Fire and Gas Detection - Design Requirements

Owning entity: STS/HSE/RM
Managing entity: STS/HSE/RM
Other approving entity(ies):

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## Contents

1. **Purpose** .................................................................................................................... 4

2. **Scope of Application** ............................................................................................... 4

3. **Reference Documents** ............................................................................................ 4

4. **Terms and Definitions** ............................................................................................. 6

5. **Fire & Gas Detection Principles** ............................................................................. 9
   5.1 Objectives .................................................................................................................. 9
   5.2 Fire & Gas Detection Concept .................................................................................. 9

6. **Installation and Design Requirements** ................................................................ 10
   6.1 Environment and Design Requirements ................................................................. 10
   6.2 Area Classification and Electrical Certification ...................................................... 10
   6.3 Safety Integrity Level (SIL) Certification ................................................................ 10
   6.4 Addressable Type Detection Systems ...................................................................... 10
   6.5 Fire and Gas Function Response Time ..................................................................... 11

7. **Selection and Location of F&G Detectors** ........................................................... 11
   7.1 Selection and Location of Fire Detectors ................................................................. 12
   7.2 Selection and Location of Gas Detectors ................................................................. 21

8. **3D Fire & Gas Detectors Mapping Study** ............................................................. 35
   8.1 Generalities ................................................................................................................ 35
   8.2 Coverage Review and Potential Optimisation ......................................................... 36
   8.3 Detection Performance Criteria .............................................................................. 36

9. **Detection Logic Principle** ..................................................................................... 37
   9.1 Detection Logic Matrix ............................................................................................ 37
   9.2 Detection Logic for E&P Installations ....................................................................... 37
   9.3 Detection Logic for RC & MS Installations ............................................................ 41
   9.4 F&G Human-Machine Interface (HMI) .................................................................. 42

10. **Typical Actions Upon F&G Detection for E&P Installations** .............................. 43
    10.1 Process Areas / Open Areas .................................................................................. 43
    10.2 Buildings ................................................................................................................ 44

11. **Manual Alarm System for E&P Installations** ....................................................... 45

12. **Documentation** ..................................................................................................... 45
    12.1 F&G Layouts and 3-D Model ................................................................................. 45
    12.2 F&G Causes and Effects Matrix ............................................................................ 45

13. **Bibliography** ......................................................................................................... 46

**Appendix 1. Example of a Causes and Effects Matrix** .............................................. 47

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Appendix 2. Guidelines for Fusible-Plug Selection and Installation (E&P Installations) ...............................................................48
1. Purpose

The purpose of this General Specification (GS) is to define the requirements governing the design, selection, siting and executive actions of the Fire and Gas (F&G) Detection System.

The philosophy for F&G detection is to detect a potentially flammable, explosive, or toxic gas concentration resulting from a leak, or to detect a fire as quickly as possible, locate it, and initiate appropriate actions.

2. Scope of Application

This GS is applicable to onshore and offshore oil and gas production and processing facilities including jetties and technical building or accommodations which are part of the facility.

It does not apply to:
- Network activities;
- Client installations (including mining facilities and LNG satellite plants);
- Transport means;
- Pipelines and pipelines stations.

For particular requirements dedicated to:
- Manned building, refer to GS-GR-HSE-302;
- F(P)SO installations, refer to GS-GR-HSE-319;
- LNG onshore facilities, refer to GS-GR-HSE-320;
- Packages and enclosed rotating equipment refer to GS-GR-HSE-316.

This specification is limited to highlight HSE requirements and does not cover:
- Technical characteristics details;
- Details of F&G System description;
- Test / Control / Maintenance.

These topics listed above are covered by instrumentation general specifications, refer to GS EP INS 134, GS EP INS 143, GS EP INS 198, GS MS INS 012 and GS RC INS 550.

Unless otherwise specified, requirements specific to E&P branch are also applicable to GRP/LNG facilities (ships excluded).

3. Reference Documents

The reference documents listed below form an integral part of this GS.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>API RP 14C</td>
<td>Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms</td>
</tr>
</tbody>
</table>
### Fire and Gas Detection - Design Requirements

**TotalEnergies General Specifications**

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

**Company HSE**

Any reference to a Company HSE General Specification (i.e. a GS-GR-HSE) is applicable to all Branches unless otherwise stipulated.

