identification numbers and where appropriate emergency contact numbers shall be displayed at the manual alarm point location.

Manual alarm call points shall be distinctly identified, labelled and RED in colour as per the requirements for DANGER signs.

Manual alarm call points shall be positioned so that they stand out against the background, i.e. they shall be clearly recognisable from a distance. If necessary provided with signs to enhance their visibility e.g. from access roads.

Manual alarm call points shall be operable by an operator whilst wearing PPE appropriate to the zone (including gloves, face mask or hood, etc).

4.9 DETECTOR IDENTIFICATION

A unique number or tag shall be assigned to each detector, manual alarm call point, horn, beacon, etc. Numbering or tagging to be in accordance with DEP 32.10.03.10-Gen. or by adopting the existing site philosophy (e.g. Brownfield cases).

Where addressable detectors are used they shall have a unique address (e.g. IP) for each detector head.

4.10 PORTABLE AND PERSONAL GAS MONITORS

Alarm levels for personal gas monitors are given in table 4-4, and are based on EH40.

Table 4-4 Alarm Set Points for Personal Gas Alarms

Type	Alarm Level 1	Alarm Level 2
Flammable gas	10% LFL	20% LFL
Hydrogen Sulphide (H ₂ S)	5 ppm	10 ppm
Carbon Monoxide (CO)	25 ppm	200 ppm
Chlorine (Cl ₂)	0.5 ppm	1 ppm
Oxygen (O ₂)	19.5%	23%
Sulphur dioxide (SO ₂)	2 ppm	5 ppm
Carbon dioxide (CO ₂)	5,000 ppm	30,000 ppm

Personal, portable and transportable gas monitors shall as a minimum comply with all of the following requirements:

- a) Fitted with pre-determined and locked alarm levels
- b) Full Data Logging (including gas reading, alarm and event history; see note 1)
 - 1. Store data that shall be retrieved up to 30 days post loss of main battery power, and with all previous data (several hundred records) retrievable.
 - 2. Minimum data to be logged is date and time for the following actions and events:
 - a. When the instrument is switched on and off.
 - b. When the instrument is bump tested. Bump test results also to be logged, including battery voltage.
 - c. When the instrument has been adjusted, such as accepting calibration adjustments or adjusted parameters. Adjustment made also to be logged.
 - d. When an alarm has operated. Also log which alarm and the alarm value.
 - e. When an alarm was accepted.
 - f. When an alarm was reset to normal operating state.
 - g. When the instrument has automatically switched off.
 - h. When there is a peak value reached for a sensors measurement. Also the peak value.
 - i. Sensor measurement values at regular intervals not exceeding 1 minute.
 - j. STEL and TWA data.
- c) Ex certified for Zone 1 (Division 1; Class1),
- d) Protected to IP 66 or higher
- e) Battery life greater than 12 hours
For instrument with rechargeable battery, at the end of 500 charge operations the battery shall be able to supply a minimum of 12 hours operating life.
- f) The instrument shall have low battery warning, with at least a further 10 minutes operating life before the instrument automatically switches off.
- g) Operating temperature -30 to +45°C (-20 to +110°F)
- h) Humidity range (10 – 90%RH)
- i) Audible alarm, greater than 95dB at 0.3 m (12 in) or 85dB at 1m (3 ft)
- j) Periodic confidence bleep with distinctive tone for fault
- k) Response time, T90 less than 20 seconds
- l) EMC compliance to EN50270 or 89/336/EEC
- m) The instrument shall be easily bump tested at location
- n) In addition for Personal detectors:
 - 1. Fitted with a secure fixing arrangement that enables the detector to be worn within 300 mm (12 in) from face.
 - 2. In case of multi-gas detectors, at least capable of alarming flammable gas, O₂ and the toxic gas related to the hazards within the area (e.g. H₂S, CO).

3. Fitted with a vibrating method for alerting in addition to the visual and audible requirements.
4. For single gas monitoring shall be supplied with the appropriate specific gas sensor for the hazard.
5. Wireless capability to alert the control point of the hazard being detected.

n) In addition for Portable detectors used for leak seeking or verification

1. Multi-gas four sensors to detect flammable gas / vapour, O₂, H₂S & CO. This is for instruments supplied for general area leak seeking and gas free verification.
2. Fitted with aspirating pumping features.
3. Capable of sampling from confined or inaccessible areas by means of an extension tube. The length of the tube / hose provided shall be restricted to 3 m (10 ft) to avoid excessive pressure drop.
4. Fitted with vibrating method for alerting in addition to the visual and audible requirements.

o) In addition for Transportable or Portable detectors for monitoring temporary work areas

1. Fitted with sensors to detect gases that are expected.
2. Free standing such that it may be placed at any appropriate location.
3. Capable of being connected to other similar detectors that may be placed in close proximity.
4. Equipped with wireless capability to alert the control point of the hazard being detected.

Note 1: Only products with full data logging provides historical data that is used for incident investigation, thus requirement is for full data logging. "Data logging" is different from "Event logging". Event logging is only logging of state changes in the monitor, such as power on/off, alarm 1 operated, alarm 2 operated, etc, and does not provide recording of gas values. Full data logging is logging of the time & date of the event, gas values and state changes, thus trending and event analysis may be carried out following an incident.

5 DETECTOR SPECIFICATIONS AND CHARACTERISTICS

5.1 GENERAL REQUIREMENTS FOR ALL DETECTORS

5.1.1 Output Signals

Where the detection signal has a measurement range (e.g. gas detection), the output signal shall be analogue that provides coverage of the whole measurement range, including associated fault levels.

Analogue outputs may be used for other types of detectors (e.g. flame / smoke) where available.

Addressable detectors may be used with the Principal's approval.

5.1.1.1 Analogue Signals

Gas detector analogue output shall be 4-20 mA aligned with the detectors range. Analogue outputs shall take advantage of the 0-4 mA range for fault condition indication.

Output from other types of detectors such as fire and smoke may be a stepped 4-20 mA output (e.g., 0 mA = power fault; 1 mA = general fault; 4 mA = normal operation; 20 mA = alarm).

5.1.1.2 Digital Signal

Digital sensor device output circuits shall incorporate line monitoring. The contacts shall be normally open and close on event detection.

Digital outputs shall be self resetting, unless set by a physical action (e.g. breaking glass on a manual call point).

Switch contacts used for interface with input circuits to the Fire & Gas system shall have a minimum rating of 1 A at 24 V DC.

5.1.1.3 Diagnostics / Fault Signals

Fire, gas, aspirated smoke detectors, open path smoke detectors, and acoustic leak detectors shall provide a fault signal as well as a measurement output. The fault signal may utilize a set of dry contacts (5.1.1.2) or manipulation of the analogue signal (5.1.1.1).

Simple smoke detectors (e.g. switched) shall be capable of providing line monitoring for circuit faults. If a fire panel is used to "group" smoke detector signals in a FAR or Control Centre, a common alarm and a common fault signal are sufficient.

Other simple devices (e.g. switched) shall be capable of providing line monitoring for circuit faults.

Analogue and addressable devices shall be capable of providing diagnostic and fault signals, and may be compatible with the FGS or hand held interrogator.

Where asset management systems are employed, the analogue devices shall be HART compatibles to enable enhanced diagnostic data to be collected. The associated analogue input modules shall support HART without the need for additional hardware.

Compatibility of the HART functionality shall be proven through interoperability testing. Systems, components and communications diagnostics may be provided wherever required to achieve or improve detection and system availability.

5.1.2 FOUNDATION™ FIELDBUS

Currently there are no FOUNDATION™ FIELDBUS Safety Instrument Systems (FFSIS) for Fire & Gas Detection or FGS. The use of this technology is not permitted, without agreement from the FGS Subject Matter Expert (SME).

5.1.3 Power supply

Devices typically operate on a nominal 24 V DC power supply within a range of 18 V DC to 32 V DC.

5.1.4 Electrical connections

Devices shall have sufficient connection terminals to accommodate all electrical conductors with one conductor per terminal.

Conductor sizes may be up to 2.5 mm² (10 SWG).

5.1.5 Hazardous Area Classification

See DEP 32.31.00.32-Gen section 2.6. and (4.1) for general info on electrical certification.

5.1.6 Vibration

Detection equipment shall be designed to ensure correct operation during vibration up to accelerations of 1 mm/s² (0.04 in/s²) from 2 Hz to 60 Hz.

NOTE: The structure may be expected to vibrate at the installation power generation frequency and its harmonics.

5.1.7 Ingress protection

The minimum acceptable degree of protection against moisture or dust ingress for EXTERNAL mounted devices shall be to IP65 in accordance with IEC 60529.

Detection devices mounted within buildings or walk-in enclosures shall generally comply with a minimum of IP41 protection. Junction boxes shall have a minimum ingress protection of IP65.

5.1.9 Environmental protection

Detection equipment shall be capable of operating and detecting in the environment that they are installed, inclusive of atmospheric chemistry, local temperature ranges and humidity.

Where necessary, the detector shall have protection from the effects of:

- Corrosion,
- Dust,
- Vibration,
- Rain / moisture / humidity
- Hosing-down operations,
- Light / heat radiation (e.g. flare, sun)

NOTE: When environmental protection is fitted, this may affect the response time of the detector – time delays shall be taken into account when assessing suitability of the detector specifications for the application

5.1.10 Environmental tolerance for Optical Detectors

For all optical detectors, including optical flame detectors, open path smoke detectors, point IR gas detectors, and open path IR gas detectors:

- Minor fouling of optical surfaces by the common contaminants found in the area of installation shall not cause unwanted Process alarms or fatal degradation of measurement signals (e.g. loss of detection).
- High levels of fouling shall be communicated as a diagnostic fault condition.

5.1.11 EMI/RFI

Fire and Gas detectors shall be resistant to EMI/RFI interference. Specifically, the devices shall be EMC compliant and not respond to a 5 watt walkie-talkie at distances greater than 0.3 m (12 in).

5.1.12 Condensation Protection

Where required by environmental conditions, optics shall have anti-condensation heating.

5.1.13 Testing

All detectors shall have the capability of being tested whilst in situ, to enable life-cycle functional proof testing.

This may be through self-test function or with a portable simulation source.

5.1.14 Wireless

Currently there are no wireless Safety Instrument Systems for Fire & Gas Detection or FGS. The use of this technology is not permitted for fixed detectors, without agreement from the FGS Subject Matter Expert (SME).

5.2 FIRE DETECTORS

5.2.1 Optical Flame Detector

5.2.1.1 Diagnostics

All optical flame detectors shall have automatic optical integrity checking functionality. The optical integrity check shall be capable of detecting when the outside of the lens has fouling (e.g. dirt, salt, oil etc.).

