INSTRUMENTATION IN REFINERY AND PETROCHEMICAL INDUSTRY

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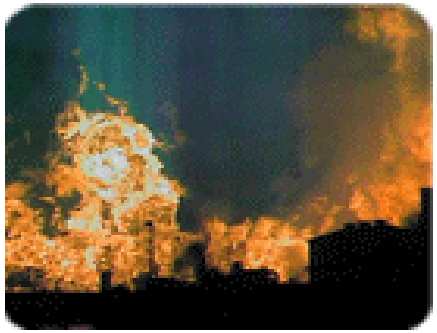
FIRE & GAS DETECTION SYSTEMS

OBJECTIVE OF FIRE & GAS DETECTION

❖Safety is a social responsibility and a requirement of sustainability. Hence, it is imperative to keep our Plants (**Process as well as Nature**) & Assets incident-free.

❖The overall objective of Fire & Gas detection systems is to warn of possible impending events that may be threatening to life and property.

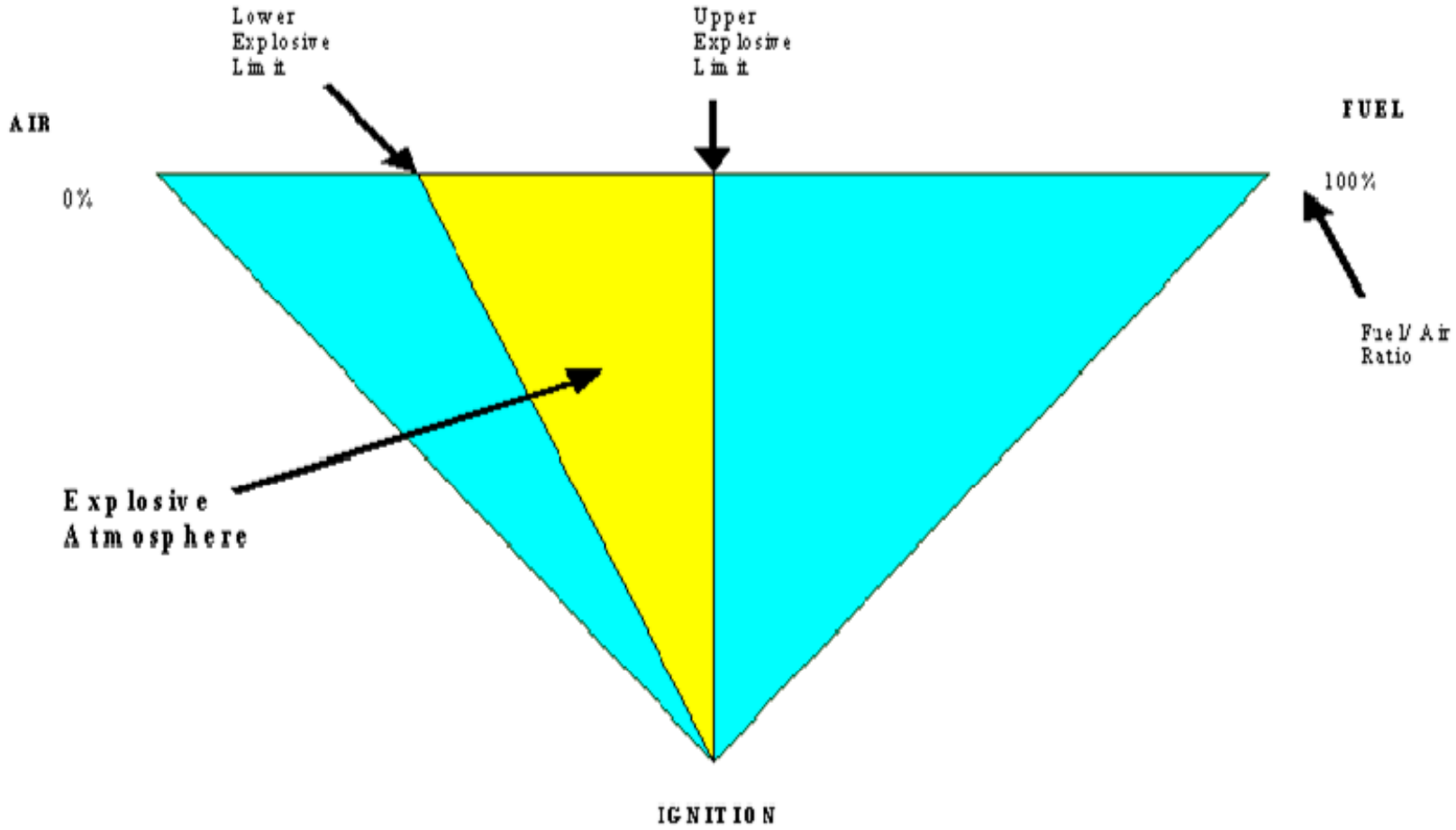
The Need For Fire & Gas Detection- Prevention



Prevention is Better Than Cure

ONGC-BHN PLATFORM

THE EXPLOSION TRIANGLE



CODES & STANDARDS FOR F&G DETECTION SYSTEM

- ✓ National Fire Protection Association (NFPA) NFPA 72

- ✓ EN 61779-1 Electrical Apparatus for the Detection and Measurement of Combustible Gases - General Requirements and Test Methods.

- ✓EN 61779-4 Electrical apparatus for the detection and measurement of flammable gases. Performance requirements for group II apparatus indicating a volume fraction up to 100%lower explosive limit.

- ✓ANSI/ISA-12.13.02 – 2003 (IEC 61779-6 Mod) Recommended Practice for the Installation, Operation , and Maintenance of Combustible Gas Detection Instruments

- ✓ ISA-RP92.0.02 Part II – 1988 Installation, Operation, and Maintenance of Toxic Gas-Detection Instruments; Hydrogen Sulfide

CODES & STANDARDS FOR F&G DETECTION SYSTEM

- ✓ NFPA 325M Fire Hazard Properties Of Flammable Liquids, Gases, and Volatile Solids For LEL Of Gases
- ✓ API RP14C – F&G Location in Offshore Platforms
- ✓ BP-GUIDANCE ON PRACTICE FOR FIRE AND GAS DETECTION-GP-30-85
- ✓ SHELL STANDARD -32302011- Fire Gas & Smoke Detection Systems
- ✓ **BP RP-30-7- Fire & Design Philosophy**

Design Process of F&G System

The typical sequence of design activities relevant to a FGS detection system is

- Identify the hazards related to Fire, Gas and Smoke event
- Define site hazardous zones, fire zones
- Classify the level of criticality of identified hazards
- Generate Fire & Gas design requirements and philosophy
- Detailed Design of FGS, including configuration and layout
- Construct and commission
- Operate and maintain

SOURCE OF LEAKAGES

Places with possible leakages:

- Flange gaskets, fittings, pipelines, valves, sampling connections (Flammable, toxic)
- Pressurised systems such as compressor seals and pump seals (Flammable)
- LPG storage and filling sites (Flammable)
- Around HOT spots like hydrocrackers, ovens etc.

GAS DETECTORS

Function of F&G Detection System

BASIC FUNCTIONALITY OF F&G DETECTION SYSTEM

- **DETECT THE HAZARD**

  F&G system give early detection of presence of Fire, Smoke, hazardous release of flammable & toxic gases due loss of containment.

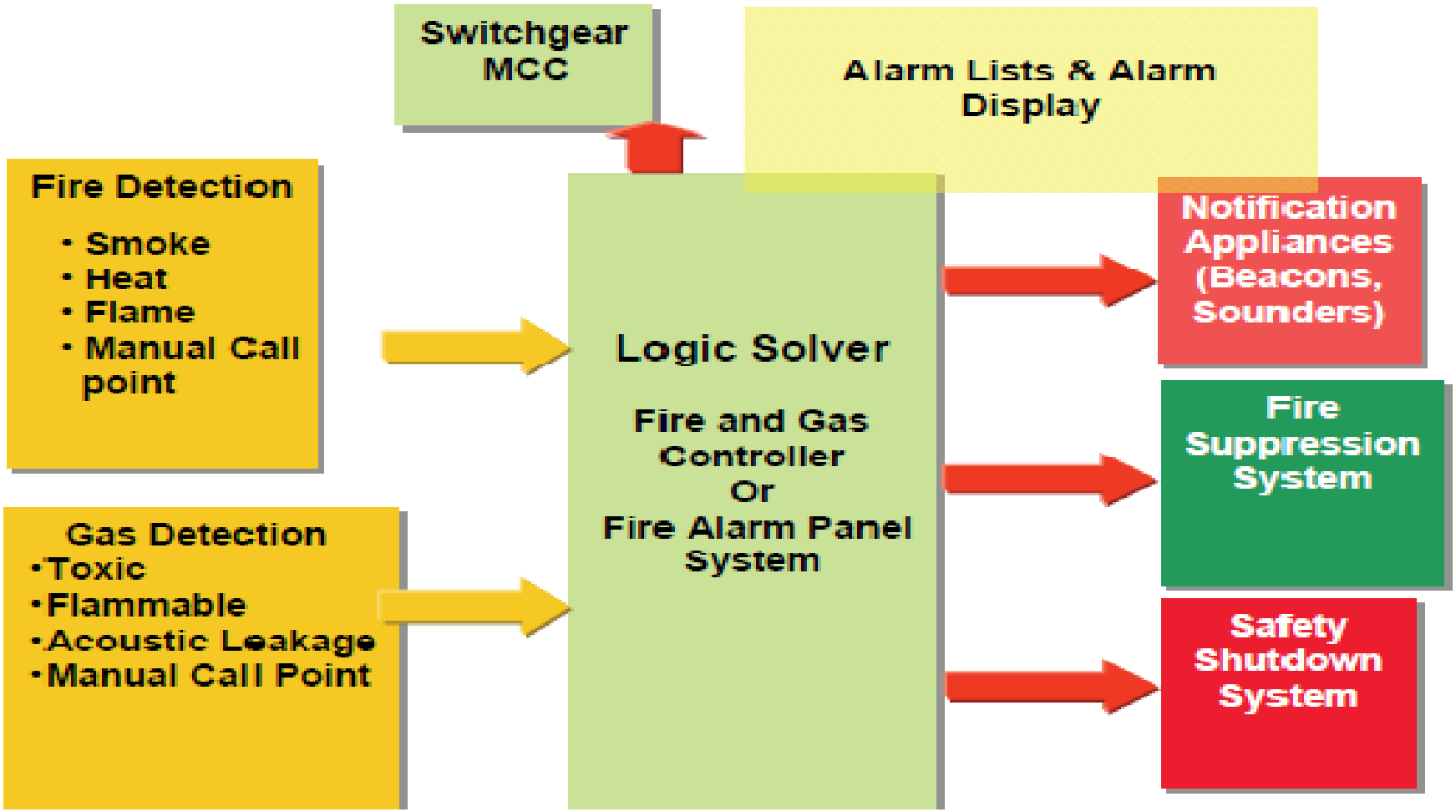
- **ALERT PEOPLE**

  Alert the operator at continuously manned control room to any hazard

- **INITIATE ACTION**

  Audio/Visual alarm, Isolate & minimize the inventory of hazardous material, minimize potential ignition sources by electrical isolation, initiate active fire protection system, **provide protection to HVAC operation (heating, ventilation, and air conditioning)**