#### Reference

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>API RP 2216</td>
<td>Ignition Risk of Hydrocarbon Liquids and Vapors by Hot Surfaces in the Open Air</td>
</tr>
<tr>
<td>API RP 505</td>
<td>Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2</td>
</tr>
<tr>
<td>NFPA 30</td>
<td>Flammable and Combustible Liquids Code</td>
</tr>
<tr>
<td>IEC 61511</td>
<td>Functional Safety - Safety Instrumented Systems for the process industry sector</td>
</tr>
<tr>
<td>ISO 7240</td>
<td>Fire Detection and Alarm Systems</td>
</tr>
<tr>
<td>ISO 13702</td>
<td>Petroleum and Natural Gas Industries - Control and Mitigation of fires and explosion - Requirements and Guidelines</td>
</tr>
<tr>
<td>NFPA 72</td>
<td>National Fire Alarm Code</td>
</tr>
<tr>
<td>UK HSE</td>
<td>UK Health and Safety Executive Research Report 1123</td>
</tr>
<tr>
<td>UK HSE</td>
<td>UK Health and Safety Executive Offshore Technology Report - OTO 93002</td>
</tr>
<tr>
<td>UN GHS</td>
<td>United Nations- Globally Harmonized System of Classification and Labelling of Chemicals (GHS)</td>
</tr>
</tbody>
</table>

#### GS-GR-HSE-301

- Layout Principles

#### GS-GR-HSE-302

- Safety Requirements for Buildings

#### GS-GR-HSE-304

- Emergency Shutdown and Emergency Depressurisation (ESD & EDP)

#### GS-GR-HSE-306

- Safety Integrity Level (SIL) Assignment

#### GS-GR-HSE-309

- Flammable and Combustible Liquid Storages and loading/unloading facilities

#### GS-GR-HSE-313

- Liquefied Hydrocarbon Storage and Loading / Unloading facilities

#### GS-GR-HSE-316

- Safety Rules for enclosed rotating equipment

#### GS-GR-HSE-319

- Safety Engineering Requirements for an F(P)SO

#### GS-GR-HSE-320

- Safety Engineering Requirements for onshore LNG facilities
Branch non-HSE

Any reference to a Branch-specific General Specification from another métier (i.e. non-HSE) is only applicable to that specific Branch unless stated otherwise.

E&P Branch

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS EP INS 134</td>
<td>Design and Supply of Integrated, Control and Safety Systems</td>
</tr>
<tr>
<td>GS EP INS 143</td>
<td>Fire and Gas detectors and associated detection systems</td>
</tr>
<tr>
<td>GS EP INS 198</td>
<td>Safety and Fire &amp; Gas Standard Functions</td>
</tr>
<tr>
<td>GS EP MEC 051</td>
<td>Fire and Gas System and Fire Extinguishing System for Packaged Rotating Machinery Enclosures</td>
</tr>
</tbody>
</table>

RC Branch

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS RC INS 550</td>
<td>Fire &amp; Gas Safety Instrumented System for petroleum and petrochemical units</td>
</tr>
<tr>
<td>GS RC INS 552</td>
<td>Flammable Gas, H₂, H₂S and O₂ deficiency fixed Gas Detector</td>
</tr>
</tbody>
</table>

MS Branch

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS MS INS 012</td>
<td>Fire &amp; Hydrocarbon detection systems</td>
</tr>
<tr>
<td>GS MS INS 401</td>
<td>Flammable gas, H₂, H₂S and O₂ deficiency fixed gas detectors</td>
</tr>
</tbody>
</table>

4. Terms and Definitions

There are four types of statements in this specification, the “shall”, “should”, “may” and “can” statements. They are to be understood as follows:

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shall</td>
<td>Is to be understood as mandatory (i.e. a requirement). Deviating from a “shall” statement requires derogation approved by Company.</td>
</tr>
<tr>
<td>Should</td>
<td>Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide a similar level of protection and this shall be documented.</td>
</tr>
<tr>
<td>May</td>
<td>Is to be understood as permission.</td>
</tr>
<tr>
<td>Can</td>
<td>Is to be understood as a physical possibility.</td>
</tr>
</tbody>
</table>

Note that “will” is not to be understood as a statement. Its use is to be avoided, unless it is necessary to describe a sequence of events.