5.2.1.2 Alignment

Optical flame detectors shall allow easy horizontal and vertical angular adjustment (pan and tilt) of at least +/- 45 degrees.

Optical flame detectors shall lock in the desired position.

5.2.1.3 False alarm immunity

Solar interference (sunlight), artificial lighting, or regularly modulated (vibrating) black body radiation shall not cause false alarms.

5.2.2 Heat Detectors (General)

5.2.2.1 Sensitivity

Fixed Temperature Heat detectors shall have an activation point set (nominally) at a temperature of 68°C. However, in areas of high ambient temperature detectors to be set at 30°C above the anticipated highest ambient temperature or nearest standard fixed setting above this 30°C value.

5.2.2.2 Set Point

Fixed electrical / electronic temperature heat detectors shall be self-resetting. Set point shall take account of ambient conditions and be appropriate to the expected fire hazard.

5.2.3 Pneumatic Heat Detectors

These detectors shall use a pressure transmitter (rather than a pressure switch) for alarm and fault indication.

Fire detection tubing shall be black (UV light resistant), fire retarding polyethylene tubing ("polytube"), and shall be manufactured from self-extinguishing material.

5.2.4 Optical Linear Heat Detectors

Optical linear heat detectors shall be capable of monitoring the temperature at any point along the fibre.

5.2.5 Aspirating Smoke Detectors

Maximum required detector response time shall be defined for each specific application.

NOTE To achieve the response time many factors have to be taken into account in the system design, such as the volume and normal air change rate of the volume being monitored, and the piping and sampling points.

The system shall contain diagnostics to detect changes in air flow in excess of $\pm 10\%$ from the commissioned value that could arise from broken or blocked pipe work.

5.2.6 Point Smoke Detectors

Each detector shall be fitted with a latching Light Emitting Diode (LED) to indicate when the detector is in the alarm state.

5.2.7 Carbon Monoxide Detection

Used also for toxic gas detection and the specification is covered under "Toxic Gas Detector Selection" (Section 5.4)

5.3 FLAMMABLE GAS DETECTORS

Flammable gas detectors shall continue to operate regardless of the concentration of gas that is present and being detected, such that when the gas concentration has reduced, the detector continues to provide information to the fire and gas system without having to be manually reset.

IR detectors shall be supplied with factory calibration so that it will never underestimate the flammability of any hazardous gas compositions that it may detect e.g. if the cross-sensitivity for any of the gases that may be present is less than 1.0 then the gas with lowest cross-sensitivity value shall be the factory-calibrated gas used, hence assuring that all gases do not under-measure.

This may require the detectors to be factory calibrated to a gas that is different from the test gas e.g. for some LOS the factory calibration would be pentane and these are tested using test filters of different composition.

5.3.1 Open Path Detectors

5.3.1.1 Mounting

Open path detectors (gas (flammable and toxic), oil mist, smoke) shall be installed on rigid supports. Rigid in this context means mechanically strong and free from impairment vibration, i.e. vibration resulting from structural flexing or other mechanically induced vibration, and misalignment / flexing due to wind buffeting. This requires detector supports to be short and braced to primary steelwork where possible. In all cases, the manufacturer's data on misalignment shall be followed.

5.3.1.2 System configuration

All open path gas detectors shall have separate transmitter and receiver units, unless restricted by the available technology such as:

- Laser based technology using a reflector panel, or
- HVAC duct applications.

NOTE Detectors with separate transmitters and receivers are more tolerant to operation in dense airborne obscurants (fog, rain, or snow) than detectors that use reflector panels. Their narrower beams also make them less susceptible to false alarm from partial obscuration.

5.3.1.3 Alignment

The system shall be tolerant of misalignment of either or both the transmitter and the receiver of 0.25 degrees without any effect on system operation.

5.3.1.4 Sensitivity

For general area use, the detector range shall be 0–5 lower flammable limit metre (LFL-m). For HVAC applications, the detector sensitivity range shall be 0–100 % lower flammable limit (LFL) with the detector calibration determined by the width of the duct, or path length.

5.3.1.5 Diagnostics

Open path devices shall have diagnostics that indicate beam performance. System shall contain diagnostics for the following conditions:

- Low signal strength (e.g. excess path length, dirt build-up or minor misalignment)
- Significant reduction or loss of signal for more than 30 seconds shall automatically indicate an optical fault (e.g. Beam block fault).

If the system is in a low-signal-strength fault, then gas concentration shall continue to be measured and reported (i.e. gas cannot be detected during a total beam block fault or gross misalignment).

5.3.1.6 False alarm immunity

Detector shall not produce a gas measurement signal indication greater than 0.25 LFL-m in response to any combination of obstructions, vibration, or external sources of infrared radiation (including solar and hydrocarbon flare radiation) in the beam.

5.3.1.7 Environmental tolerance

Solar interference (sunlight) shall not cause false alarms, detector faults, or detector unavailability.

Detector shall be capable of operating in fog, rain, snow or steam densities equivalent to a transmittance of 0.05 (95% drop in visibility) over 30 m (100 ft).

5.3.2 Point Infrared Gas Detectors (including pellister replacement)

5.3.2.1 Sensitivity

The standard sensitivity range of the detector shall be 0–100 % LFL.

5.3.2.2 Diagnostics

System shall contain fault diagnostics for optical fault condition.

5.3.3 Point Catalytic Gas Detectors

5.3.3.1 Sensitivity

The standard sensitivity range of the detector shall be 0–100 % LFL.

5.3.4 Aspirated gas detection systems

Requirements for aspirated systems shall follow the flammable gas detection requirements stated above.

5.3.5 Oil Mist Detectors

5.3.5.1 Sensitivity

Alarm sensitivity shall be a signal loss of 0.5 dB or greater.

5.3.5.2 Retro-Reflectors

Where retro-reflectors are used they shall be installed such that they are appropriate to the size and type of Oil Mist Detector. An anti-condensation insulating layer shall be provided between the retro-reflector and steel mounting plate.

5.3.5.3 System faults

The detector and supporting electronic equipment shall include functions to detect and communicate any condition that might prevent a response to oil mist in the optical path.

5.3.5.4 False alarm immunity

Oil-mist detectors shall differentiate between an oil-mist release and accidental beam interruption.

5.3.6 Acoustic Leak Detectors

5.3.6.1 Sensitivity

Detector sensitivity to detect in the range typically 44 dB to 104 dB.

For hazardous releases the detection performance requirements shall specify a release rate and potential leak sources for coverage. A default detection performance requirement is a leak rate of 0.1 kg/s (0.22 lb/s).

5.3.6.2 Response time

The detector / system shall be capable of providing up to 30 second delay to prevent false alarm due to background noise.

Ambient noise conditions shall be analysed to determine the time delay to be used.

5.3.6.3 Diagnostic Capability

To ensure a reliable leak detection system, only leak detectors with integrated acoustic self-test function or fault-identifying diagnostics shall be used to ensure operation that will prevent unrevealed failures.

5.4 TOXIC GAS DETECTORS

5.4.1 Sensitivity

The minimum sensitivity of the detector shall not be greater than 25% of the high alarm concentration.

The detector's concentration range maximum shall be between 2 times and 4 times the highest alarm concentration. e.g. if the highest alarm level is 40 ppm, then the measurement range shall be between 0–80 ppm and 0–160 ppm.

5.5 MANUAL ALARM CALL POINT

See (4.8.1)

Simple Manual Alarm Call (e.g. switched) shall have volt-free latching contacts for Alarm, and with end-of-line resistors for circuit monitoring via FGS analogue input modules.

Where alarm call points possess a telephone they shall meet the requirements of DEP 32.71.00.10-Gen. sections 3 and 5.

Addressable Manual Alarm Call shall use a discrete protocol (e.g. Internet Protocol).

6 DETECTOR LAYOUT PERFORMANCE, MAPPING, OPTIMISATION AND VOTING

6.1 LAYOUT OPTIMISATION

The ability for the FGS to detect a hazard scenario shall be assessed in an auditable manner, with rationale for detector placement documented.

The detector layout design for accumulation events shall use 3D modelling to assure that the detection meets the identified detection performance criteria (e.g. fire sizes, gas cloud sizes).

Fire and gas detector deployment may be optimised to meet the detection performance requirements (see (3)).

To optimise the layout, each detector shall be considered individually, and as part of a group of detectors. In each zone, the number and location of the detectors shall be set such that the combined coverage of all the detectors in the zone meets the requirements for detecting the fire or gas hazardous events that have been considered.

6.2 DETECTION PERFORMANCE CRITERIA

Detection performance requirements for both flame and gas detectors shall be set through consideration of detecting a fire or hazardous release or accumulation as early as practicable or before they are large enough to cause an escalating situation or health hazard if not mitigated. This is to provide the detection when the event is small rather than when it has escalated to a large event, however large events also need to be detected.

The detection performance shall be based on hazards from products that are in the area, and the area topography. Where a gas migration hazard has been identified by the HEMP process, the detection performance shall also include products that are able to migrate into the area.

Where appropriate, consideration to be given to neighbouring areas e.g. where event migration could be an issue.

6.2.1 Minimum Fire Size for Detection

The detection performance requirements shall specify the fire size (in radiated heat output, kW) and fuel type.

The default flame detection performance, used to assess, orientate and position flame detectors shall be based on the detectors' response to a n-heptane pool fire with 100 kW Radiant Heat Output. At the discretion of the Principal, a local specific fire size for the site or zone may be determined, taking into account the following:

- Overall installation layout.
- Passive Fire Protection.
- Location of nearby adjacent hydrocarbon inventories.
- Location of Safety Critical Elements.
- Speed of response required to avoid escalation

6.2.2 Cloud Size for Detection

The gas cloud size determination is dependent on the principal (or most critical) gas that is likely to be present.

6.2.2.1 Flammable Gas

The detection performance requirements shall specify the cloud size and gas/vapour. For flammable gas the appropriate cloud size for the detection performance requirements for each zone shall be based on explosion analysis and the predicted explosion overpressures with respect to the designed tolerance of the hazardous zone.

If no analysis has been carried out, then the flammable gas cloud sizes for general volatile hydrocarbon vapours (e.g. methane through to hexane) shall be as shown in Table 6-1.