F&G DETECTION SYSTEM COMPONENTS



TYPES OF GAS DETECTORS

TYPES OF GAS DETECTORS

FLAMMABLE (LEL)

TOXIC (H2S, CL2)

FLAMMABLE : TO DETECT FLAMMABE GAS & FIRE

TOXIC : TO DETECT POISONOUS AND HARMFUL GASES

LEL : LOW EXPLOSIVE LIMIT

LOW EXPLOSIVE LIMIT : 20%

UPPER EXPLOSIVE LIMIT: 60%

CLASSIFICATION FOR TYPES OF GAS DETECTORS

Gas detectors are further classified into:

Portable Gas Detectors	Fixed Gas Detectors
Used for personnel protection	Used for Man & Machinery protection
Can be carried along with person	Fixed at one point in the Hazardous area
Battery operated	Line powered, Continuous Operation
Economical	High Cost & application based.
Person needed to carry	Fixed, no need of person to carry

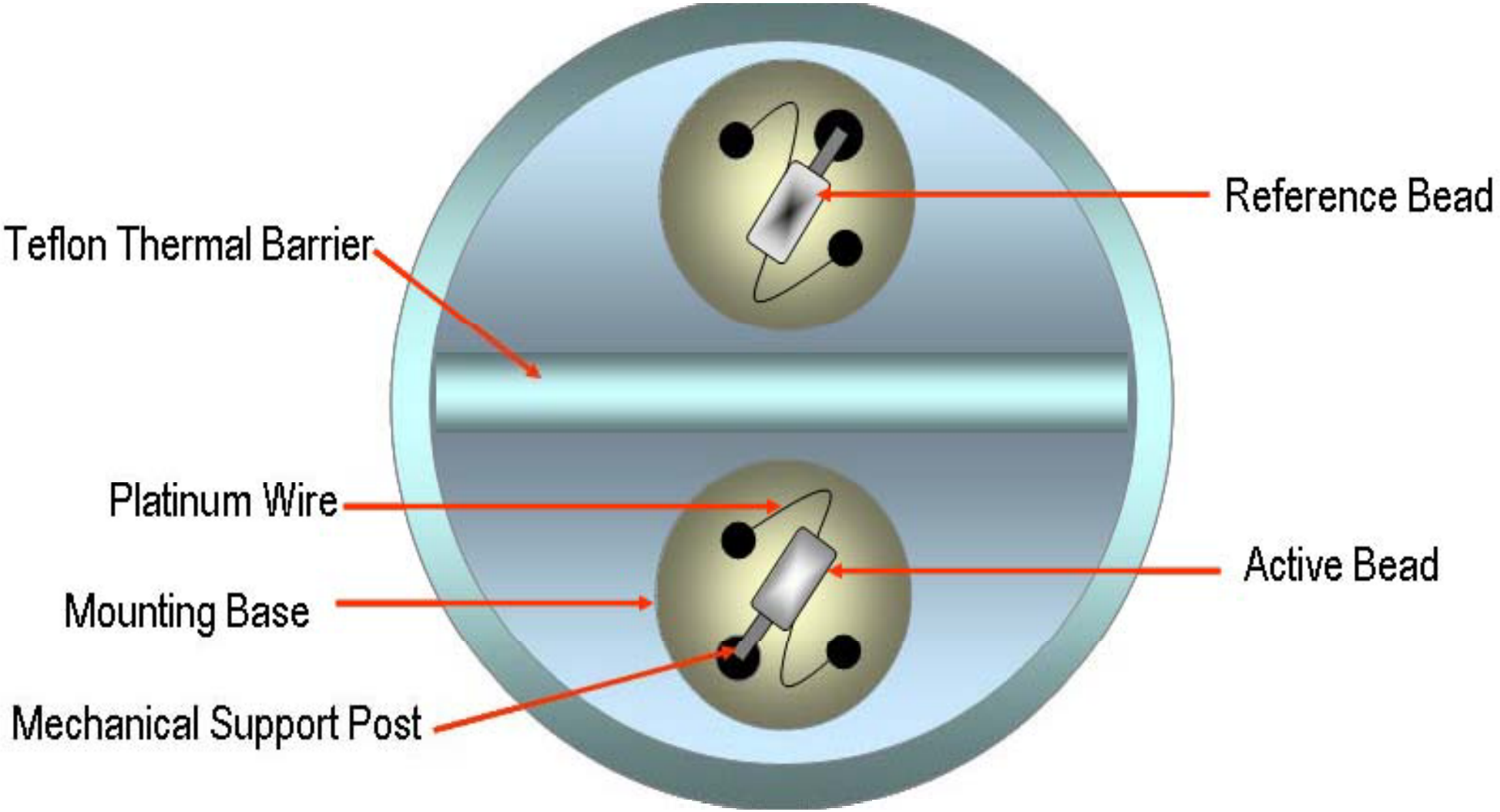
FLAMMABLE GAS DETECTORS

Flammable gas detector can be broadly classified as

- Point Detector (Catalytic type detectors, Infrared type detectors, Aspirated gas detection)
- Open Path Detector

The correct selection of gas detector type is most important if early detection is to be achieved to mitigate incipient hazards. The proper type of detector, is best selected taking into account the process parameters and environmental condition of the plants

CATALYTIC TYPE DETECTORS



CATALYTIC TYPE DETECTORS

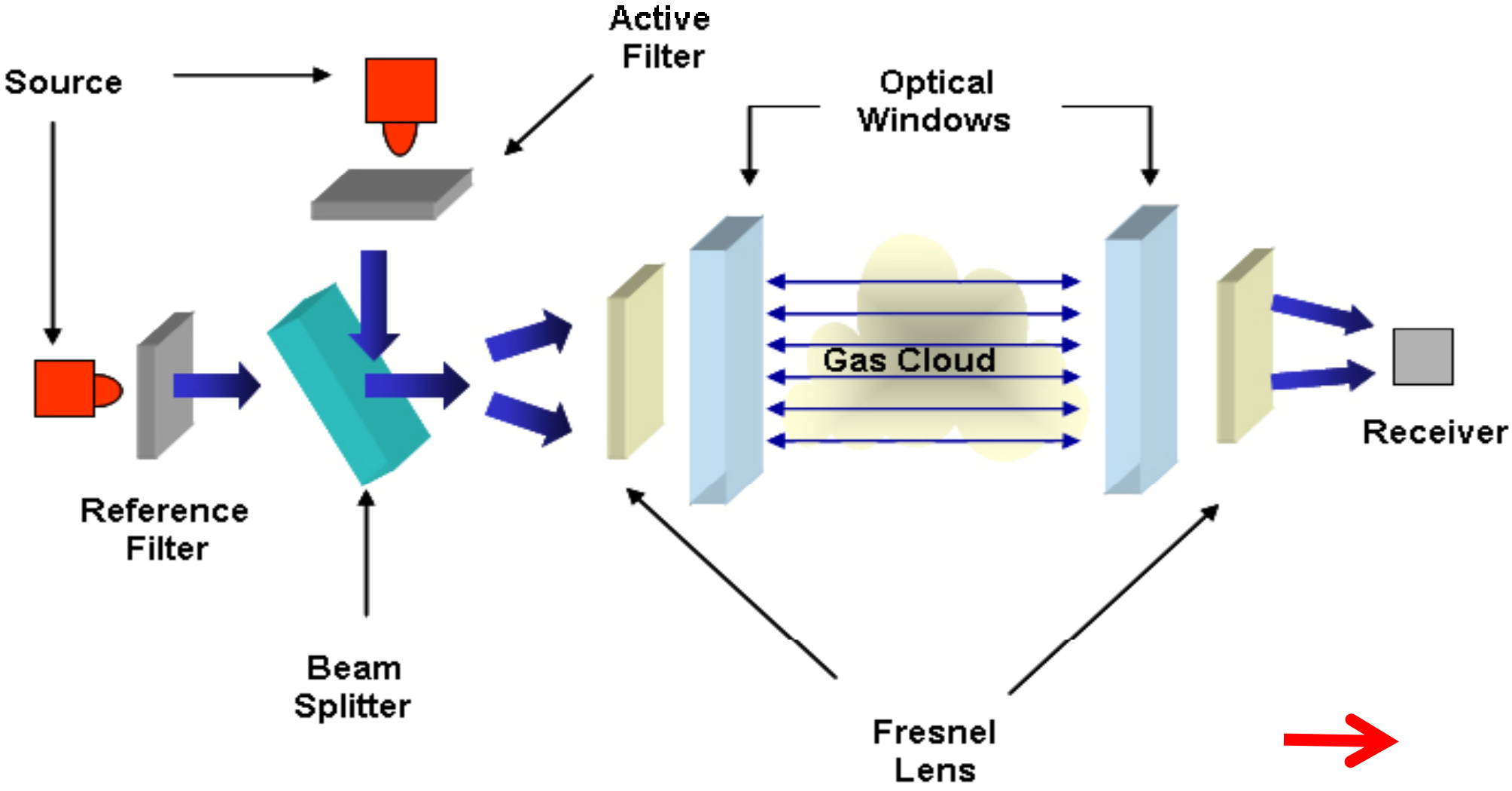
Advantages of Catalytic Type Sensors:

- Robustness
- Easy to mount,
- Low life-cycle cost

Limitations of Catalytic Type Sensors:

- Response time of typically 10 to 30 seconds.
- Bead life span limitation.
- Needs Oxygen for combustion