For the purpose of this specification, the following definitions apply:

<p>| Addressable detectors | A detector that can be individually identified at the Control and Indicating Equipment. |</p>
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoIgnition Temperature (AIT)</td>
<td>The lowest temperature of a heated surface that, under specified conditions, will ignite a flammable substance in the form of a gas or vapor mixture with air. (API RP 505)</td>
</tr>
<tr>
<td>BPCS</td>
<td>Basic Process Control System as per Standard IEC 61511</td>
</tr>
<tr>
<td>CCR</td>
<td>Central Control Room</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit TeleVision</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
</tr>
</tbody>
</table>
| Combustible Liquid | Any liquid that has a closed-cup flash point at or above 100°F (37.8°C), as determined by the test procedures and apparatus set forth in NFPA 30. Combustible liquids are classified as Class II or Class III as follows:  
  1. Class II Liquid - any liquid that has a flash point at or above 100°F (37.8°C) and below 140°F (60°C);  
  2. Class IIIA - any liquid that has a flash point at or above 140°F (60°C), but below 200°F (93°C);  
  3. Class IIIB - any liquid that has a flash point at or above 200°F (93°C). |
| ESD | Emergency Shut Down |
| F&G | Fire and Gas |
| Flammable Gas | A gas having a flammable range with air at 20°C and a standard pressure of 101.3 kPa. (ref. UN GHS) |
| Flammable liquid | Have flash points below 100°F (37.8°C), and vapor pressures not exceeding 40 psia (2068.6 mm Hg) at 100°F (37.8°C). (NFPA 30) As per NFPA 30, flammable liquids are classified as follows:  
  1. Liquid having a flash point below 73°F (22.8°C) and:  
     - Fluid class IA: Atmospheric boiling point below 100°F (37.8°C);  
     - Fluid class IB: Atmospheric boiling point above 100°F (37.8°C).  
  2. Fluid class IC: Liquid having a flash point at or above 73°F (22.8°C) and below 100°F (37.8°C). |
| Flash point | The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitable mixture with air, near the surface of the liquid or within the vessel used, as determined by the test procedure and apparatus specified in NFPA 30. |
| FGA | Fire & Gas Area  
Each escalation zone is segregated into several FGA. FGAs shall be physically limited by active or passive fire protection such as fire rated and or blast rated walls, bulkheads or decks, dedicated protection systems and areas that will be segregated for the facilitation of fire and/or gas detection cause and effect logic implementation. |
| FGS | Fire & Gas System (F&G Safety Instrumented System) |
| HAC | Hazardous Area Classification |
| HC | HydroCarbon |
HF  Hydrogen Fluoride
HMI  Human Machine Interface
HSSD  High Sensitivity Smoke Detector
HVAC  Heating, Ventilation and Air Conditioning
ICSS  Instrumented Control and Safety System which includes the ESD system, PSS, FGS and PCS
IMO  International Maritime Organisation
IR  InfraRed (detector)
Liquified Flammable gas  A liquid which has a saturated vapor pressure exceeding 2.8 bar absolute at 37.8°C formed by refrigeration, pressurisation, or a combination of both and certain other substances of similar characteristics specified in the IMO Gas Code.
LNG  Liquefied Natural Gas
Lower Flammability Limit (LFL)  Lower concentration of gas (by volume and expressed in percentage) in a gas air mixture that will form an ignitable mixture (based on API RP 505).
LPG  Liquefied Petroleum Gas
LQ  Living Quarters
MAC  Manual Alarm Call (point)
Minimum Installation  Installations handling oil and gas for production or transfer purposes, with no processing facilities. Offshore, they correspond to satellite wellhead and/or manifold platforms which are not bridged to a process installation. Onshore, they correspond to remote (stand-alone) wellhead and/or production manifold clusters. A minimum installation may include helideck, (dry) firewater network, electrical cabin, vent with associated Knock-Out drum, etc. Test separators and pig traps are not considered as processing facilities. Wellhead platforms or clusters with Free Water Knock-Out drums or water degassing drums or gas-lift compressors are not considered as minimum installations.
MIR  Multi-frequency Infrared Flame Detector
PAGA  Public Address General Alarm
PCS  Process Control System
PLC  Programmable Logic Controller
PT  Pressure Transmitter
Not permanently manned installation  Stand-alone offshore or onshore installation on which personnel can be present, but less than 12 hours per day or less than 42 hours per week. (Company concept)
Permanently manned installation  Installation on which people are routinely accommodated or which is continuously occupied during normal operation. (ISO 13702 and Company)
5. Fire & Gas Detection Principles

5.1 Objectives

The objectives of the F&G System are:

- To protect personnel, the environment and the asset,
- To detect hazardous releases or fire at an early stage of their development,
- To provide information to operators to allow them to react before escalation to an emergency situation, and where required,
- To initiate the safety shutdown system and active fire protection.