Table 6-1 Flammable gas cloud sizes

Zone characteristic	Cloud Size to use
Enclosed area ¹ or Mostly-enclosed area ²	5 m (16 ft) diameter sphere ⁶
Part-enclosed area ³ or Congested area ⁴	7 m (23 ft) diameter sphere ⁶
Open area ⁵	10 m (33 ft) diameter sphere ⁶

- NOTES
1. Fully walled/floored area with or without forced ventilation or vents.
 2. A congested area with one open side.
 3. A congested area with two or more open sides and grated floor/ceiling or more than two open sides.
 4. Process plant that has closely installed piping/equipment.
 5. Open lightly congested areas without walls
 6. The sphere diameter is based on a LFL concentration or greater within the diameter.

6.2.2.2 Toxic Gas

For toxic gases the detection performance requirements is determined from the level of protection required from the specific hazard. The default toxic cloud size shall be an 8m sphere for detection in all area types, unless specific cloud size is determined taking into account but not limited to the following:

- Installation layout.
- People access / access control.
- Toxic inventories location.
- Toxic concentrations within the process streams.
- Time to protect (e.g. time for operator to fit SCBA (Self Contained Breathing Apparatus).

6.2.3 Detection Coverage Criteria

The detection coverage requirements for fire or gas events in each zone is defined as the proportion of modelled idealised events within a zone that would be detected, expressed as a percentage.

This definition does not take account of frequency or likelihood of any event – all instances of gas accumulation or fire within a zone are given equal weight when assessing the coverage.

The detection coverage requirements shall be defined for each zone. In absence of specific requirements the following minimum detection coverage per zone is to be applied:

- 90% for a single detector alarm based on N detectors in the zone.
- 85% for two or more detectors alarming based on N detectors in the zone.

The number of detectors N is determined by the identified voting requirements and how the voting provides availability for detection in the zone, typically $N \geq 3$.

6.3 FIRE AND GAS DETECTION MAPPING

Applications where detection modelling is not considered a method for optimising optical flame detector or gas detector layouts, includes:

- Gas detection for zones where the total volume of the zone is less than the hazardous release cloud, such as small buildings / enclosures (analyser houses) and air locks. In that case placement of detectors shall be at or near extract ventilation or where equipment is fitted.
- Flame detection in areas that are heavily congested. Reduction in the detection minimum fire size and installation of more detectors to provide coverage may be considered.
- Locations where detectors are required for a selective purposes (e.g. detectors associated with a particular item of equipment) but do not lend themselves to detector mapping.
- Flame detection for a single storage tank
- Fire or gas detection for a simple pump or compressor application where there is an enclosure.

2-D mapping of detector coverage shall not be used without approval of the Principal.

6.3.1 Detector Settings Used In Modelling

The parameters used in modelling the response of the detectors shall be aligned to the installation's alarm settings and the detector performance parameters.

6.4 DETECTOR VOTING

6.4.1 General

Any fire or gas alarm from a single detector shall be annunciated at the control point HMI, even if they are part of a voted system.

Voting of multiple detectors provides redundancy and ensures that fire or gas detector configurations are robust against spurious events and will provide the action to mitigate the event. The vote shall revert to 1ooN-1 providing a vote condition when one or more detector is in fault or inhibited, or when a detector is in alarm condition.

For all areas where detector voting is applied, there shall be a minimum of 3 detectors, except where:

- 2ooN for a given zone; N may be 2 for optical flame detection in a small zone (typically < 400 m² (1,300 ft²) floor area) where it is demonstrated that two detectors provide >85% coverage AND the logic solver is negative logic (where one detector in fault or inhibit provides a fire input into the logic, reverting system to 1oo1).
- 2ooN for a given zone, N may be 2 for LOS detection in a zone where it is demonstrated that two detectors provide >85% coverage AND the logic solver is negative logic (where one detector in fault or inhibit provides a gas input into the logic, reverting system to 1oo1).
- 1ooN for a given zone; N may be less than 3 for fire or LOS gas detection in small zones (typically < 400 m² (1,300 ft²) floor area) where it is demonstrated that on identifying a detector in fault or inhibited and until the detection has been restored:
 - o An alternative detection method is provided (e.g. temporary detection, fire watcher, etc), OR
 - o Stopping the process to remove the hazard the detection is there to detect.

The fault signal or signals used for negative logic shall be those that are given when the detector cannot perform its function of detecting the hazard (e.g. beam block).

Warning fault levels (such as dirty optics) where the device can still perform its detection function shall be alarmed for intervention before the degradation reaches the point where the detector no longer functions.

Detector voting may not be required where it is demonstrated that the detectors and detector systems themselves are robust with high reliability, or when the consequences of spurious shutdowns are not significant.

Combining detectors to vote logically in any configuration requires additional detectors to provide the same degree of coverage. Generally, the number of detectors required increases as the voting architecture becomes more complex.

Voting detection shall not delay the notification of a detected hazard to the process operator.

There shall not be voting between different detection hazards, such as fire detection devices with gas detection devices.

Where there are Executive Action (automatic), e.g. process or plant shutdown, activation of fire protection systems, tripping HVAC, etc., 2ooN voting logic may be employed.

6.4.2 Safe failures

Voted installed configurations shall be designed to take into account safe failure conditions.

Voted Executive Action applications where voting is 2ooN may be configured not to trip (maintain plant operation) when there are multiple detectors inoperable due to either fault or inhibit when there is an alternative means of identifying events during this temporary condition, such as identifying an event from inferred detection or CCTV. Figure 1 gives a diagrammatic representation. When all detectors in the vote are in fault or inhibited, then this shall provide an executive action output.

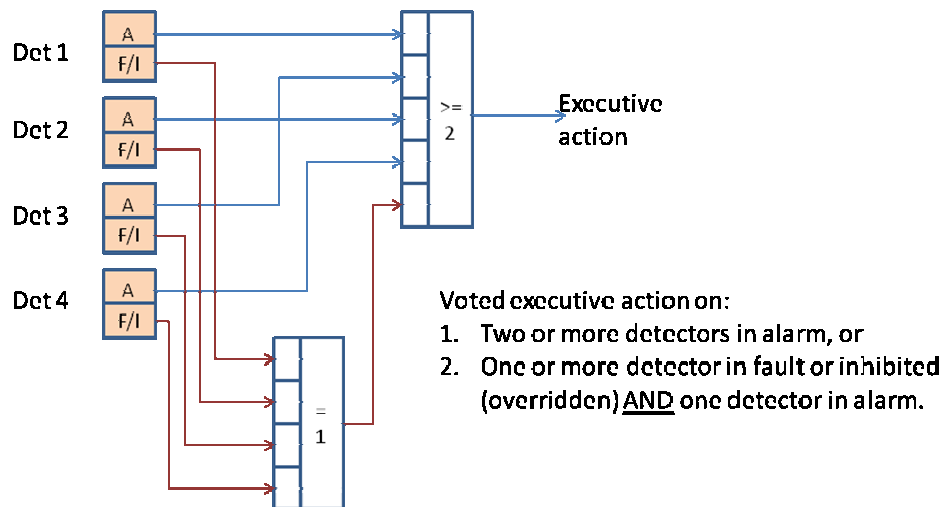


Figure 1: Example of voting logic accounting for fault and inhibit actions

>=2 represents two or more inputs at logic status

>=1 represents one or more inputs at logic status

A = Detection Alarm

F/I = Fault / Inhibited

6.4.3 Manual Alarm Call Points in Voted Systems

Manual initiated alarms **shall** be independent of automatic detected events, and thus shall not be voted with other manual alarms, fire or gas alarms.

6.4.4 Voting of Fire Detectors

Confirmation of fire detection is typically required before Executive Action is taken in response.

In a 2ooN voted configuration, triggering of two detectors in a zone is classed as "Confirmed fire".

Certain detection technologies may be regarded as sufficiently robust for a single detector to generate "confirmed fire". Consult the FGS SME.

Point heat type devices shall not be voted.

Pneumatic fire detection systems may be voted at the discretion of the Principal. If voting is deployed, then first detection loop provides an alarm, with the second loop detection providing Executive Action.

Smoke detection systems may be voted, depending on requirements for action upon hazard detection.

Detectors used to automatically shut down machinery / plant equipment and initiate the fire protection system shall be voted in a 2ooN configuration.

6.4.5 Voting of Gas Detectors

Gas detection (flammable or toxic) may be implemented with one alarm level provided it can be demonstrated that this alarm level provides detection at a point where corrective action is initiated. The alarm value should be set at alarm level 2 as shown in Table 7-1.

If gas detectors are configured to have two alarm levels, then initiation of alarm level 1 on a single detector in a zone provides "alarm only", with the initiation of alarm level 2 on a same single detector may be used as "confirmed gas" for other actions.

Executive Action is taken upon "Confirmed Gas"

In a 2ooN voted configuration, initiation of two detectors at alarm level 1 may also be classified as "Confirmed gas".

6.4.5.1 Acoustic Detectors

Acoustic Leak Detectors shall not be voted together. An acoustic detector may be voted with another gas detection technology (e.g. IR gas detector).

6.4.5.2 Ventilation intakes

Voting of gas detection within ventilation intakes shall consider the impact of flow stratification, with the selected design demonstrating the ability to detect all air flow patterns.

6.4.6 Looping

Looping is a practice of having more than one detector on an input circuit. Generally the detectors are in series.

Where looping is used for Executive Actions there shall be voting redundancy using a minimum of three loops. Devices voted shall not be on same loop, unless the loop has redundancy and diagnostics that on loop failure or part failure a "valid" vote is achievable to initiate Executive Action.

Where looping is implemented, consideration shall be given to the use of addressable heads within the loop.

7 ALARM LEVELS, DETECTOR SETTINGS

Alarm settings for fixed gas detectors are shown in Table 7-1.

Table 7-1 Alarm Settings for fixed gas detectors

Type	Alarm Level 1	Alarm Level 2	Note
Flammable gas point sensor inside turbine / compressor hood / compartment	10% LFL	40% LFL	
Flammable gas point sensor process plant and HVAC inlets	10% LFL	40% LFL	
Flammable gas line of sight sensor	1 LFL-m	2 LFL-m	See Note (1)
Hydrogen sulphide (H ₂ S) point sensor	10 ppm (vol)	40 ppm (vol)	
Hydrogen sulphide (H ₂ S) line of sight sensor	To be determined	100ppm-m	See Note (2)
Hydrogen fluoride (HF) point sensor	5 ppm	10 ppm	See Note (3)
Carbon Dioxide (CO ₂)	5,000 ppm (vol)	30,000 ppm (vol)	
Carbon Monoxide (CO)	25 ppm (vol)	200 ppm (vol)	
Chlorine (Cl ₂)	1 ppm (vol)	3 ppm (vol)	
Oxygen Deficiency	19.5% (vol)		
Oxygen Enrichment	23% (vol)		
Sulphur dioxide (SO ₂)	2 ppm (vol)	5 ppm (vol)	
Heat Detectors (fusible plugs, frangible bulbs, polyflow)	68°C (155 °F)		See Note (4)

- Notes:
- 1) For confined areas with "heavy end hydrocarbons" greater than C₃, use 0.5 LFL-m for alarm level 1.
 - 2) H₂S LOS are emerging into the market. Guidance for their use is currently under review.
 - 3) These are typical values. Actual HF alarm levels are subject to local conditions and requirements.
 - 4) In areas of high ambient temperature, heat detectors to be set at 30°C (50 °F) above the anticipated ambient temperature or nearest standard fixed setting above 30°C (50 °F).