INFRARED TYPE DETECTORS - PRINCIPLE



INFRARED TYPE DETECTORS - ADVANTAGES

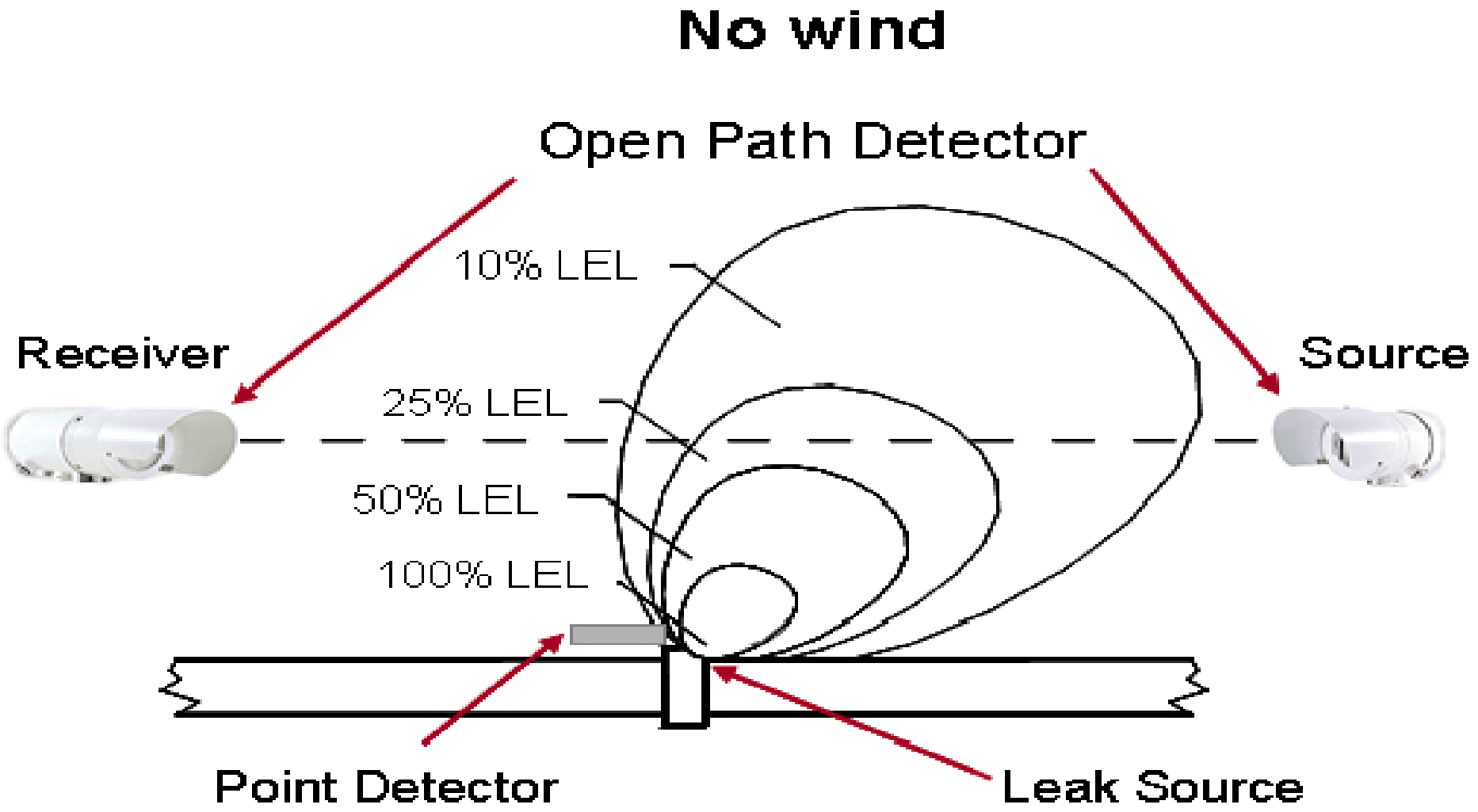
Infrared gas detectors are preferred to catalytic detectors:

- Rapid response to gas (3 seconds).
- Not sensitive in oxygen-reduced atmospheres.
- Show improved sensitivity to higher order hydrocarbons (which is also desirable)
- The technique is immune to poisoning by airborne pollutants such as silicones, lead compounds and H2S.
- **Infrared type detectors provide fail-safe operation due to its active optical sensing technology.**

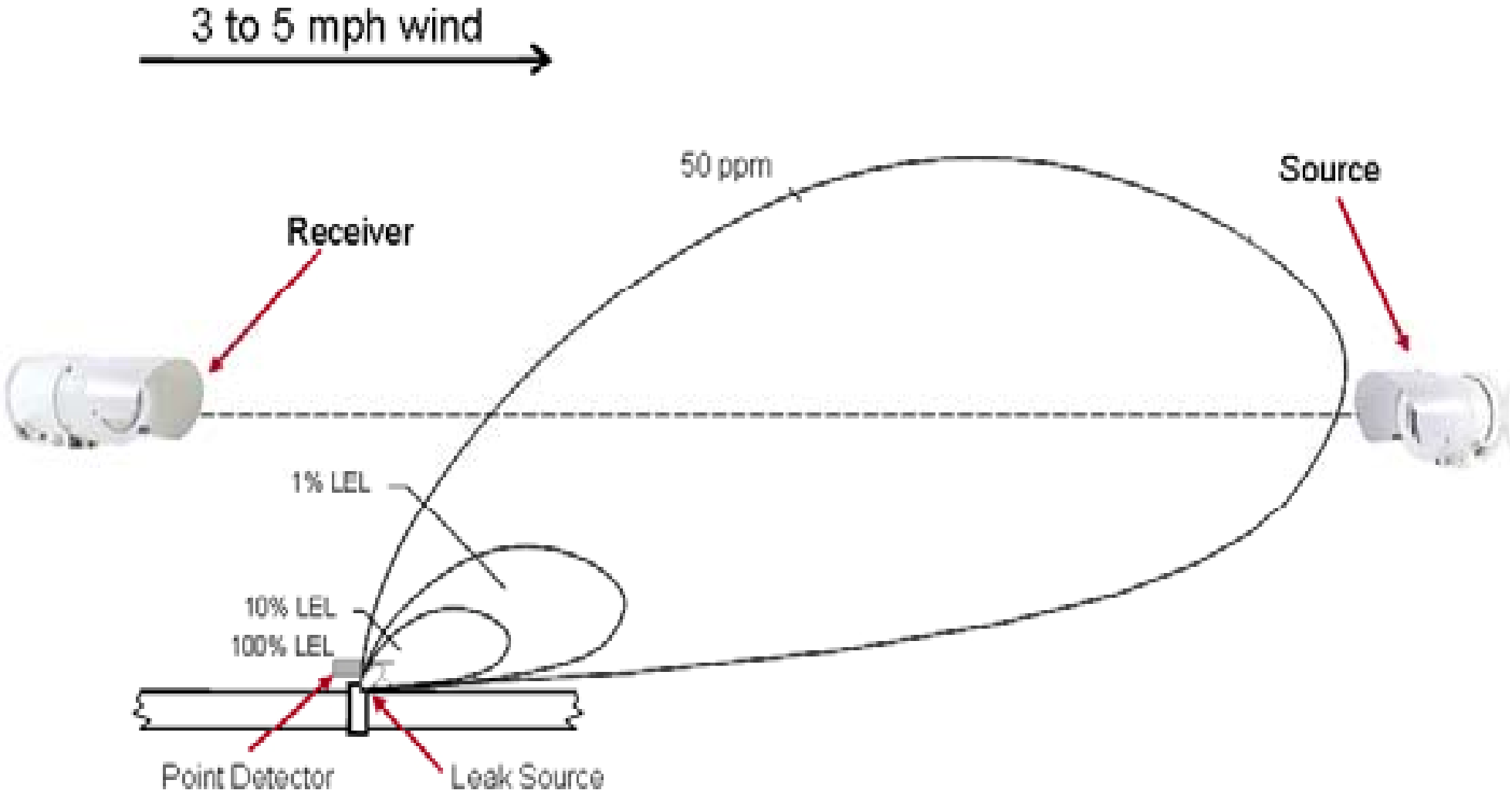
INFRARED TYPE DETECTORS (OPEN PATH TYPE)

- Can be used when potential sources leakage cannot be defined at a particular point
- Can cover a large area (100M), along a array of multiple potential leak sources like row of valves or pumps or even for fence monitoring.
- Reduced sensitivity to alignment and partial obscuration
- Robust and Shock Resistant