5.2 Fire & Gas Detection Concept

The need for F&G detection Systems shall be based on product risks and characteristics.

An integrated Fire and Gas System (FGS) shall be designed in order to meet the following safety goals:

- To continuously monitor all areas of the installation where either a fire hazard can exist or an accumulation of flammable or toxic gas can occur from initiation of a leak to gas cloud migration and in particular:
  - To provide an early detection of flammable gas HydroCarbon (HC), Hydrogen (H₂), asphyxiant gases (CO, etc) and toxic gas (H₂S, NH₃, Cl₂ etc) leakage;
  - To provide an early detection of fire via heat, flame or smoke detectors;
- To alert, through Public Address General Alarm (PAGA) system, personnel of the detected hazard by means of visual and audible alarm;
- To initiate manual and/or remedial actions to avoid escalation of hazardous event (e.g. Emergency ShutDown (ESD) system, activation of fire protection systems, closure of air dampers);
- To monitor all F&G detectors.

Detection means shall then include:

- Loss of containment detection:
  - Flammable gas detection;
  - Hydrogen gas detection;
  - Toxic and/ or asphyxiant gas detection;
  - Oxygen depletion detection;
  - Oil mist detection;
  - Ultrasonic gas leak detection.
- Fire detection:
  - Flame detection;
  - Heat detection;
  - Smoke detection;
- Manual call points.

<table>
<thead>
<tr>
<th>SIF</th>
<th>Safety Instrumented Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIL</td>
<td>Safety Integrity Level</td>
</tr>
<tr>
<td>T₉₀</td>
<td>Time interval between the moment when it is subject to a gaseous atmosphere and the moment when the indication reaches 90% of the final indication.</td>
</tr>
</tbody>
</table>
6. Installation and Design Requirements

6.1 Environment and Design Requirements

Range of operability of F&G detectors shall be in line with the environmental and climatic conditions (e.g. temperature, humidity).

To prevent malfunction of F&G detectors, protective measures shall be installed such as sunshade on sensors in case of excess of temperature or solar radiation, tracing in case of arctic conditions, tight weather protection for rain etc.

Where necessary, detectors shall be protected against mechanical damage.

6.2 Area Classification and Electrical Certification

F&G detectors shall comply with the requirements of the Hazardous Area Classification (HAC) they are installed in.

However, F&G detectors located outdoors shall be certified for use in Zone 2 as a minimum.

Whereas F&G detectors located indoors may be non-Ex rated when non ATEX classified.

Specific Requirements for E&P installations:

All F&G detectors whether located outdoors, within airlocks, or air intakes of buildings located within the restricted area shall be certified for use in Zone 1, gas group IIA, temperature Class T3 as a minimum. In any case, gas detectors, even if located indoors, shall be certified for use in Zone 1, IIA, T3 as a minimum.

6.3 Safety Integrity Level (SIL) Certification

The architecture and detectors shall comply with safety requirements defined in the risk analyses, particularly with regards to the Safety Integrity Level (SIL).

In any case, the FGS shall be at least equivalent to SIL1 and the F&G sensors shall be at least SIL2, except fire detectors located indoor.

Specific Requirements for E&P installations:

The FGS logic solver shall be SIL3 certified.

F&G detectors, as they are part of a Safety Instrumented Function (SIF), shall be certified suitable for SIL2 applications.

Except fire detectors located indoors (rotating machine enclosures excluded) which shall be SIL1 rated minimum.

6.4 Addressable Type Detection Systems

All executive actions shall be performed by F&G detectors directly connected to the FGS.

Addressable fire detection system may be installed in buildings with restrictions specified in GS EP INS 134 / GS RC INS 550.

Refer to GS-GR-HSE-316, for addressability requirements dedicated to enclosed rotating equipment.
Specific Requirements for E&P installations:
Addressable fire detectors shall be interfaced with the FGS, which further controls executive actions (refer to GS EP INS 134).