7.1 FIRE DETECTORS

Fire and smoke detectors typically only have one alarm point which is factory set.

7.2 ALARM FOR NARCOTIC EFFECTS

For applications where narcotic gas has been identified as a hazard, and the fixed gas detection is being used to alert personnel, then alarm level 1 shall be capable of alerting personnel of potential narcotic gas, at a setting that enables the personnel to take action (typically 10% scale for point detector).

7.3 ACOUSTIC LEAK DETECTOR ALARM LEVELS

The alarm levels for acoustic gas detectors shall take into account background ultrasonic noise and shall be set at a minimum of 6 dB or nearest setting above this noise.

Any delayed response from an acoustic leak detectors shall be less than 30 seconds, refer (5.3.6.)

8 ALARMS, EXECUTIVE ACTIONS, ANNUNCIATION

8.1 GENERAL

Fire or Gas or Manual detection SHALL [PS] initiate automatic visual and audible alarms to alert personal to evacuate the affected area, and to alert the entire facility of an event.

The degree of Executive Action initiated by fire and gas alarms is dependent upon whether the facility is manned or unmanned, the complexity of the process (e.g. processing plants like oil and gas platforms, gas plants, refinery processes, to distribution truck loading terminals), the risks associated with a nuisance trip and subsequent process restart and the reliability of the FGS in the particular service. Therefore, the level of automatic action shall be determined following the process described in (Section 3) and the actions listed in (2.3). Appendix C and D to be read in conjunction with this section.

Effects of executive actions shall also be considered. For example, where fire or gas is detected in the Flare / Vent facilities (Knock Out drums) areas then the determination of actions from this event shall take into consideration the effects of increasing the product inventory at the flare area through process status change e.g. venting or emergency depressurisation. Isolation or removal of sources of ignition shall not be implemented in such a manner so as to create additional hazards or unexpected consequences.

8.2 ACTIONS

8.2.1 Fire detection

8.2.1.1 Hydrocarbon Processing Areas

On a single detector detecting fire the visible and audible alarms shall be initiated directly from the FGS, for the zone and area of detection.

Where Executive Action has been identified for Confirmed Fire the following actions shall be considered:

- The isolation of flows of fuel products into the area, including backflow from outlets of products where applicable
- Depressurisation of process products
- For offshore installation a process shutdown, including automatic depressurisation of the installation and closure of all import and export riser ESD valves.
- Shutdown of rotating equipment
- Shutdown and isolation of heaters and heat exchangers
- Activate the fire protection system where applicable (firewater, gaseous extinguishants)
- Initiate the firewater pump start
- Closure of fire dampers and tripping of the ventilation fans of forced ventilation systems

8.2.1.2 Non-Hydrocarbon / Hydrogen Processing Areas (Utilities) and Buildings

On a single detector detecting fire the visible and audible alarms shall be initiated directly from the FGS, for the zone and area of detection.

Where Executive Action has been identified for Confirmed Fire the following actions shall be considered:

- Minimise spread of smoke and supply of oxygen to the fire by closure of automatic fire doors, where applicable.
- Activate the Fire protection system
- Activate the Fire pumps start
- Close Fire dampers and tripping of ventilation fans

8.2.2 Flammable Gas detection

8.2.2.1 Hydrocarbon Processing Areas

On a single detector detecting gas the visible and audible alarms shall be initiated directly from the FGS, for the zone and area of detection.

Where Executive Action has been identified for Confirmed Gas the following actions shall be considered:

- Tripping of electrical supplies to electrical apparatus / equipment that are not hazardous area certified or deemed non-emergency equipment and are located within the affected areas.
- The isolation of fuel product flows into the area, including backflow from outlets of products where applicable
- Depressurisation of process products
- Shutdown of rotating equipment
- Shutdown and isolation of heaters and heat exchangers
- Where forced ventilation systems is provided for maintaining a gas free environment in an enclosures (e.g. process buildings, etc), the ventilation systems shall continue to operate when gas is detected in the enclosure so as to maintain a safe environment (e.g. extraction and/or disperse the gas).
- For offshore installation a process shutdown, including automatic depressurisation of the installation and closure of all import and export riser ESD valves.
- Water release (deluge or fine water spray), where the HEMP has identified this as a requirement for reducing blast overpressure or toxic event mitigation.
- Shutdown of drilling operations when gas is in the drilling area.

- NOTE
1. For drilling installations, it is recognised that during critical activities (e.g. drilling close to the reservoir), shutdown of drilling equipment may be hazardous. Nevertheless, drilling installations shall be monitored for and protected against fire to the same standards as the remainder of the installation.
 2. The driller shall be provided with a secure mechanism (e.g. a single key-switch) to override automatic Executive Actions from tripping items of equipment, which are critical to make a well safe. The override shall only be used during critical activities and its status shall be displayed at the drilling panel, the LCC and the emergency control point.

8.2.2.2 Non-Hydrocarbon Processing Area (Utilities) and Buildings

On a single detector detecting gas the visible and audible alarms shall be initiated directly from the FGS, for the zone and area of detection.

Where Executive Action has been identified for Confirmed Gas the following actions shall be considered:

- For offshore installations the tripping of electrical supplies to electrical apparatus/equipment that are not hazardous area certified or deemed non-emergency equipment throughout the installation.
- For offshore installations inhibiting the start of diesel fire pumps or emergency generators when gas is detected in the area that these are installed. If these machines are running when gas is detected in the area then the equipment shall remain running.
- Closure of fire dampers and tripping of the ventilation fans of forced ventilation systems where applicable (e.g. flammable or toxic gas may be drawn into an unclassified building (e.g., FAR)).

For Confirmed Gas in a generator room, all electrical equipment and generators housed within the room SHALL [PS] trip.

8.2.2.3 Turbine Hood

Confirmed Gas in a turbine hood or extract shall trip the associated machine and fuel supplies.

Confirmed Gas at the turbine hood forced ventilation inlets (combustion and enclosure) shall be in accordance with (8.2.2.2).

8.2.3 Manual Call Point Alarm

A manual alarm call shall provide visible and audible alarms directly from the FGS for the zone and area of detection.

For offshore installations activation of a manual alarm call shall provide visual and audible alarms across the whole installation via the Public Address (PA) in addition to the visual and audible alarms activated directly from the FGS, for personnel mustering. Start of the fire pumps may also be activated where this has been assessed as a requirement.

8.2.3.1 Pneumatic manual call point - LAV

Local activation of shutdown and extinguishant release (i.e. water deluge, gaseous systems) may be possible through activation of local devices (Local activation valve, LAV) and from a safe location.

These shall also provide alarms and Executive Action through the fire and gas system as per "confirmed fire" (see 8.2.1).

8.2.4 Offshore specific

Table 8-1 Typical applications and actions in offshore facilities

Hazard	Type of Detector		Typical Application	Typical Actions
FIRE	Optical Flame		All Process areas, Drilling areas, wellheads, utilities	Alarm, shutdown, emergency depressurisation, close SSSV, active fire protection
	Heat	Pneumatic	Second detection system for process areas, wellheads, utilities	Alarm, shutdown, emergency depressurisation, active fire protection
		Electric	Turbine hoods, workshops, stores, engine rooms.	Alarm, shutdown, emergency depressurisation, active fire protection
	Smoke		Control rooms, electrical rooms, computer rooms, accommodation	Alarm, isolate power, active fire protection
			Air intakes to Temporary Refuge and control stations	Alarm, isolate ventilation
FLAMMABLE GAS			All process areas, drilling areas, wellhead utilities areas, engine rooms	Alarm, shutdown, emergency depressurisation, isolate power
			Air intakes	Alarm, shutdown, emergency depressurisation, isolate power, trip ventilation system
TOXIC GAS			All process areas, drilling areas, wellhead utilities areas	Alarm
			Air intakes	Alarm, trip ventilation system
OIL MIST			Enclosed areas handling low GOR liquid hydrocarbons	Alarm, shutdown, emergency depressurisation, isolate power
MANUAL CALL			All areas, escape routes, muster points, Temporary Refuge	Alarm, start fire pumps

9 FIRE & GAS DETECTION SYSTEMS DESIGN

9.1 GENERAL

For typical block diagram of configuration, see Appendix B.

The FGS design is dependent on the size of the system, the system's performance and whether the system provides automatic action, such as:

- The FGS Logic Solver shall be a PES if the physical I/O > 100. If the FGS Logic Solver is a PES, it shall comply with all requirements of DEP 32.80.10.10-Gen.
- Solid state logic system may be used where the systems have small physical I/O of <100.
- If the physical I/O < 20, a relay system may be utilized.

For an extension or upgrade to an existing system, (i.e. Brownfield development) the existing system technology may be retained where it is still available and supported by the manufacturer.

Standalone Fire and / or Gas Systems that are not fully integrated into the main FGS shall not be used.

The FGS SHALL [PS] be independent of the BPCS. The BPCS may provide the HMI interface.

The FGS Logic Solver may be part of the SIS Logic Solver depending on the system size and the system commonality with the SIS.

The FGS shall be designed to prevent overload of the system when there is an avalanche of alarms or events.

The FGS shall be designed, such that commissioning and function testing may be carried out without disabling the system.

9.2 DIAGNOSTIC ALARMS

The FGS may provide diagnostic information to the user either as alarms or status change alert, depending on the criticality of the condition. High priority conditions that affect the system operation shall be through alarm to the operator. Low priority conditions shall be recorded and routed to the appropriate person (e.g. maintainer). See Alarm Management DEP 32.80.10.14-Gen.

9.3 PANEL SYSTEMS

9.3.1 Panel Architecture

The panel equipment used for detector interface shall be at a centralised unit / central control point. In specific cases where use of a centralised logic solver is not practical, an alternative location may be used with the approval of the Principal.