OPEN PATH TYPE DETECTORS



OPEN PATH TYPE DETECTORS



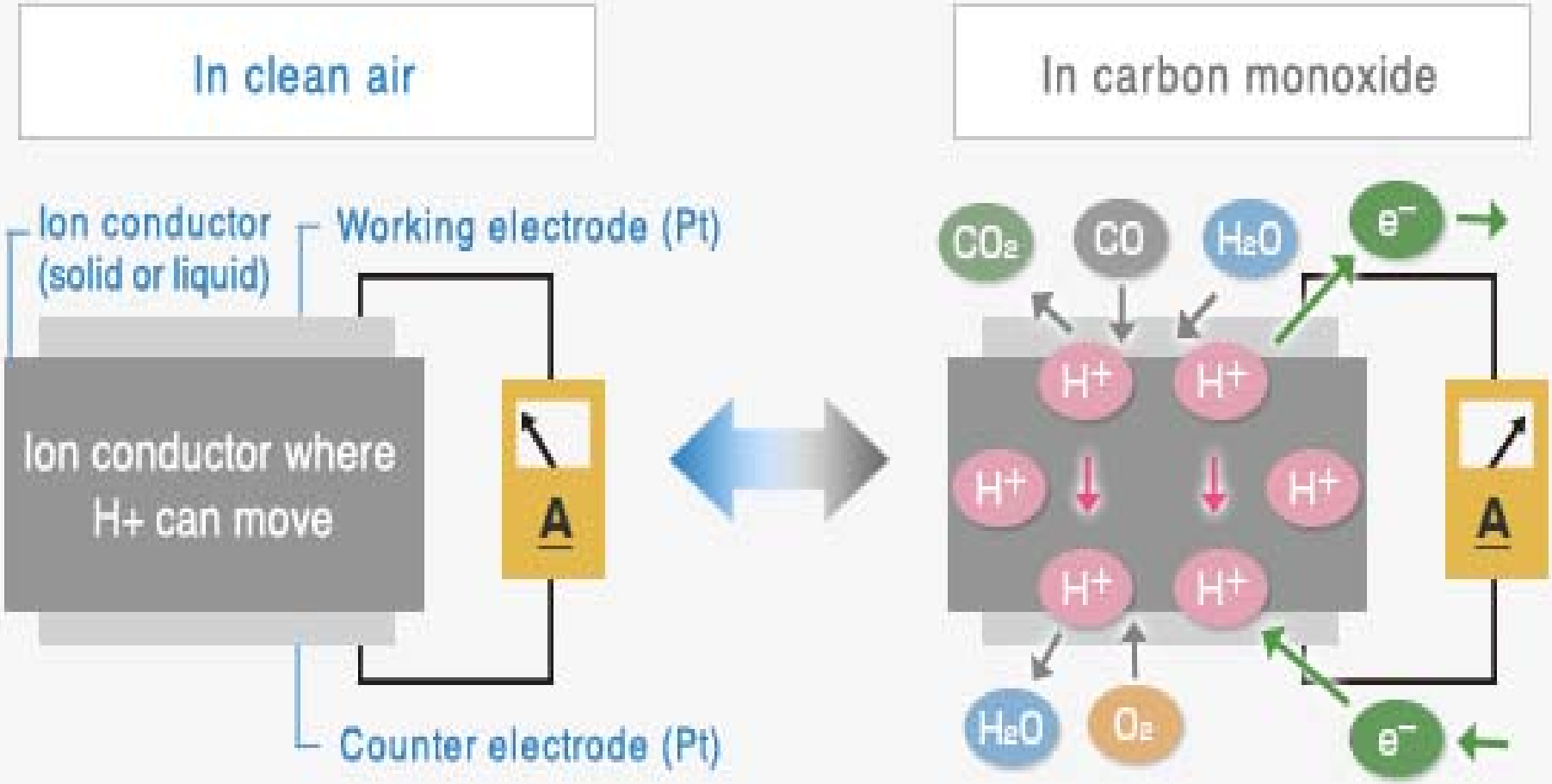
TOXIC GAS DETECTOR

- **Category-1:** H2S, CO, HF, HCl, Cl2 – immediate hazard
- **Category-2:** Benzene, Toluene, Vinyl Chloride, into the atmosphere will generally create a health hazard rather than an explosive hazard, although ultimately the latter situation may develop
- The concentrations at which toxic gases need to be detected are far lower than for flammable gas detection
- Flammable gas detectors shall therefore not be used for the detection of toxic gas, even if the latter coexists with a flammable gas of a different compound, e.g. H2S in conjunction with a hydrocarbon mixture

TOXIC GAS DETECTORS (H2S/ CL2)

- Principle of H2S detector: Electrochemical cell or solid state semiconductor
- Field life of electrochemical sensor shall be 2 years minimum.
- The semiconductor sensor shall be thin film MOS type. Life expectancy shall be minimum 5 years.
- H2S detector and its terminal box shall have a metallic body.
- Principle of Cl2 detector : Electrochemical cell type.
- Range : Unless specific requirement is there, 0-100 ppm is considered for H2S detectors and 0-10 ppm for Cl2 detectors.

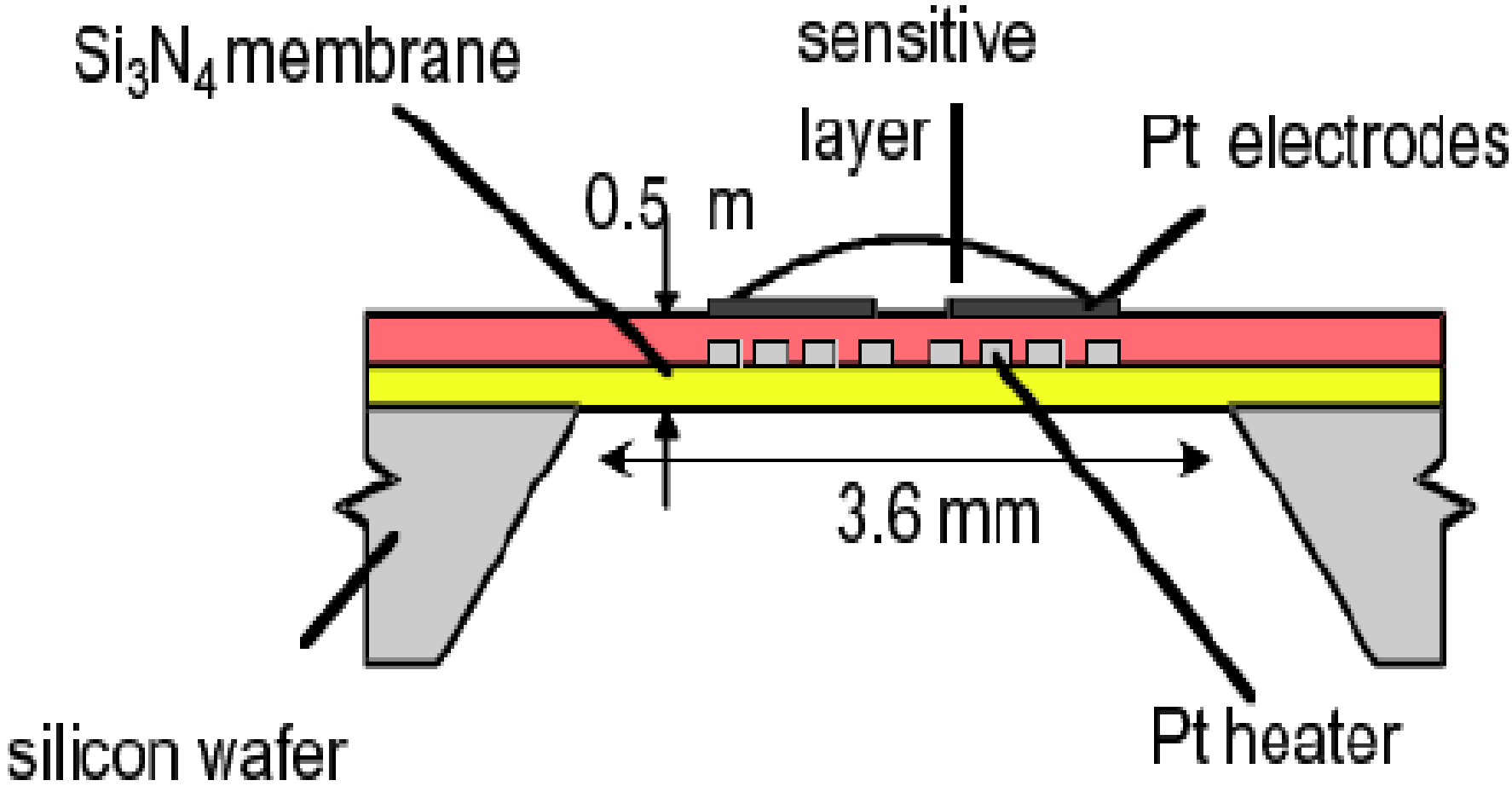
Toxic Gas Detector – Electrochemical type



Electrochemical Type Detector

- Highly Sensitive and works in harsh environment
- Low Power consumption & good specificity to target gases
- Miniature in size but sensitivity depends on number of reactivity sites of the electrode.
- **Measurement affected by decrease in low temperature(cold place)**
- Sensor affected by Alkaline metals and become insensitive when silicon vapor coats it.
- Low Oxygen environment also alters its performance

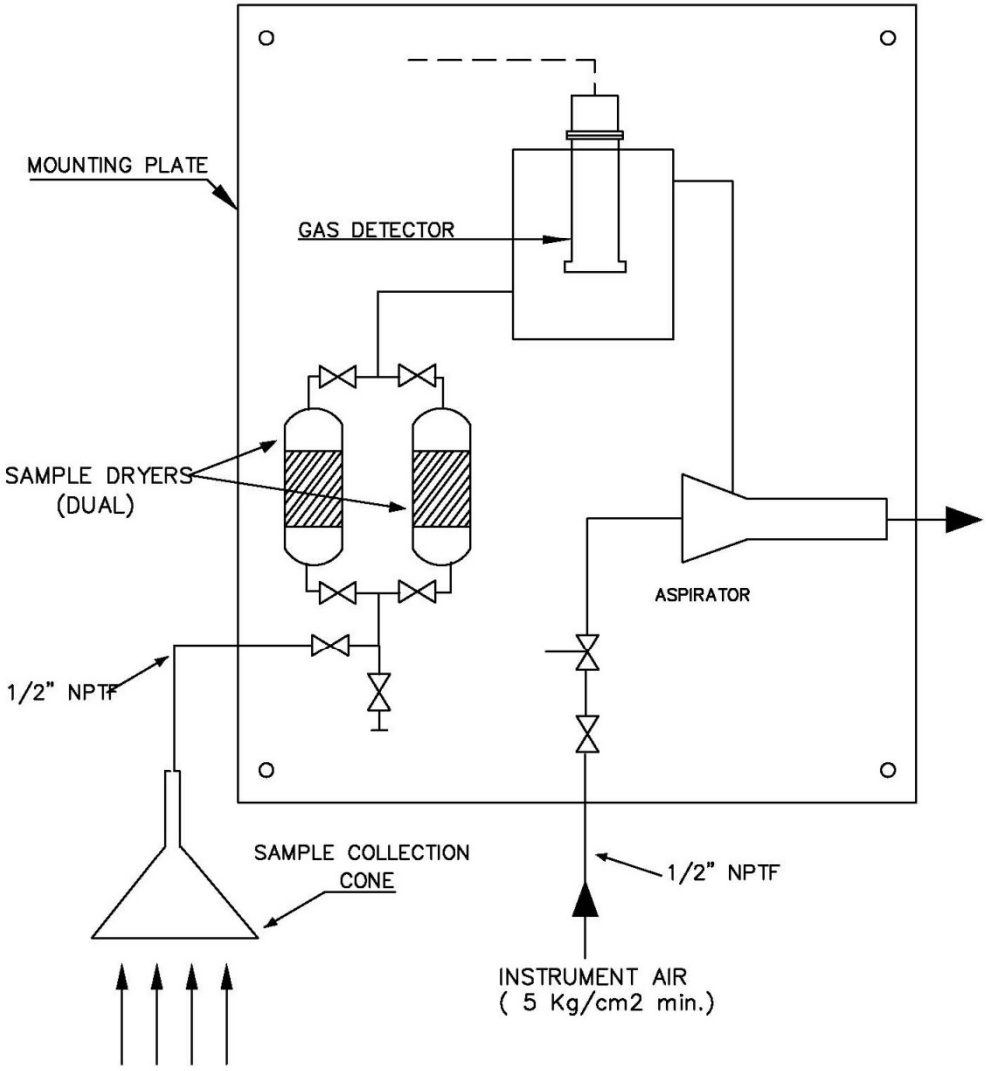
Toxic Gas Detector – Semiconductor Type



Semiconductor Type Detector

- Semiconductor type Gas detectors are versatile and can detect variety and wide range of Gases.
- Long Lived – More than 10 years
- Robust and high tolerance to corrosive environment
- Costly
- Affected by interfering gases Methyl Mercaptan, Cl2, NOx
- High Power consumption due to Heater
- Sensor reading decreases with continuous exposure of same gas called SLEEP EFFECT so needs regular calibration.