Only non-addressable type detectors/systems shall be used for automatic executive actions by the main FGS / ESD systems.

Therefore, fire detected by an addressable type system shall be interfaced with the main FGS / ESD systems, which further controls executive actions (refer to GS EP INS 134).

As per GS EP INS 134, addressable type detectors/systems comprise of a network of addressable smoke, heat and Manual Alarm Call (MAC) point loops reporting back to a central control unit which shall only be used for fire detection in residential / administrative building (e.g Living Quarters (LQ) or a technical building inside residential buildings).

The addressable system shall then be certified SIL2.

Addressable type systems shall have their own dedicated operator panel and be connected to the Process Control System (PCS) for alarm announcement on the Central Control Room (CCR) operator workstations, and for event recording (via redundant serial communication link).

It shall not compromise reliability and availability.

In case of floating production facilities for which the International Maritime Organisation (IMO) classification rules stipulate the installation of an addressable fire detection system in any room part of the LQ, then an additional certification by the applicable IMO classification body shall be provided.

6.5 Fire and Gas Function Response Time
Automatic actions shall be compatible with the development kinetics of the studied incident.

Therefore, response times of detectors, logic solvers and final elements shall be assessed.

The minimum performances expected from gas detectors (i.e T₅₀, T₉₀) are defined in instrumentation general specifications (refer to GS RC INS 550, GS RC INS 552, GS EP INS 143, GS MS INS 012, GS MS INS 401).

7. Selection and Location of F&G Detectors
The type, number, and the location of F&G detectors shall be assessed based on the following criteria:

• Potential leak sources and their direction;
• Characteristic phenomena of combustion and its kinetics;
• Type of product release (e.g. toxicity and/or flammability);
• Type of gas to be detected (i.e. heavier or lighter than air);
• Ignition risks;
• Vulnerability of the environment (potential impact of population);
• Installation manned or unmanned;
• Direction of the prevailing winds;
• Topography of the site.

In addition, the F&G detection philosophy shall be formalised within the Safety Concept or the dedicated project F&G detection philosophy based on this GS.
For the risks not identified (i.e. product not listed in this GS), associated F&G detection shall be further investigated with Company approval.

A 3-Dimensions (3-D) F&G detectors mapping study may be performed during detailed engineering phases in order to validate the number and location of F&G detectors (refer to chapter 8).

7.1 Selection and Location of Fire Detectors

7.1.1 Fire Detectors Location

As a general rule, when locating fire detectors, the following points shall be assessed to ensure that detection is effective:

- The type of fire to track (e.g. HC, Methanol or H₂);
- The zone / equipment to be monitored;
- Location of release sources;
- Congestion (e.g. obstacles).

For specific requirements refer to Tables 1 and 2.

7.1.1.1 Multi Infra-Red (MIR) Flame Detectors

When locating flame detectors, the following points shall be followed, taking into account the fact that flame detectors are “field of view” devices:

- As a preliminary approach, a 15 m maximum distance will be used from the detector;
- Location of flame detector will take into account potential obstacles and shadow effects in the zone to be covered.
- Flame detectors will be sited so that their vision cones (i.e. field view; 90°) cover areas where fire can occur;
- Radiation from the flare system / sunlight / workshop (welding activities).

7.1.1.2 Optical Smoke Detectors

When locating smoke detectors inside buildings, the following criteria shall be followed:

- Location of Heating, Ventilation & Air Conditioning (HVAC) air intake (ventilation flow patterns) are as per NFPA 72;
- For rooms detection refer to Table 3.

7.1.1.3 Heat Sensitive Cables

For heat sensitive cables the following points shall be implemented:

- Heat sensitive cables selected as per the Table 1 below.
- Heat sensitive cables will not be used in ambient temperature above 100°C.
- A minimum of +11°C between maximum normal ambient and minimum alarm temperature will be ensured in order to avoid any potential false alarm conditions.
- Care will be taken during installation, avoiding compressed areas for example that could lead to cable damage.

Heat sensitive cable could be recommended if classic flame detectors cannot be used because of very cold temperature (ex: Arctic region).
7.1.1.4 Point Heat Detectors

Point heat detectors shall be selected as per the table 1 below.

7.1.2 Fire Detectors Selection

Fire detectors shall be selected as per Table 1 below.