9.3.2 Independent Fire Panels

Independent fire panels may be used where it is cost effective to do so to group smoke alarms and control strobes and beacons inside buildings such as FARs and Control Centres. The Principal shall approve their use.

When used the following applies:

- a) Interfaces between Fire Panels and FGS I/O modules shall be hard wired.
- b) The Fire Panel shall be capable of supporting communication to the FGS for the alarm status on individual detectors. In addition common alarm and fault signals shall be provided to the FGS.
- c) Fire panels shall not be used to collect signals from manual alarm call points.
- d) The fire panel detection system shall be a fully integral part of the FGS. It shall be

self-contained only to the extent that it will monitor and process all fire detection inputs, execute logic based on these inputs and deliver critical hard wired outputs to the FGS where required for facilities emergency responses.

- e) Non-critical signals (signals that do not provide detection information or affect detectability or operability) may be transmitted via serial data links.
- f) A fire panel may be separate or may be one of multiple fire panels set up to communicate to a master panel. Each panel shall operate independently but shares status data with the master so that it may be polled as one from the facility FGS.
- g) Functions provided at each local fire panel shall include:
 - a. Alphanumeric displays to provide local fault indication and alarm conditions initiated by the end devices associated with that panel.
 - b. Supervision of all I/O wiring, and intelligent interface devices.
 - c. Self-diagnostics, with appropriate displays.
 - d. End device test procedure initiation for end devices connected to the panel.
 - e. Audible alarm, silence, acknowledge and reset functions.
 - f. Standby power capability and autonomy as required by DEP 33.64.10.10-Gen, including battery charging.
 - g. Network communications to any other fire panels on a peer-to-peer highway.
- h) The fire panel HMI(s) shall provide operators with displays and interactive functions as required to manage any Fire Detection System showing the location of any devices initiating action, detected fire, diagnostic event. The HMI shall be legible and operable by operators wearing normal PPE that is appropriate for the sited location, area and the hazards.

9.4 POWER SUPPLIES

Electricity supply for the Fire & Gas and Audible and Visual system shall meet the requirements of DEP 33.64.10.10-Gen.

FGS systems that require power to operate shall be provided with a power failure alarm, and this shall be configured as a high priority alarm.

9.5 HMI INTERFACE

9.5.1 General

FGS HMI shall comply with requirements in DEP 30.00.60.16-Gen.

The HMI may be through the DCS VDU systems if:

- The automatic action on confirmed Fire or Gas will operate without intervention from the operator, OR
- Any single point of failure cannot remove the operator's ability to monitor and take action on a FGS event; OR
- The FGS is a PES.

A hardwired mimic panel or Alarm Summary Unit (ASU) shall be used where these conditions cannot be met. The indications on the mimic panel or Alarm Summary Unit shall be driven via hardwired signals from the FGS.

The FGS shall be designed to provide re-flash of alarms, such that additional or repeat events or alarms re-initiate audible and visual indication for the affected zone.

The FGS HMI / mimic and ASU alarm colours shall be as specified in Table 9-1.

Table 9-1 HMI Alarm colours

Alarm state	Alarm colour
Flammable gas alarm level 1	Red
Flammable gas alarm level 2	Red
Toxic gas alarm level 1	Yellow
Toxic gas alarm level 2	Yellow
Fire	Red
Manual alarm call	Red
Deluge released	Red
Fault	Red
Inhibit applied	White

When a sensor or system goes into alarm or is inhibited the status indication at the display area (e.g. HMI) shall start flashing and the audible alarm shall sound.

It shall not be possible to reset Executive Actions whilst the hazard is still being detected, with exception of audible alarms that may have a manual facility to mute parts or the whole audible alarm sounders.

9.5.2 Display information

The HMI at the LCC and the emergency control point shall provide and display, as a minimum, the following to enable the operator to act / react to events:

- Changes to Fire & Gas status.
- Single flammable gas alarm.
- Confirmed flammable gas alarm.
- Single fire alarm.
- Confirmed fire alarm.
- Toxic gas alarm.
- Manually initiated alarms.
- Occurrence of fire protection system alarms.
 1. sprinkler flow switches,
 2. deluge water release pressure,
 3. deluge fire loop system low low and low air pressure,
 4. gaseous release pressure,
- Individual detector faults.
- System status and faults.
- Device Line monitoring.
- Individual inhibits for each detector.
- Drilling shutdown inhibit status (where applicable).
- The zone location for the detected state.

9.5.3 VDU System

The FGS HMI may be integrated within the DCS / SIS HMI as long as there is / are dedicated UPS to the DCS VDU / controllers to enable continued display operation on loss of the DCS system and for the required autonomy time for the FGS.

VDU or VDUs used as HMI interfaces for FGS shall be dedicated to the FGS, and not used for process control.

VDU based operator interfaces shall be based, where feasible, on the Supplier standard products.

9.5.3.1 Page access

Page hierarchy shall be arranged so that any page is displayed in no more than two commands.

9.5.3.2 Previous/next paging

Special keys shall enable access to one display forward or back in the display hierarchy, up to the last 10 pages displayed.

9.5.3.3 Alarm banner area

An alarm banner shall be provided (e.g. at the bottom of VDU displays), and available on all display screens.

9.5.3.4 Trending pages

Trending page displays shall be available, and user configurable to show the value of analogue parameters associated with individual detectors.

The trend resolution to be adjustable to one second sample intervals.

9.5.3.5 System output

System output displays shall show the state of all system outputs as either activated or not activated.

An alarm or fault condition shall be automatically displayed on the correct subdivision of the area mimic in alarm, and simultaneously give an audible warning that may be silenced by the operator.

9.5.3.6 Alarm lists

Alarm management in the FGS will be consistent with alarm management in the DCS, such as standard alarm lists, rolling alarms detailing tag number, alarm type, location, and time.

There shall be two alarm listings:

- Current showing status of alarms for fire, gas, manual alarm call point, and fault.
- Historical records and may be sorted for display on either a device basis or a time period basis via the directory. The historical alarm listing shall be capable of listing all events and operator actions.

Alarm storage capacity shall hold on file at least the last 10,000 events.

9.5.4 Area Graphic / Mimic Display

Area graphic / mimic displays shall show an overall view of the site plot plan, and shall be divided into subsections per fire zone.

Each subdivision of the area graphic / mimic per fire zone shall provide status information on alarms, faults, or inhibit/override condition. Individual detectors may not be shown on area mimics.

They shall be spatially compatible with the spatial layout of the facility.

Where wind direction is available it shall be displayed, in real-time.

9.5.4.1 Expanded Graphic / Mimic Display

Each expanded display shall show a detailed part of an area, including more text information (where space permits), and a reference to the presence of an active fire or explosion protection water system where relevant.

Each individual detector and Manual Alarm Call shall be shown in its approximate location.

Fire areas where non-addressable fire circuits are installed shall show one indication per fire area of smoke, heat, flame, and manual alarm call point.

Where expanded display becomes congested and difficult to read due to the amount of information, then further subdivisions may be used.

Alarm condition shall automatically display the correct area and detector symbol, for the area where the alarm has occurred.

Alarms shall be individually acknowledged from the expanded display, where the flashing symbol identifier will go steady and continue to stay in alarm until the alarm condition is no longer present and reset.

Global acknowledge and reset facilities shall only be available on pages where all the indications that will be affected by their action are displayed.

9.5.5 Inhibits and overrides

The application of an inhibit or override shall prevent the inhibited detector from automatically generating control actions, but shall not prevent audible and visual alarms at the operating control point.

Maintenance overrides for FGS shall be installed as defined in DEP 32.80.10.10-Gen., except:

- Maintenance Overrides Switches may be installed to override a group of sensors in the same zone to support an efficient testing campaign,) if approved by the Principal.
- Maintenance Overrides Switches may be installed on FGS outputs to ancillary systems (i.e. HVAC, electrical tripping, extinguishing systems) if approved by the Principal.
- Maintenance override Switches shall not be installed on FGS outputs that initiate tripping process plant (e.g. ESD).

9.6 SYSTEM INTERFACES

9.6.1 General

The Fire & Gas system may be required to interface with several systems (for example, SIS, HVAC, fire protection, fire pumps, audible and visual alarm systems, etc).

9.6.2. SIS interface

The FGS and SIS may be integrated as far as practicable, leveraging the use of the SIS logic solver as the FGS logic.

Where the FGS is separate from the SIS then the communication to the SIS over certified SIL3 communication links is acceptable if the SIS is also a SIL 3 system and from the same manufacturer. In the event that the SIS does not share a common SIL 3 communication system with the FGS, hardwired communication for critical alarms and shutdowns shall be used. Communications to be restricted to essential information that is required by the SIS.

If communication to other interfaces that initiate action or take action is not via SIL3 secure network, then the interfaces shall be hardwired discrete circuits, through volt free contacts or power driven as below.

Interfaces to networks shall comply with DEP 32.01.23.17-Gen. section 15.

There shall be no impairment to the overall Fire & Gas integrity from failures within any of the interfaced systems.

For relay interface normally open (shelf state) relay contacts shall be used, such that when a relay is energized a closed contact (healthy state) is given to SIS, and on loss of power to the output relay an open contact (trip state) is given to the SIS.

9.6.3 HVAC

Output relays may be provided in the Fire and Gas system to interface with the HVAC system to initiate the starting and stopping of fans and opening and closing of dampers.

A single output contact shall be provided for each control action.

The normally open (shelf state) relay contacts shall be wired to the HVAC system such that when relay is energized a closed contact (trip state) is given to HVAC system to enable normal operation. Trip action is the de-energized state and open contact to HVAC system.

9.6.4 Fire protection systems interface

Output circuits shall be normally de-energized with energize to operate control action, and power fed from the Fire and Gas system.

These output circuits to the field device shall be monitored for all fault conditions that could prevent the solenoid being energized on demand (for example, open circuit or short circuit detection).

The interface shall have the facilities to manually initiate the fire protection systems. This shall be from the HMI, and shall be in accordance with local fire code requirements (e.g. manual key switch).

The interface shall, where a fire protection system is installed, have input alarm signals from fire extinguishant systems. For interfaces which initiate gaseous extinguishant applicable NFPA standard shall be followed.

9.6.5 Fire pumps

Read in conjunction with DEPs 80.47.10.12-Gen. and DEPs 80.47.10.31-Gen.

The normally open (shelf state) relay contacts shall be wired to the fire pump(s) control system such that when relay is energized a closed contact (pump start command) is given to fire pump(s) control system.

The output circuit including the relay coil shall be monitored for all fault conditions that could prevent the relay coil being energized on demand (for example, open circuit or short circuit detection).