ASPIRATOR ASSEMBLY

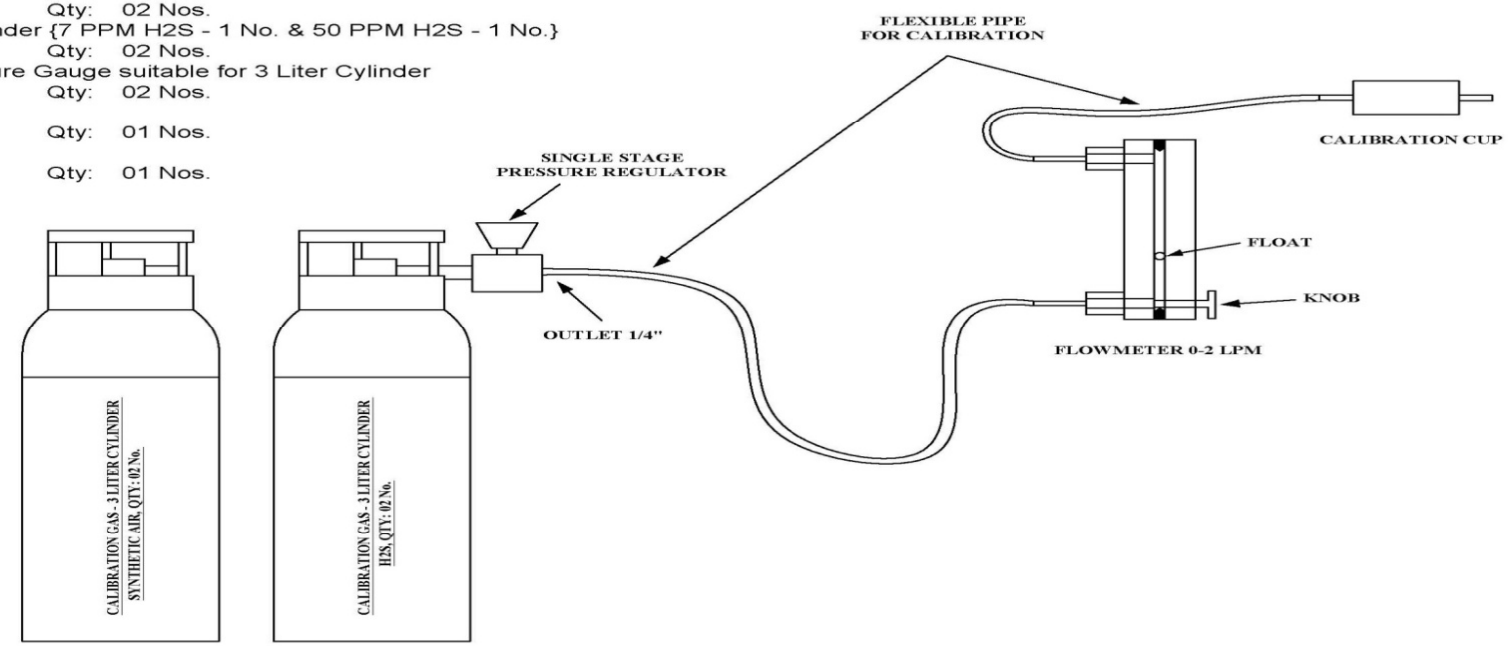


CALIBRATION OF GAS DETECTORS

H2S CALIBRATION KIT

Calibration Kit for H2S detector: Qty- 1 Set

- Zero Gas Canister - 3 Liter Cylinder (Pure Air)
  Part Code: H2S-3LCS-CE Qty: 02 Nos.
- Span Gas Canister - 3 Liter Cylinder {7 PPM H2S - 1 No. & 50 PPM H2S - 1 No.}
  Part Code: H2S-3LCS-CE Qty: 02 Nos.
- Fixed Flow Regulator with Pressure Gauge suitable for 3 Liter Cylinder
  Part Code: S-SS-3LCS-CE Qty: 02 Nos.
- 0-2 LPM Flow meter with Hose
  Part Code: H-FM-2LPM Qty: 01 Nos.
- Calibration Cup
  Part Code: S3KCAL Qty: 01 Nos.



The calibrated range for fixed detectors shall be:

a. 0 to 100 PPM - hydrogen sulfide in air (10 ppm & 15/20 ppm)

b. 0 to 100% LEL - combustible gas in air. (20% LEL & 60% LEL)

SIGNAL ANALYSIS

- Gas detectors have integral transmitter with 4-20 Ma output. SMART detectors with HART output and Addressable detectors with RS-485 output are available .

➢ The transmitted signal shall be linear, within a range of 0 to 22 mA, per the following requirements:

a. Analog output signal (4-20 mA DC)

b. Detector trouble/open loop alarm (0-4 mA DC)

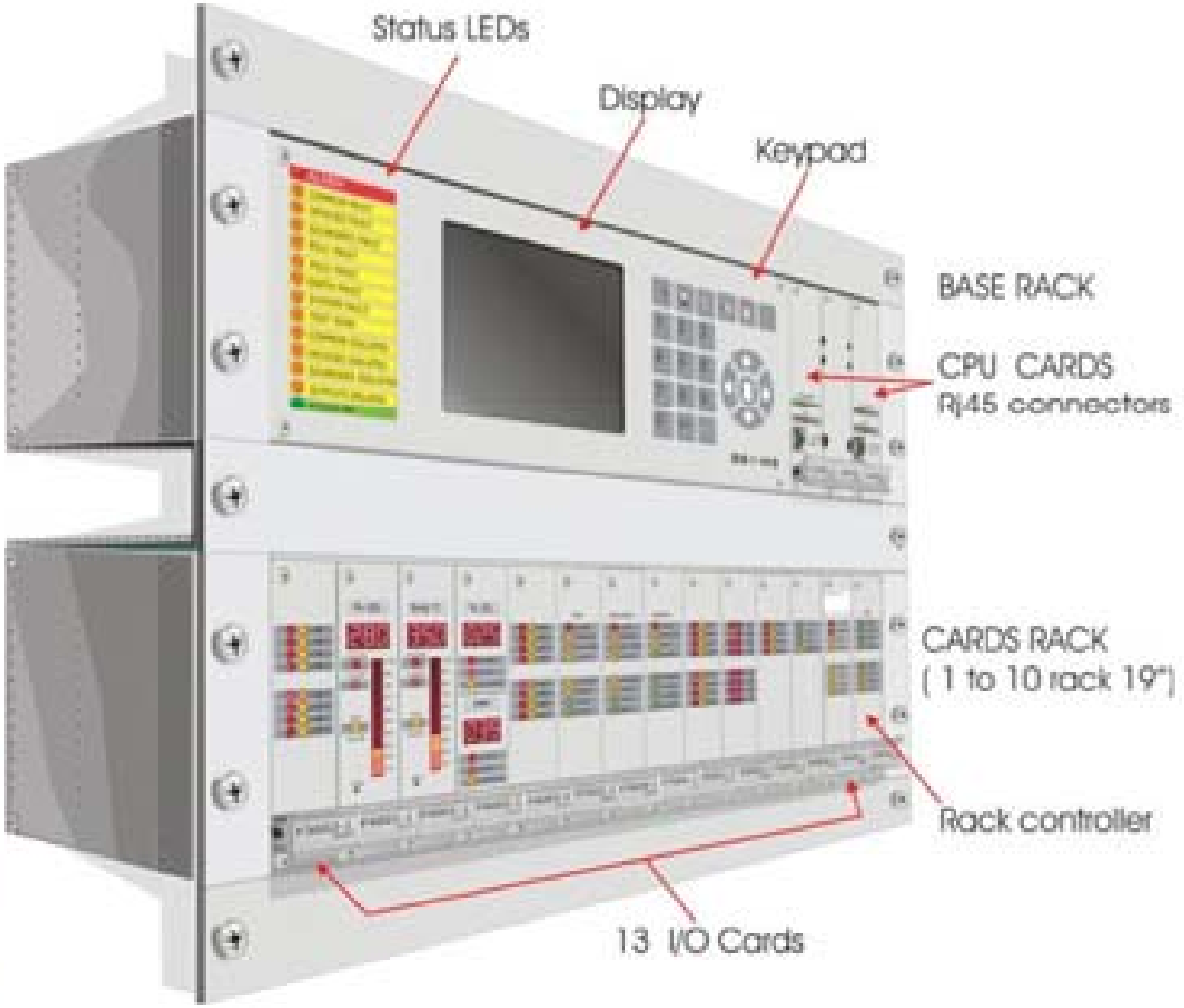
c. **Detector bypass/calibration mode alarm** (0-4 mA DC)

d. Signal over-range alarm (greater than 20 mA DC)