The following represents the minimum requirements in terms of fire detection to be applied. In the absence of requirements on a specific topic in the below table from the relevant branch of the project, then similar requirements from another branch shall be used. Similar approach applies for GRP branch, with due consideration on the section 2 - Scope of Application.
### Table 1 - Selection and Implementation of Fire Detectors

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process areas / wellheads areas (manned installations)</td>
<td>E&amp;P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Can be used to supplement flame detection. Mandatory for methanol fires. Pressure detection (i.e. use of Pressure Transmitter (PT)) installed in a 2oo3 voting configuration is required for ESD-1 level executive actions. Fusible plugs can be used at both ends of slug catcher. (2) MIR flame detectors shall be used. (3) Can be used in complement or replacement of MIR flame detectors upon Company’s Approval. (4) Can be used as a complement to other type of flame detection above wellheads. For alarm only. (5) To monitor process areas + gas compressors + equipment handling flammable liquids or combustible liquids with temperature above their flash point + metering skid + above impounding basins + flanges of fuel gas lines feeding gas turbines in utility areas + slug catcher (both ends). (6): - To monitor rotating equipment handling flammable gas or liquids with temperature above their AIT. - Fire detectors shall be installed if hot surfaces (Top&gt;AIT) are identified during risk analysis (example HP steam with T &gt; AIT + Delta T (according to API RP 2216). - Fire detectors shall be installed where streams</td>
</tr>
<tr>
<td></td>
<td>RC</td>
<td>(1)</td>
<td>(4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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<td></td>
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<td>(7)</td>
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<td></td>
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</tr>
</tbody>
</table>

(M1 to M8) Choice shall be done between these types of detectors. (1) Can be used to supplement flame detection. Mandatory for methanol fires. Pressure detection (i.e. use of Pressure Transmitter (PT)) installed in a 2oo3 voting configuration is required for ESD-1 level executive actions. Fusible plugs can be used at both ends of slug catcher. (2) MIR flame detectors shall be used. (3) Can be used in complement or replacement of MIR flame detectors upon Company’s Approval. (4) Can be used as a complement to other type of flame detection above wellheads. For alarm only. (5) To monitor process areas + gas compressors + equipment handling flammable liquids or combustible liquids with temperature above their flash point + metering skid + above impounding basins + flanges of fuel gas lines feeding gas turbines in utility areas + slug catcher (both ends). (6): - To monitor rotating equipment handling flammable gas or liquids with temperature above their AIT. - Fire detectors shall be installed if hot surfaces (Top>AIT) are identified during risk analysis (example HP steam with T > AIT + Delta T (according to API RP 2216). - Fire detectors shall be installed where streams |
### Areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process areas / wellheads areas (Remote or unmanned installations)</td>
<td>E&amp;P</td>
<td>(1) X (2, 3, 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Can be used to supplement flame detection. Mandatory for methanol fires. Pressure detection installed in a 2oo3 voting configuration is required for ESD-1 level executive actions. Can be connected to a nitrogen rack bottles. (2) MIR flame detectors shall be used. (3) To monitor process areas + equipment handling flammable liquids or combustible liquids with temperature above their flash point + metering skid. (4) shall not be installed on minimum installation (refer to definition in section 4) providing fusible plug detection is installed and Company’s approval.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>For special fluids refer to RC philosophy.</td>
</tr>
<tr>
<td></td>
<td>RC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not applicable</td>
</tr>
<tr>
<td>Cryogenic product (e.g. LNG) Storage &amp; handling areas and jetty</td>
<td>E&amp;P / RC / MS</td>
<td>(3) X (1, 2, 5) X (4, 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) MIR flame detectors shall be used. (2) For LNG tanks: To cover manifolds and pumps on top of tanks + valves at bottom. (3) To supplement flame detection. (4) For EP, upon Company’s Approval. (5) For RC and MS: choice between M4 or M5. For more details, refer to GS-GR-HSE-320.</td>
</tr>
</tbody>
</table>
## LPG Storage & handling areas and LPG jetty

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E&amp;P / RC / MS</td>
<td>(3)</td>
<td></td>
<td></td>
<td>X (1, 2, 5)</td>
<td>X (4, 5)</td>
<td></td>
<td></td>
<td></td>
<td>(1) MIR flame detectors shall be used.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2) For LPG storages: To cover manifolds, associated pumps and tanks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3) To supplement flame detection.</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4) For EP, upon Company’s Approval.</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5) For RC and MS: choice between M4 or M5.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>For more details, refer to GS-GR-HSE-313.</td>
</tr>
</tbody>
</table>