9.6.6 Audible alarm and Public address

In areas where the ambient noise exceeds 85 dB (A) flashing beacons shall be provided. Beacons may be provided for other installations, at approval of the Principal.

Typical beacon colours are shown in table 9-2.

Table 9-2 Field Alarm colours

Alarm	Colour
Flammable gas	Amber
Toxic gas	Blue
Fire	Red

Audible alarm systems shall be fault tolerant, i.e. capable of withstanding one single failure without total loss of the alerting systems in an area.

Output relays shall be provided in the Fire and Gas system to interface with the audible and visual alarm system and the public address (PA) system where applicable.

NOTE The PA system may have automatic pre-recorded voice announcements, if the PA system includes such a facility.

**Amended per
Circular 72/12**

Each area shall have a single normally open (shelf state) relay contact such that when the relay is energized a closed contact (healthy) is given to the system.

9.6.6.1 Public Address systems

See DEP 32.71.00.10-Gen. section 5.

9.6.7 Other systems

Controls, alarms, and status indications shall be provided on the Fire & Gas system for standalone FGS packages.

Output relays shall be provided:

- In the Fire & Gas system for all control actions.
- At the local control panel for all inputs to the Fire & Gas system.

Output relays shall be normally de-energized (shelf state) with volt-free closed contacts, and shall open for a control action command.

The output circuit including the relay coil shall be monitored for all fault conditions that could prevent the relay being energized on demand (for example, open circuit or short circuit detection).

9.7 SEQUENCE OF EVENT RECORDING

Fire & Gas events (alarms, faults, overrides etc) shall be recorded in a sequence of events data logging facility, which may be the same facility used for the shutdown and process control systems.

NOTE Data may be communicated to the DCS system for event logging as long as there is a secure and dedicated link, AND that the DCS operating time from its dedicated UPS on loss of AC power is the same or greater than that for the Fire & Gas system.

Historical data shall be archived and stored as per local requirements by means of standard facilities.

The data logging facility, as a minimum, shall log the following events, together with the tag number, description, type of alarm and the date and time of occurrence:

- Changes to Fire & Gas status.
- Single LLG or HLG detection per zone.
- Confirmed LLG and HLG per fire zone.
- Single fire detection per zone.
- Confirmed fire per fire zone.
- Toxic gas alarms per zone.
- Any manual initiations per zone.
- Occurrence of fire protection system events:
 1. sprinkler flow switches,
 2. deluge water release pressure,
 3. deluge fire loop system low low and low air pressure,
 4. gaseous release pressure,

- Individual detector fault levels.
- System status and faults.
- Device Line monitoring.
- Individual inhibits for each detector.
- Drilling shutdown inhibit status (where applicable).
- Input/Zone inhibits.
- Maintenance Override Switch activation

9.8 UNATTENDED INSTALLATIONS

The Fire & Gas system shall be designed and installed using the assessment process as described for a normally manned installation.

The Fire & Gas status information shall be locally available at the facility to provide for those occasions when it is manned or visited.

The status of the Fire & Gas system shall be capable of being monitored from a remote location, either the control room of a nearby platform or a nearby control room of a shore station.

The following are guidelines for the minimum amount of information and controls for each location:

- Audible and Visual Alarm System.
- Fire & Gas system and panel in the control room (including local toxic or asphyxiant alarms if applicable).

For unattended installations the Fire & Gas alarms shall be capable of being remotely accepted and reset.

9.9 ELECTRO MAGNETIC COMPATIBILITY (EMC)

See DEP 33.64.10.33-Gen.

9.10 FGS ENVIRONMENTAL CONDITIONS

See DEP 32.80.10.10-Gen.

9.11 STANDARD DOCUMENTATION

Documentation shall in general follow requirements of Instrument Protective Systems DEP 32.80.10.10-Gen and DEP 32.31.00.34-Gen.

9.12 TRAINING

In general training requirements shall follow requirements of Instrument Protective Systems DEP 32.80.10.10-Gen.

9.13 AFTER SALES SERVICE

Shall in general follow requirements of Instrument Protective Systems DEP 32.80.10.10-Gen.

9.14 SPARE PARTS

See DEP 70.10.90.11-Gen.

10 COMMISSIONING AND TESTING

10.1 GENERAL

Factory Acceptance and Site Acceptance Testing shall be carried out on all new and upgraded systems. In general the FAT and SAT shall follow requirements of DEP 32.80.10.10-Gen and DEP 62.10.08.11-Gen.

Certification and inspection records shall be provided as defined by the Principal or their representative on the purchase order. These records may include:

- Hazardous area certificates.
- Test and inspection records.
- Calibration certificates.
- Third party approvals.
- EMC compliance.
- Any document required demonstrating compliance with local legislation.

10.2 FACTORY ACCEPTANCE TEST

A factory acceptance test (FAT) shall be performed to demonstrate that the FGS performs as per specification, including any site specific configuration.

Each different type of input (e.g. fire / gas detectors) shall be tested through use of an actual field / interface device, where practicable. Simulators may be used by the agreement of the Principal.

Each output shall be demonstrated through the simulation of inputs, thus proving logic and outputs.

FAT will be performed against a procedure, provided by Supplier, and subject to Principal approval. Test results shall be accurately recorded, including any simulators used and any ad hoc tests performed.

10.3 SITE ACCEPTANCE TEST

Site acceptance tests (SAT) shall be performed to demonstrate that the installed equipment performs as specified including any site-specific configuration.

SAT will be performed against a procedure, provided by the supplier, subject to Principal approval.

All loops shall be function tested to demonstrate their ability to function on demand. This covers demonstration of the ability to sense (gas / fire), the ability to alarm, and the ability to provide interfaces to other systems.

All gas detectors shall be verified as part of the SAT. Which will include calibration as part of the verification process, with the exception of Infrared gas detectors that are factory calibrated and shall be function tested with a test gas.

Gas detection system shall be commissioned with a test gas that simulates the type of gas(s) expected, with the exception of open path detectors which shall be commissioned using calibrated optical filters.

Optical fire detection systems shall be commissioned using an appropriate test procedure / method to ensure that the detector's cone-of-vision as detailed by engineering design is correct.

Smoke detection systems shall use smoke generators where practical, to ensure that positioning of installed smoke detectors takes cognisance of local air-flow regimes. In this respect, HVAC systems where appropriate, shall be operational during the commissioning tests.

Heat detectors may be calibrated or tested using an appropriate test method for the device.

Acoustic leak detection system tests shall be carried out when the plant is in normal operation to ensure that the background noise level will not influence the leak detection performance. This test may be undertaken by simulating a gas leakage at 0.1 kg/s (0.22 lb/s) using a test gas (air / nitrogen) or test source.

SAT results shall be accurately recorded, including any ad hoc tests that were performed.

11. REFERENCES

In this DEP, reference is made to the following publications:

- NOTES:
1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.
 2. The DEPs and most referenced external standards are available to Shell staff on the SWW (Shell Wide Web) at <http://sww.shell.com/standards/>.

SHELL STANDARDS

Human factors engineering – Human machine interface design for situation awareness	DEP 30.00.60.16-Gen.
Process control domain - Security requirements for suppliers	DEP 32.01.23.17-Gen.
Instrumentation symbols and identification on process engineering flow schemes	DEP 32.10.03.10-Gen.
Instruments for Measurement and Control	DEP 32.31.00.32-Gen.
Instrumentation documents and drawings	DEP 32.31.00.34-Gen.
Plant Telecommunication	DEP 32.71.00.10-Gen.
Instrumented protective functions (IPF)	DEP 32.80.10.10-Gen.
Alarm management	DEP 32.80.10.14-Gen.
Electrical Engineering Design	DEP 33.64.10.10-Gen.
Electromagnetic compatibility (EMC)	DEP 33.64.10.33-Gen.
Inspection and Functional Testing Of Instruments	DEP 62.10.08.11-Gen.
Spare parts	DEP 70.10.90.11-Gen.
Water-based fire protection systems for offshore facilities	DEP 80.47.10.12-Gen.
Active fire protection systems and equipment for onshore facilities	DEP 80.47.10.31-Gen.
Arrangement of polyethylene tubing for fire detection of pumps underneath pipe rack	S 88.020
Arrangement of polyethylene tubing for fire detection of pumps outside pipe rack	S 88.021

AMERICAN STANDARDS

National Fire Alarm Code	NFPA 72
Life Safety Code	NFPA 101

Issued by:
National Fire Protection Association
One Batterymarch Park
PO Box 9101
Quincy, MA 02269-9101
USA

BRITISH STANDARDS

Guide for Selection, Installation, Use and Maintenance
of Apparatus for the Detection and Measurement of
Combustible Gases or Oxygen

BS EN 50073 (1999)

*Issued by:
Health and Safety Executive
Redgrave Court
Merton Road
Bootle
Merseyside L20 7HS
United Kingdom*

EUROPEAN STANDARDS

Council Directive on the Approximation of the Laws of the Member
States Relating to Electromagnetic Compatibility

89/336/EEC

Electromagnetic compatibility - Electrical apparatus for the detection
and measurement of combustible gases, toxic gases or oxygen

EN 50270

INTERNATIONAL STANDARDS

Degrees of Protection Provided by Enclosures (IP Code)

IEC 60529

APPENDIX A TYPICAL DETECTOR CROSS-SENSITIVITY CURVES

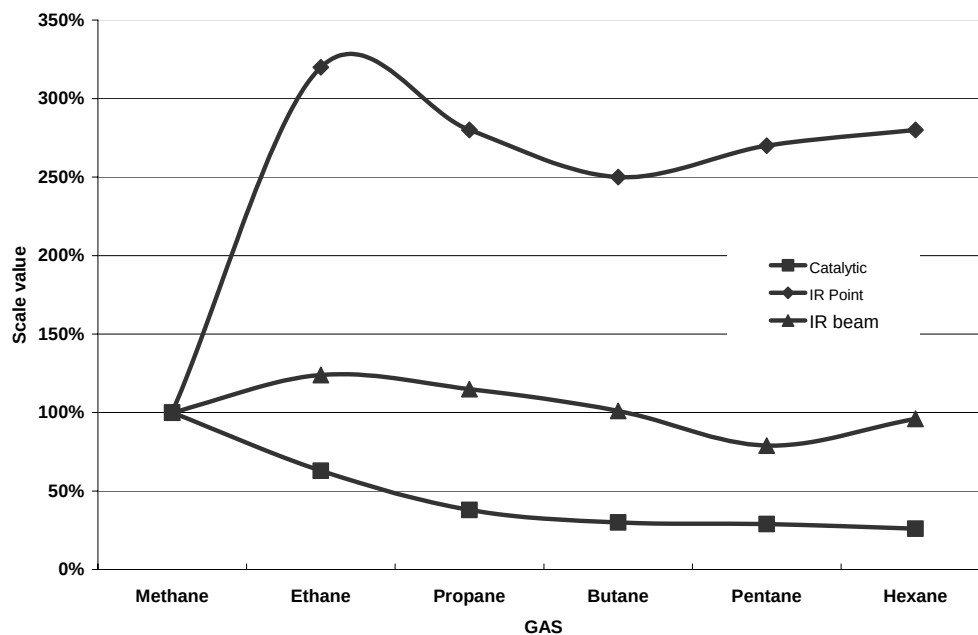


Figure A-1 Typical LFL relationship versus measurement display

The curves are based on methane calibration and are representative only and are not to be used as definitive responses. The user of this document shall examine the characteristics of individual detectors during design with manufacturers consulted for their products response to different gases.