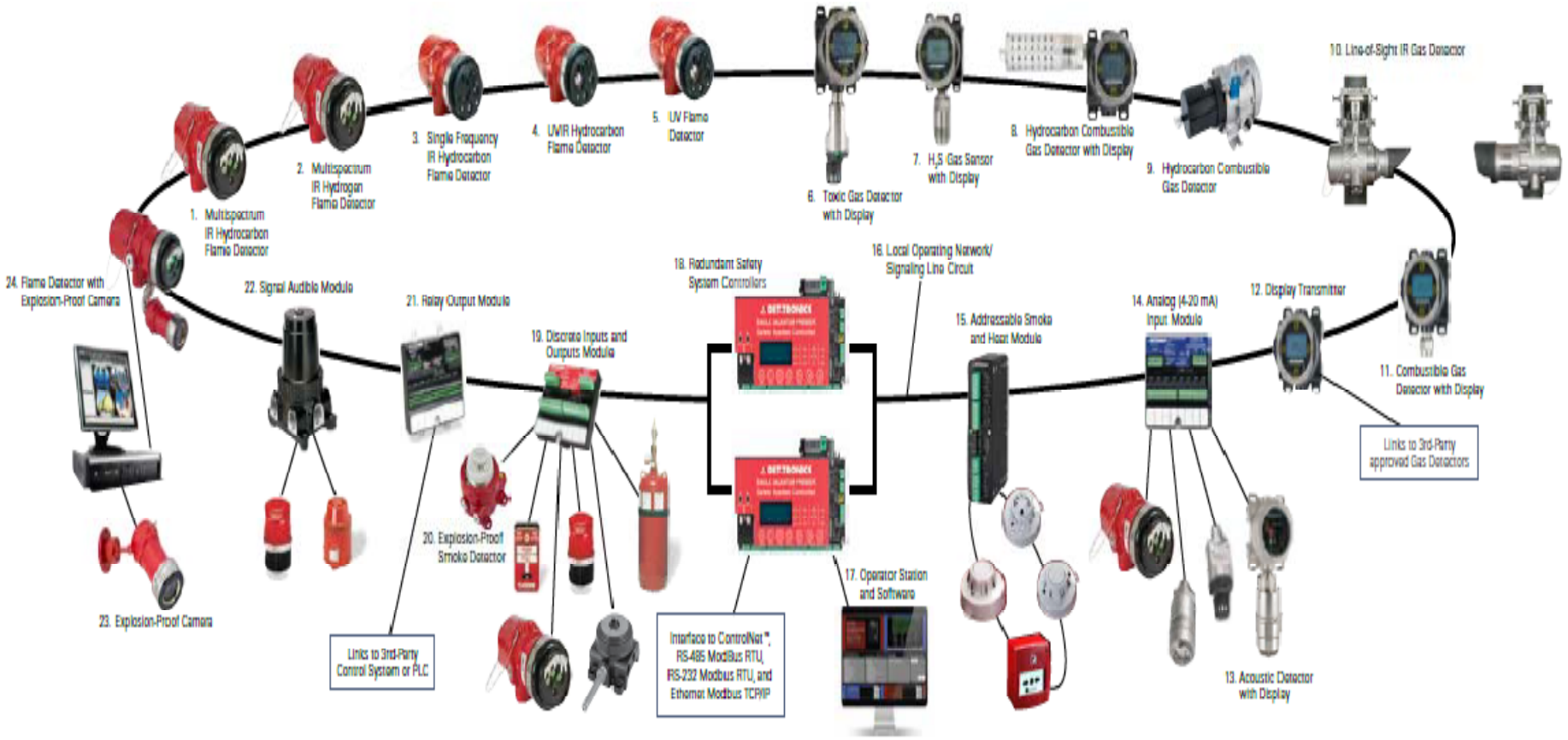
KEY POINTS WHILE ORDERING

- Detectors shall incorporate an integral linear scale or digital indicator, or a temporary connection for detector calibration.
- Detectors shall incorporate smart microprocessor calibration and fault diagnostic features. Calibration shall be non-intrusive, i.e., may be performed without opening the sensor/transmitter enclosure.
- Detectors shall incorporate non-interactive zero and span adjustments
- Hydrogen sulfide and infrared point combustible gas detectors shall have automatic temperature compensation for ambient temperature and humidity changes.
- **Special detectors must be specified to be installed in the gas turbine high temperature compartments with remote calibration facilities.**
- **Performance criteria like Response Time, False immunity, Detection Range, Self Diagnostic, Field of View to be indicated for Flame detectors**

F&G SYSTEM FOR SMALL SYSTEMS



TWO WIRE ADDRESSABLE TYPE F&G SYSTEM

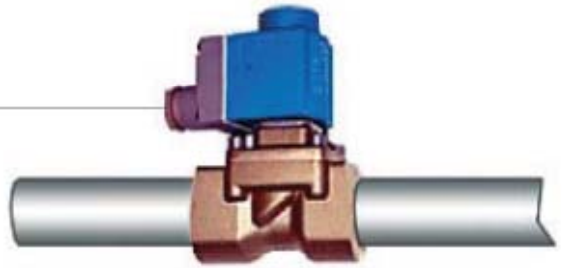


SIL SYSTEM

SE – Sensing Element.
The gas detection transmitter **detects** the potential dangerous condition.

LS – Logic Solver.
The controller **reacts** to the potential dangerous condition and activates countermeasures.

FE – Final Element.
The activated solenoid valve **averts** the dangerous condition by closing the gas pipe reliably.

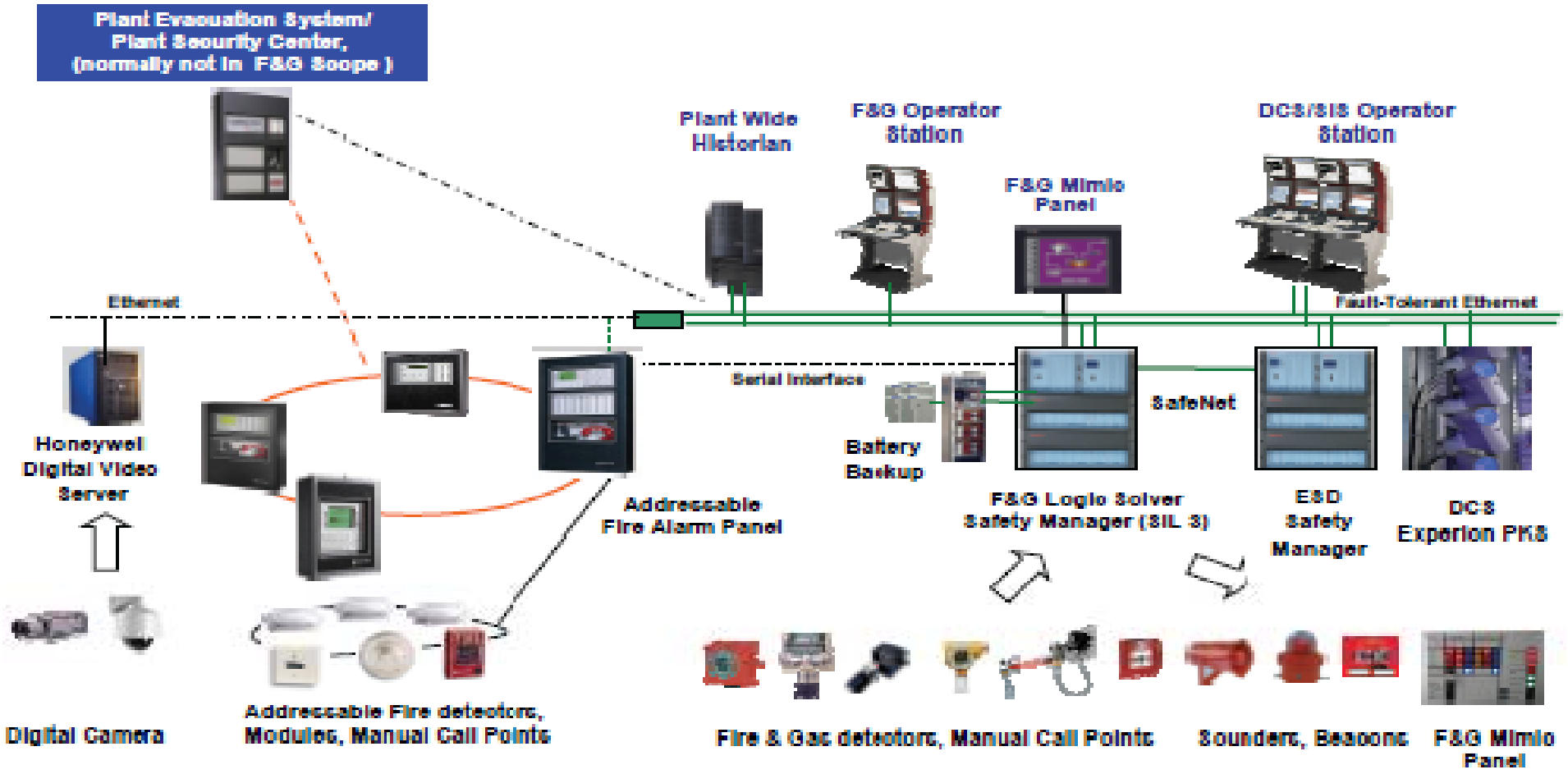


Polytron 7000
with sensor
Type B
PFD_{SE} = 1.56E-03
T_P = 8760 h
λ_{DU} = 3.57E-07 h^{-1}
SFF = 90 %

4-20-mA-Module REGARD
incl. REGARD Master Card
Type B
PFD_{LS} = 2.23E-04
T_P = 8760 h
λ_{DU} = 5.10E-08 h^{-1}
SFF = 94 %

Solenoid valve
(open if energized)
Type A
PFD_{FE} = 5.20E-03
T_P = 8760 h
λ_{DU} = 1.20E-06 h^{-1}
SFF = 68 %

INTEGRATED F&G SYSTEM



CRITERIA FOR POSITIONING GAS DETECTORS

- The vapours being formed due to release of flammable liquids shall be always heavier than air and they propagate through the air close to the ground **and wind direction**. In such cases, detectors must be placed near to the ground leaving accessible space for calibration.

- Gases like Methane & hydrogen are lighter than air so they tend to rise and can gather together to form gas clouds unless they are very cold.

- H2S Detectors shall be located at the bottom of release source as it is heavier than air.

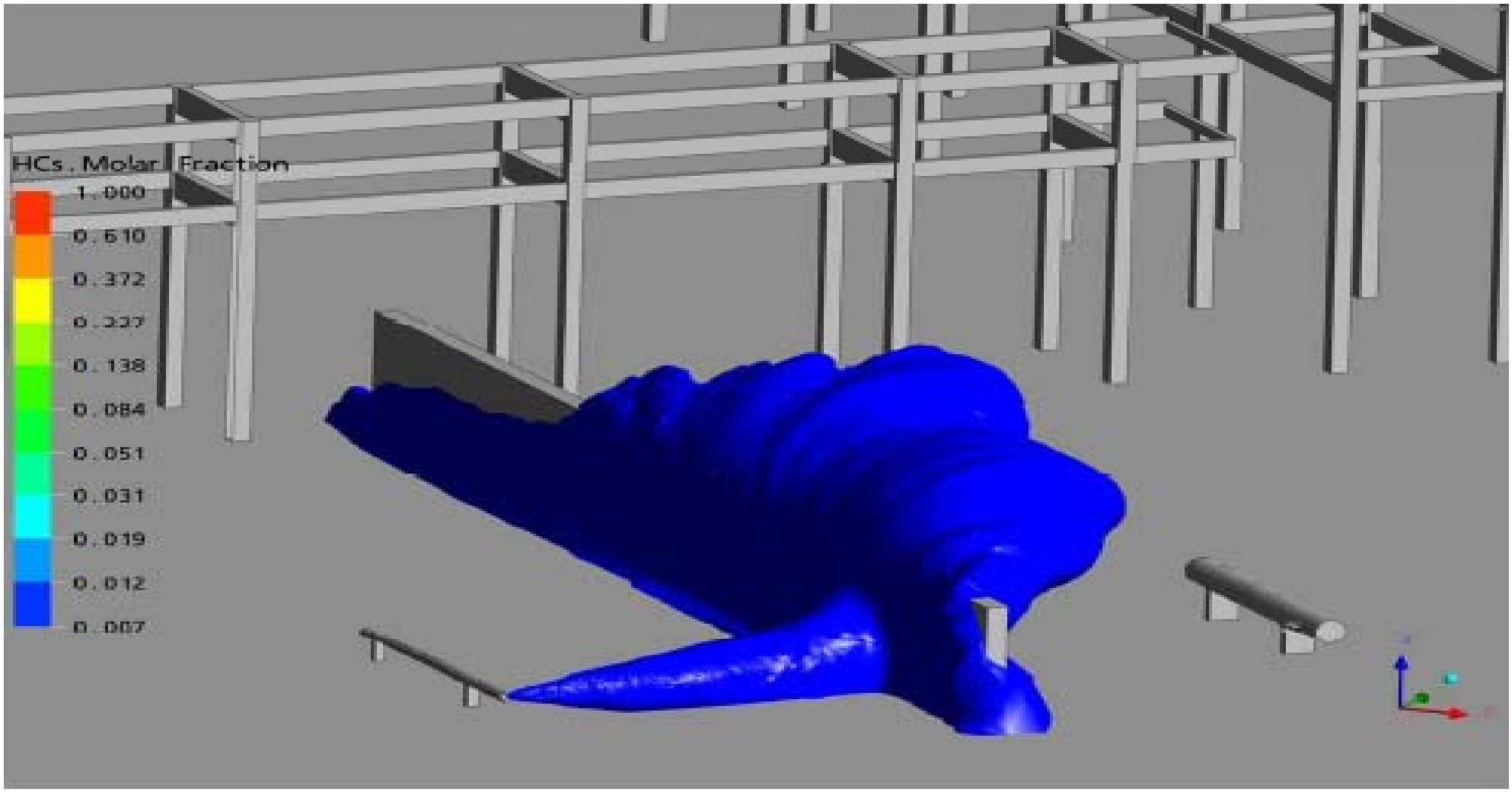
- In addition, Toxic Gas Detectors shall also be provided near all probable leak sources of other toxic gases i.e. Chlorine, Ketone etc.

HSE during Project Execution

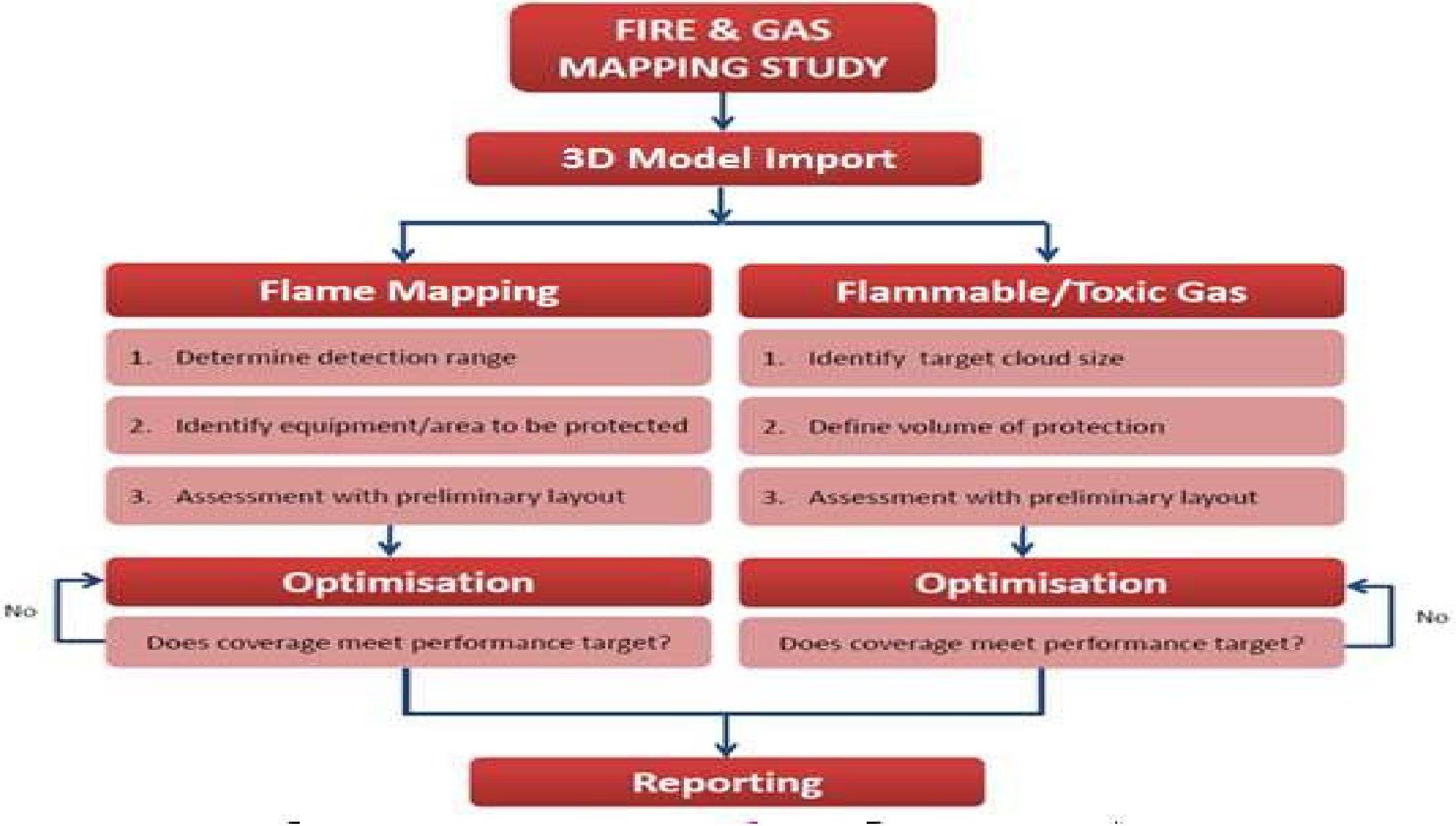
Engineering Stage

- P&ID Review
- Plot Plan Review Through Plot Plan Risk Review Committee (PPRRC)
- Quantitative Risk Assessment
- Detailed HAZOP & HAZOP Close Out Report
- **3D Model and Fire & Gas Safety System Review**
- Cause & Effects/Safety Charts Review
- Preparation of HSE Dossier & PHSER
- Safety Manual & Operating Manual Preparation

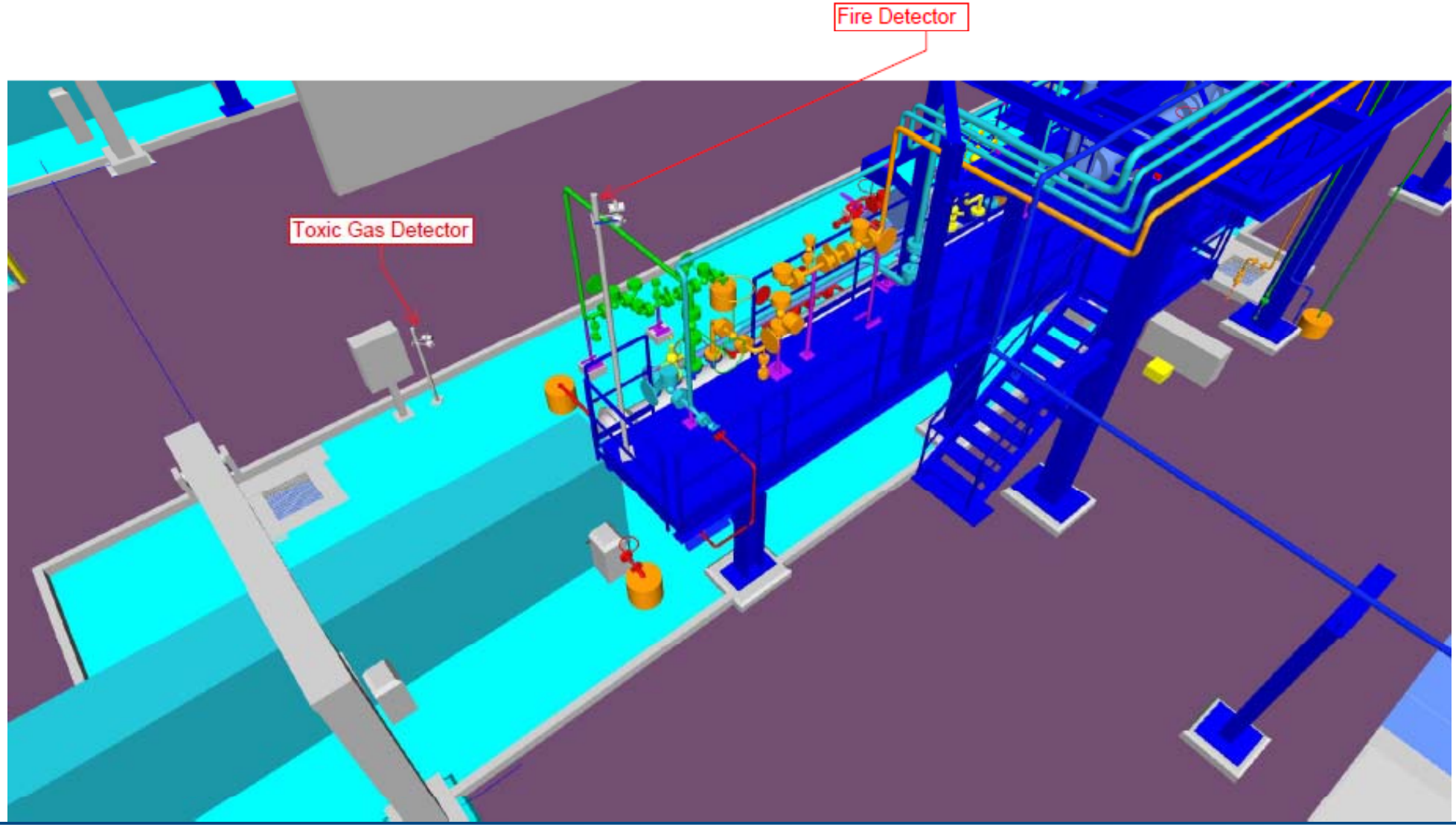
DISPERSION ANALYSIS (3D)