Setting the calibration and alarms has to consider several variables, particularly where catalytic detectors are installed and there are heavier fraction gases.

The general principle is to set the alarms high enough to stop spurious operation, but low enough to enable alarming before the LFL for expected gases is reached. The calibration sensitivity used for catalytic detectors may assist with the setting of alarm values. By increasing the sensitivity the LFL curves move up giving increased scale indication for heavier fraction gases, i.e. calibrated twice sensitive gives scale value of 200 % for methane and hence a scale display of 60 % for pentane. This loss of sensitivity shall be considered during designs and for setting calibration regimes and alarm settings.

There is no change required to the sensitivity for IR point detectors, as a 100 % display is less than 100 % of the actual LFL for the heavier fraction gases, when calibrated on methane.

IR beam detectors become more sensitive for ethane and propane but may be less sensitive for pentane when supplied as methane calibrated. Loss of sensitivity for individual gases shall be considered during designs.

With inter-changeability of maintenance and operating personnel, one calibration regime and alarm settings be employed for an operating sector or country. This to cater for all types of detectors used.

APPENDIX B EXAMPLE OF FIRE & GAS SYSTEM ARCHITECTURE

A typical architecture for FGS systems is shown in Figure B-1 below. The actual architecture, size and complexity of the system is dependent upon the application. The selected system shall provide the requirements for detection, alerting and the ability for action.

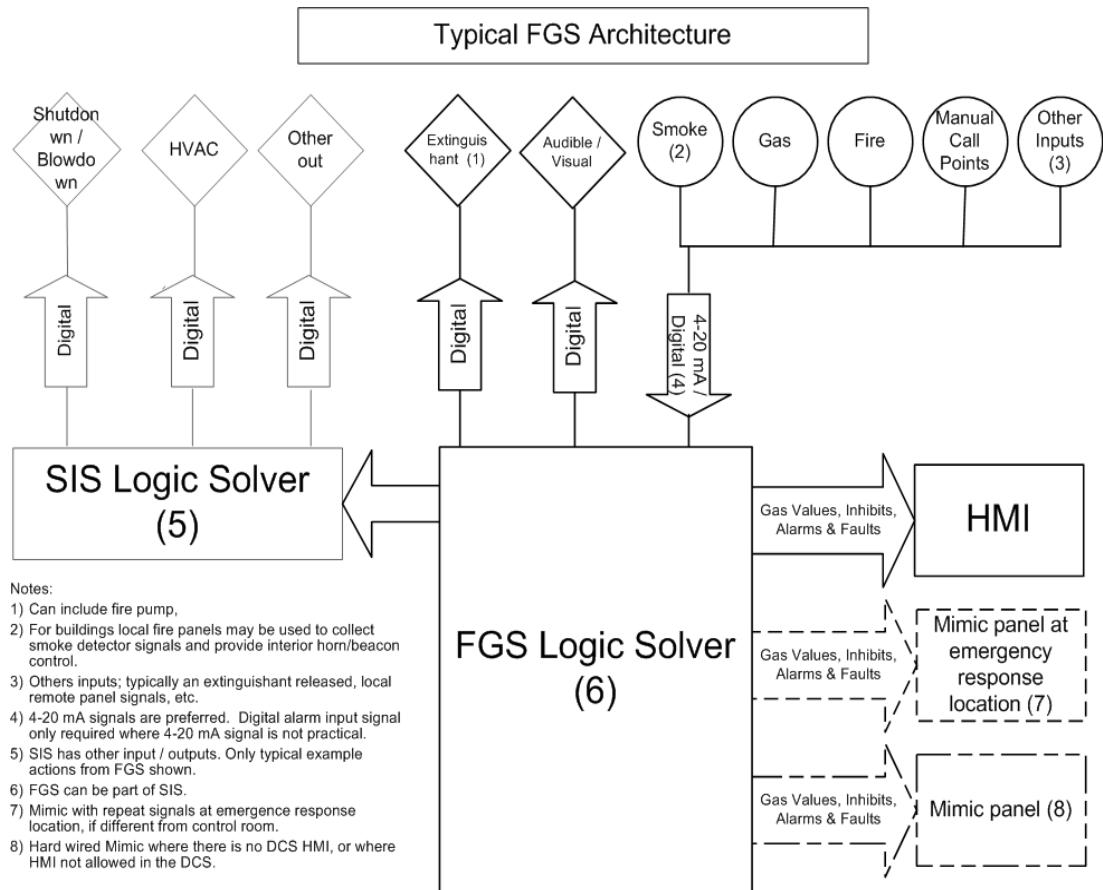


Figure B-1 Block Diagram of typical FGS system architecture

APPENDIX C TYPICAL CAUSE AND EFFECT PLUS ALARM MATRIX

		RESULTING ALARM OR ACTIONS															
		Alarms						Executive Action									
		Alarm in CCR		Alarm in process buildings/ open plant				HVAC			Fire extinguishing			Trips			
CAUSE	Detected or signalled by	Visual and audible alarm on DCS	Visual alarm on mimic panel	Audible alarm in building	Visual alarm in building	Audible alarm in open plant (8,12)	Visual alarm in open plant (8,12)	Trip ventilation fans (1)	Close air intake / extracts (1)	Close fire tight dampers (1)	Start fire water pump (1)	Activate water systems (1)	Activate gaseous system (1)	Emergency Shut Down (ESD) (7)	Emergency Depressure (EDP) (7)	Shutdown Power (SP)	Local Equipment Shutdown (LSD)
General Alert	Manual call point (in building)	X	X	X	X	X	X	X	X	X							
	Manual call point (in open plant)	X	X	X	X	X	X				X						
Heat	Space	X	X	X	X	X	X	X (6)	X (6)	X (6)		X (12)	X (12)	X	X (2)	X (11)	X (11)
	Rate of rise	X	X	X	X	X	X	X (6)	X (6)	X (6)		X (12)	X (12)	X	X (2)	X (11)	X (11)
	Polyethylene tube	X	X	X	X	X	X				X	X	X	X	X (2)		
	Frangible quartzoid bulb	X	X	X	X	X	X	X (6)	X (6)	X (6)	X	X	X	X	X (2)	X (11)	X (11)
Fire or Flame	Infrared	X	X	X	X	X	X	X (6)	X (6)	X (6)	X	X		X	X (2)	X (11)	
	Ultraviolet	X	X	X	X	X	X	X (6)	X (6)	X (6)	X	X		X	X (2)	X (11)	
Smoke (11)	Ionisation	X	X	X	X			X	X	X							
	Scattered light	X	X	X	X			X	X	X							
	Ultra sensitive	X	X	X	X			X	X	X							
Gas (13)	Toxic gas Alarm Level 1	X	X	X	X	X	X	X (11,13)	X (11,13)	X (11,13)							
	Toxic gas Alarm Level 2	X	X	X	X	X	X	X (11,13)	X (11,13)	X (11,13)				X (3)	X (2,3)		
	Acoustic Detector	X	X	X	X	X	X							X (4)	X (2,4,5)		
	Flammable gas Alarm Level 1	X	X	X	X	X	X	X (9,11,13)	X (9,11,13)	X (9,11,13)						X (3,11,13)	
	Flammable gas Alarm Level 2	X	X	X	X	X	X	X (9,11,13)	X (9,11,13)	X (9,11,13)		X (10)		X (3)	X (2,3)	X (3,11,13)	

NOTES:

- 1) Where revealed failure robust initiators are implemented, action shall only be performed when 2 out of 'n' initiators are in alarm.
- 2) Emergency Depressurisation venting to a safe area or burnt in flare
- 3) Activation upon confirmed gas, i.e. two concurrent alarms
- 4) Action taken on second device ONLY if second device is NOT acoustic (acoustics shall not be voted together)

- 5) As note 2) if acoustic is being used to detect toxic gas.
- 6) Fire in a building
- 7) May be manual or automatic
- 8) Includes evacuation siren, operator initiated. Offshore, evacuation is through Installation Manager
- 9) Upon gas detection the ventilation fans in process buildings shall not be stopped upon gas detection alone. Ventilation fans in process buildings shall only be stopped upon simultaneous detection of fire and gas detection alarms where the fire alarm logic shall override the gas detection logic.
- 10) On condition where water mist is used as part of overpressure suppression.
- 11) Non Process related building e.g. Administration Building, Accommodation, Warehouse, Switch Room, Fire Station, Workshop, Garage, Canteen, Kitchen, etc.
- 12) Process and utility areas including related building e.g. Analyser House, FARs, Control Room, Compressor/Turbine House, Metering Houses, etc.
- 13) For onshore building assessed as requiring detection at air inlets e.g. Administration Building, Warehouse, Analyser houses, Switch Room, etc