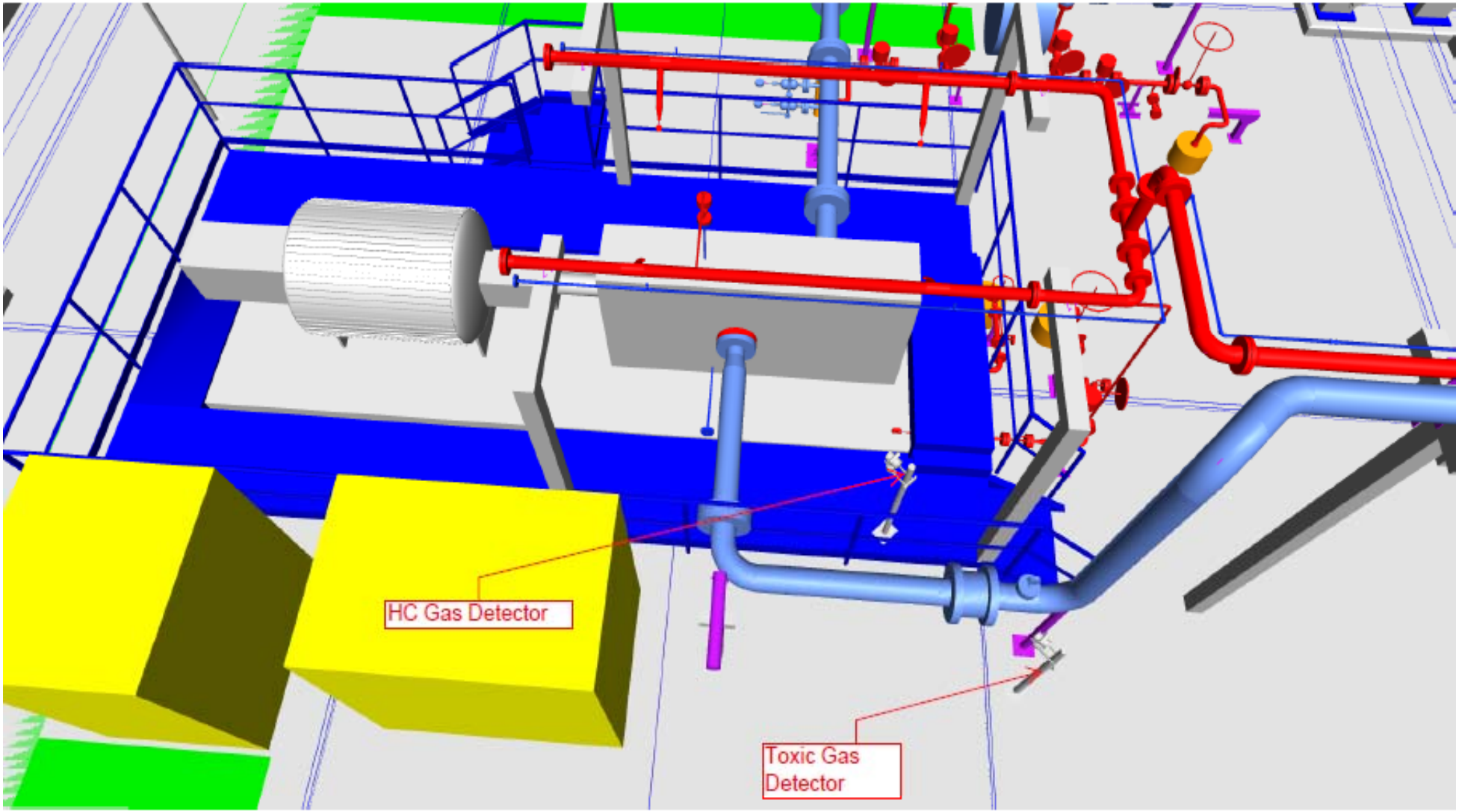
General Approach for F&G Mapping



3-D MODEL SNAPSHOT OF LOCATION OF DETECTORS



3-D MODEL SNAPSHOT OF LOCATION OF DETECTORS



RECOMMENDATION OF MB LAL COMMITTEE

- Hydrocarbon detectors shall be installed near all potential leak sources of petroleum products i.e tank dykes, tank manifolds, pump house manifolds etc.

- Hence the committee recommended that gas detectors shall be properly selected and located and **shall always be maintained in good condition.**

Hydrocarbon (HC) Detector Typical Location

- Around Class A hydrocarbon pumps in process units.
- Process cooling tower top deck or water distribution channels.
- Knock out drums (compressor, fuel gas, flare)
- Around Fired heater fuel gas piping manifold
- Suction side of forced draft air blowers if located where hydrocarbon vapors can be present.
- Around vessels containing light hydrocarbon **(C5/C6 and lighter)**
- Around Gas compressors
- Air-intake point for control room and other buildings in an electrically classified area

Hydrocarbon (HC) Detector Typical Location

- LPG , lighter hydrocarbons (i.e. Propane/Butane/ Propylene etc) and Pentane storage area (Horton spheres / Mounded bullets, pump house and piping manifold, bulk truck loading area, bulk wagon loading area, LPG bottling, storage, repair sheds)
- All hydrocarbon pump stations, near filters, control valves and pig traps for cross-country pipelines
- Near all potential leak sources of class A & B petroleum products e.g. tank dykes, tank manifolds, pumps, Pump house manifold etc in offsite facilities/ terminals.
- Cryogenic (i.e. LNG etc) tanks and pumps (near all potential leak sources)
- Offshore drilling and production facility and Jetty

Hydrogen (H2) Detector Typical Location

- Around Hydrogen compressors
- PSA section
- Piping manifold
- Around vessel / Reactor containing Hydrogen
- Hydrogen containing surge drum
- Near flange of Equipment in partially covered Technical Structure
- Hydrogen Detectors shall be located at the top of release source as it is lighter than air.

H2S Detector Typical Location

- Around pumps handling H2S content fluid capable of producing Threshold Limit Value (TLV) on release
- Piping manifold and HP let down control valves having probable potential for leak
- Around compressor handling H2S rich gas
- Around KOD/ surge drum containing H2S rich gas
- Near Sulfur pit in SRU
- In SRU Near Reaction Furnace ,Sulfur condenser, Amine Regenerator ,Overhead/Air Fin cooler Platform, SWS Day Tank, SWS Stripper overhead, Sulfur seal Pot

General Guidelines for Installation of Gas Detectors

Process Unit/ Intermediate Pump and Compressor Station of cross-country pipelines.

Pumps

Detectors shall be installed near each pump close to the pump seal in such a manner that it should cover entire periphery of same group of pumps. Location of HC /H2S detectors shall be downstream of prevailing wind direction.

Air coolers

Detectors shall be installed at the top of each tube bundle in such a manner that it should cover entire periphery of same group of air coolers, clustering most of the HC detectors downstream of prevailing wind direction.

General Guidelines for Installation of Gas Detectors

Vessels & Drums:

Detectors shall be installed around Reflux Drums and Vessels.The location of the detectors should be near maximum nozzles on the vessel. The factor of prevailing wind direction should also take in to consideration. HC detectors shall also be located near Fuel Gas/flare KOD.

Compressor House:

Detectors shall be installed near flange, close to the seal and Instrument fittings inside compressor house in such a manner that it should cover entire house area. -3 detectors shall be installed for every compressor based on the size and number of stages. KOD in every stage is also to be provided with 1 detector

General Guidelines for Installation of Gas Detectors

Reactors & Columns

Detectors shall be installed near inlet/outlet flange

Battery Limit & Sampling Points

Detectors shall be installed at B/L covering entire periphery and near Sour Service/ Class A Hydrocarbon sampling points, vents/drains etc.

Exchangers

Detectors shall be installed at exchanger flanges handling H2S rich/ Aromatics Rich (considerable amount of Benzene/Toluene/ Xylene) hydrocarbon.

General Guidelines for Installation of Gas Detectors

Furnace

HC detectors at inlet of FD/ID fans for combustion air (whichever applicable),around Fired heater fuel gas piping manifold (near PV, SDV on fuel gas header)

Sulphur Pit

H2S Detectors shall be installed near Sulphur Pit in such a manner that it should cover entire periphery of pit, clustering most of the HC detectors downstream of prevailing wind direction

General Guidelines for Installation of Gas Detectors

Offsite Storage &Tank Farm, Road &Wagon loading Facilities

The following HC Gas detectors shall be provided for class A products storage and transfer but not limited to

- One number HC Detector at Piping manifold outside the dyke
- One number near each Pump

General Guidelines for Installation of Gas Detectors

LPG Mounded Bullet

Gas detectors shall be provided at all critical location of Mounded Storage.

- One near each ROV
- One near each Dome
- One near manhole cover
- One in Inspection tunnel
- One Water Draining point
- One each sample Point

General Guidelines for Installation of Gas Detectors

LPG Storage Area and Transfer and Loading/Unloading Area

Suitable gas detectors shall be placed at critical locations in the LPG storage and Transfer area. Such as near the ROVs, in inspection tunnel, inside the nozzle box enclosure or dome connection, near water draining/ sampling points

- One detector per sphere on the top
- One detector per ROV connected to the sphere (liquid in/out, vapour balance)
- One detector near the outlet of combined water draining location
- One detector per pump/compressor

General Guidelines for Installation of Gas Detectors

LPG Storage Area and Transfer and Loading/Unloading Area

- One detector near the outlet of combined water draining location
- One detector at each bay of Tank truck gantry
- One detector for every two bays or 30 m whichever is less at bottom for Wagon gantry
- Some detectors at suitable locations at top of the platform
- Two numbers for Filled cylinder shed
- one number for Valve change shed
- Two numbers near carousel , one number near evacuation unit tank, one number in weight correction unit of Empty-cum-filling shed

General Guidelines for Installation of Gas Detectors

Cryogenic LNG Terminal/Re-gasification

Gas detectors shall be provided at all critical locations of LNG Installation

- 1 no. near every flange of Ring main
- 1 no. near each flange on Top of Tank viz., Pumps, PSV,VSV,FE (App 10 nos.

  for each tank)
- 1 No. near De-super heater Nozzle
- 2 nos. at BOG Compressor top

General Guidelines for Installation of Gas Detectors

Cryogenic LNG Terminal/Re-gasification

Gas detectors shall be provided at all critical locations of LNG Installation

- Near flanges of BOG compressor inlet and outlet
- 1 no. near each FE Flanges
- 1 No near each Inlet and outlet Nozzle of Re-condensers
- 1 No. near each Inlet &Outlet Flange of LNG Send out Pumps
- 1 no. near each Vaporizer Nozzle Flanges
- 2 nos. in each Metering Piping Manifold
- 1 no covering Pipe rack area covering each Control Valve
- 1 no. in Ventilation each Air Intake

DETECTOR VOTING

- Detector voting is one method of ensuring that fire or gas detector configurations are robust against failure and robust against spurious alarms.
- Detector voting may not be required; for example, where detectors or detector systems themselves are robust, or where appropriate actions are taken by experienced operators.
- 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 become more complex.
- For all areas where detector voting is applied, there shall be a minimum of 3 detectors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