APPENDIX D TYPICAL CAUSE AND AFFECTS PLUS ALARMS - COMPRESSOR/TURBINE MACHINE ENCLOSURES

Initiator	RESULTING ALARM OR ACTIONS								
	Alarms			Executive Action					
	Alarm In CCR	Local		HVAC		Fire Extinguishing	Trips		
		Alarm Local Panel (1)	Alarm At Machine	Trip Ventilation fans	Close Dampers	Hood Carbon Dioxide Release	Trip Machine	Inhibit Machine Restart	Trip fuel supply
1. Automatic Actions									
a. Single Alarm level 1 gas in combustion air intake	X		X	-	-	-	-	-	-
Single Alarm level 1 or 2ooN Alarm Level 1 or 2 Gas (1)	X	X	X	-	-	-	X	X	X
b. Single Alarm level 1 gas in ventilation air intake	X		X	-	-	-	-	-	-
Single Alarm level 1 or 2ooN Alarm Level 1 or 2 Gas (1)	X	X	X	X	X	-	X	X	X
c. Single Alarm level 1 gas in machine hood / compartment	X		X	-	-	-	-	-	-
Single Alarm level 1 or 2ooN Alarm Level 1 or 2 Gas	X	X	X	-	-	-	X	X	X
d. Fire in hood / compartments	X	X	X	X	X	X	X	X	X
2. Manual Activation									
a. Turbine trip from 1) FGS in main control room	-	X	X	-	-	-	X	-	X
2) Local CO ₂ panel	X	X	X	-	-	-	X	-	-
b. Hood / Compartment CO ₂ Release 1) FGS in main control room	X	X	X	X	X	X	X	X	X
2) Local CO ₂ panel	X	X	X	X	X	X	X	X	X
e. Power failure on CO ₂ system (incl. Detection)	X	-	-	-	-	-	-	-	-
g. Pressure switch downstream of automatically operated release valves (CO ₂ discharge)	X	X	X	X	X	-	X	X	X

Notes: See Appendix C for ESD, EDP, PS

APPENDIX E EXAMPLE CAUSE & EFFECT ACTIONS

Table E-1 Example of a Cause and Effect matrix

AREA TITLE					ALARMS		SHUT DOWN		EXTINGUISHING		HVAC		H ₂ S		FIRE & GAS MATRIX PANEL		DRIILING		GENERAL		NOTES	
AREA TITLE ZONE 100 PROCESS SEPARATION TRAIN A																						
LEGENDS																						
X = ACTION																						
Δ = AND ACTION																						
N = NUMBER OF DETECTORS																						
P = POINT DETECTOR																						
L = LINE OF SIGHT DETECTOR																						
AREA CLASSIFICATION ZONE 2																						
EFFECTS																						
CAUSE																						
TAG IDENT	DESCRIPTION	TYPE	VOTE	NOTES	DESCRIPTION	TAG IDENT	NOTES	DESCRIPTION	TAG IDENT	NOTES	DESCRIPTION	TAG IDENT	NOTES	DESCRIPTION	TAG IDENT	NOTES	DESCRIPTION	TAG IDENT	NOTES	DESCRIPTION	TAG IDENT	NOTES
LD-881	GAS	P			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LD-882	GAS	P			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LD-883	GAS	P			3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
LD-884	GAS	P			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
LD-885	GAS	P			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
LD-886	GAS	P			6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
LD-887	GAS	P			7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
LD-888	GAS	P			8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
LD-889	GAS	P			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
LD-890	GAS	P			10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
LD-891	GAS	P			11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
LD-892	GAS	P			12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
LD-893	GAS	P			13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
LD-894	GAS	P			14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
LD-895	GAS	P			15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
LD-896	GAS	P			16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
LD-897	GAS	P																				

APPENDIX F EXAMPLE FIRE AND GAS SYSTEM PROJECT CHECKLIST

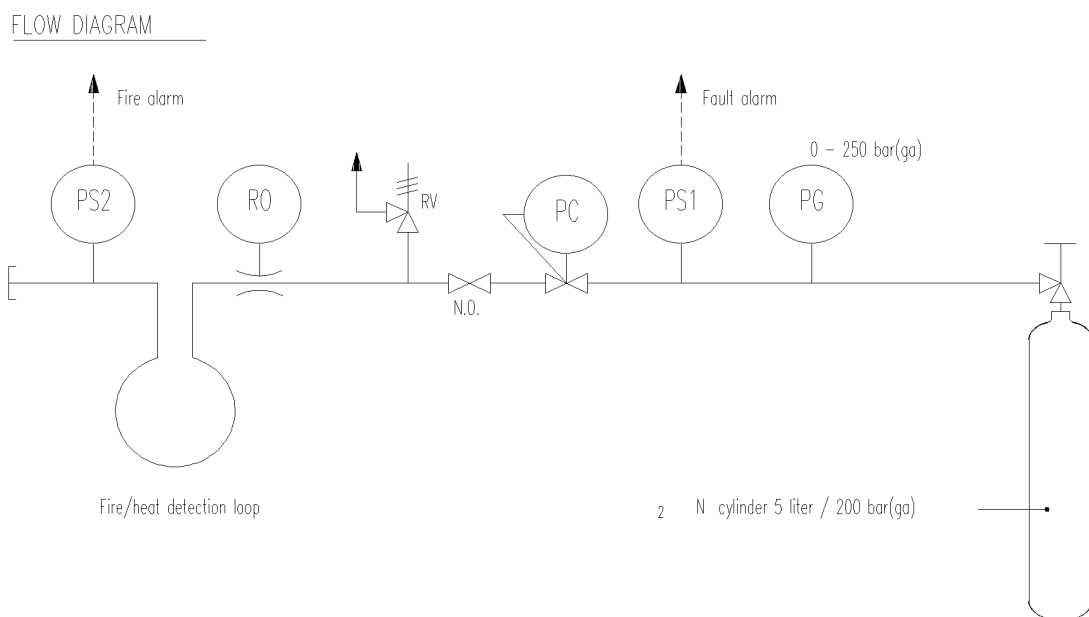
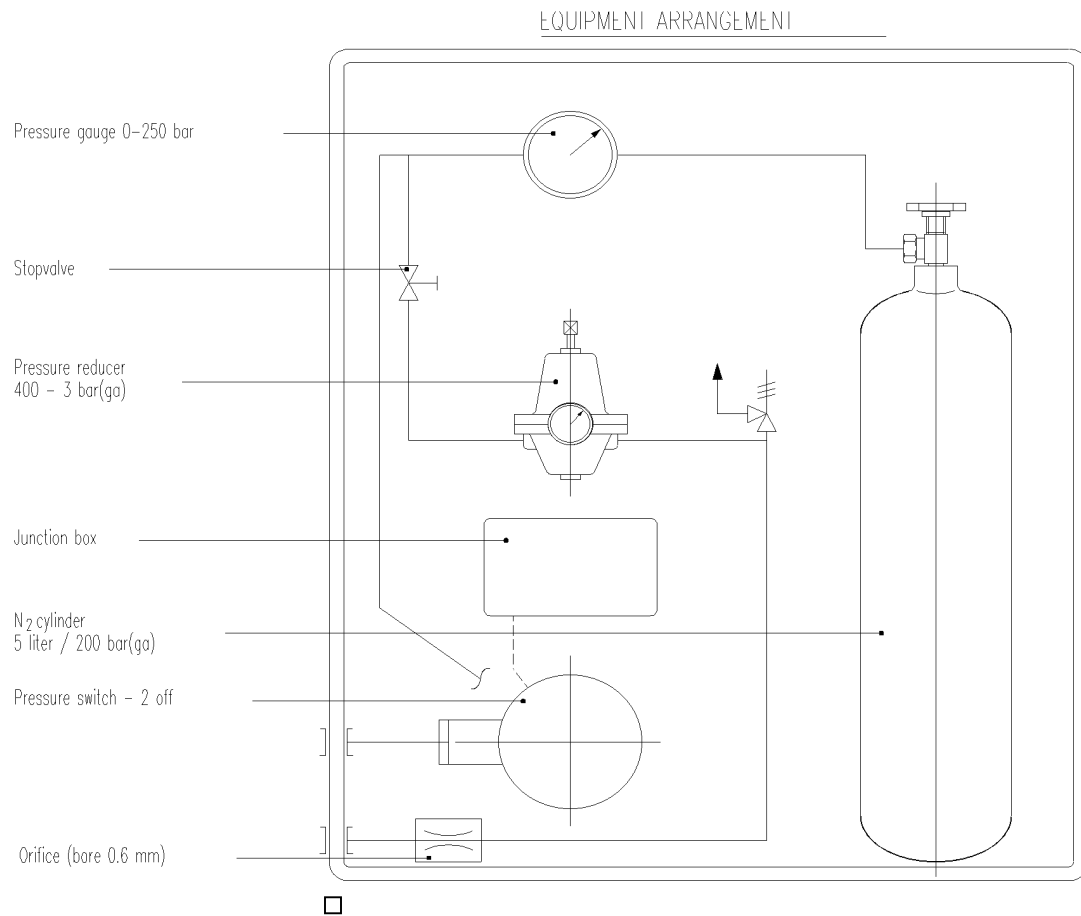
Table E-1 is an example of a Fire and Gas Detection Project Checklist that may be used in a project for identifying various requirements for the system.

Table F-1 Fire and Gas Detection Project Checklist

Project			Date	
Location			Revision	
Technologies	Applicable	Not Applicable	Comments	
Flammable Gas Detection				
Infrared (Point Sensors)	☐	☐		
Infrared (Open Path – Low Sensitivity)	☐	☐		
Infrared (Open Path – High Sensitivity)	☐	☐		
Catalytic Bead	☐	☐		
Toxic Gas Detection				
H ₂ S (Point Sensor)	☐	☐		
H ₂ S (Open Path)	☐	☐		
SO ₂	☐	☐		
Chlorine	☐	☐		
Carbon Monoxide (IR)	☐	☐		
Carbon Monoxide (electrochemical)	☐	☐		
Other (Specify)	☐	☐		
Other (Specify)	☐	☐		
Smoke Detectors				
Ionization	☐	☐		
Optical	☐	☐		
VESDA (High Sensitivity)	☐	☐		
Fire Detectors				
Infrared Triple Spectrum	☐	☐		
UV/IR	☐	☐		
Other				
Heat Detectors				
Polytube	☐	☐		
Fusible Link	☐	☐		
Other (Specify)	☐	☐		
HMI Hazard Colour Codes				
Fire	Red ☐	Other ☐		
Flammable Gas	Red ☐	Other ☐		
Toxic Gas	Yellow ☐	Other ☐		
Sensor Fault	Red ☐	Other ☐		
Other (specify)	☐	☐		
General				
Plant Evacuation Horn	☐	☐		

Link to Local Fire Department (by exception only)	☐	☐	
Link to Administration/Guardhouse/Fire Hall	☐	☐	
Project Specific Device Manufacturer List	☐	☐	
Sensor Mapping	☐	☐	
Ultrasonic Loss of Containment Detection	☐	☐	
Closed Circuit Television (CCTV)	☐	☐	
Detector Voting	☐	☐	
Notes:			

APPENDIX G TYPICAL NITROGEN UNIT FOR FIRE/HEAT DETECTION



APPENDIX H TYPICAL ELECTRICAL LINEAR HEAT DETECTION FOR FLOATING ROOF TANK