## Flammable liquid Hydrocarbons Storage & handling areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>E&amp;P</td>
<td>X (1, 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Shall only be used as a complementary detection to conventional fire detectors in a voting configuration for automatic executive action, but not entirely replace them. May be used for alarm only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2) MIR flame detectors shall be used.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3) Can be used in complement or replacement of MIR flame detectors upon Company’s approval.</td>
</tr>
<tr>
<td></td>
<td>RC</td>
<td>X (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(4) For bunds area. Flame detectors shall be used to monitor valves at tank bottom within bund for product class I and II (if Tstorage ≥ flash point).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5) To be installed on rim on external floating roof.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(6) To be installed for tank double wall annular space.</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(7) For pumps area with product class I and product class II*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*Pressurized Class II (P &gt; 20 b) product can create an aerosol in the event of a leak (stabilized product only).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(8) For pumps stations for flammable liquids class IB/IC (FP &lt; 37.8°C) without permanent visual during pumps operations.</td>
</tr>
</tbody>
</table>

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## Fire and Gas Detection - Design Requirements

**Company General Specification**

**GS-GR-HSE-314**

### Areas

<table>
<thead>
<tr>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG process train + LNG jetty</td>
<td>E&amp;P</td>
<td>(2)</td>
<td>X</td>
<td>(1, 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(9) To monitor valves in bunds area. For more details, refer to GS-GR-HSE-309.</td>
</tr>
<tr>
<td>RC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not applicable</td>
</tr>
<tr>
<td>Truck/Rail/Sea loading &amp; unloading station</td>
<td>TRS</td>
<td></td>
<td>X</td>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) One flame detector shall be located at the bottom of the arm. For more information, refer to GS-GR-HSE-309.</td>
</tr>
<tr>
<td>Enclosed spaces / rooms containing hydrocarbons</td>
<td>E&amp;P / RC / MS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>(2, 3)</td>
<td>X</td>
<td>(3)</td>
<td>(1) In ambient and raised floors. (2) Thermostatic heat detectors type. (3) A mix of flame and heat detectors shall be specified in case of extinguishing system activation.</td>
<td></td>
</tr>
<tr>
<td>Packaged Rotating Machinery Enclosures (i.e. diesel engine, gas turbine enclosures etc.)</td>
<td>E&amp;P / RC</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) Rate of rise or thermostatic heat detectors. Minimum of 2 inside an enclosure. (2) MIR or Ultraviolet UV/IR. 2 minimum inside enclosure. (3) A mix of flame and heat detectors shall be specified in case of extinguishing system activation. For more details, refer to GS-GR-HSE-316.</td>
</tr>
</tbody>
</table>
# Fire and Gas Detection - Design Requirements

**Areas** | **Branch** | **M1** | **M2** | **M3** | **M4** | **M5** | **M6** | **M7** | **M8** | **Comment**
--- | --- | --- | --- | --- | --- | --- | --- | --- | --- | ---
Workshop (without flammable product stored) | E&P / RC / MS | X | (1) | | | | | | | Not applicable

- (1) Rate of rise heat or thermostatic detectors type.
- (2) Only if workshop is an artificially ventilated area and in raised floors only.

HVAC Room | E&P / RC | X | (1) | | | X | (2) | | (1) Thermostatic heat detectors type. (2) When required by CLASS rules, in addition to heat detectors (floating installations).

Warehouse (without flammable / combustible liquid stored) | E&P / RC / MS | | (3) | | | X | (1) | (1, 2) | | (1) Only if Warehouse is an artificially ventilated area. In ambient and raised floors. (2) May be used to replace point smoke detectors. (3) May be used for alarm only if no smoke detectors are provided.

- (1) To install for combustible products. (2) May be used to replace point smoke detectors. (3) To install for flammable products. (4) For storage area with a ceiling higher than 9 m, early smoke detection shall be installed.

Warehouse (with flammable / combustible liquid stored) | RC / MS | X | (3) | X | (1) | | (2) | (4) | | (1) 3 smoke detectors in building air intake. (2) In ambient and floor voids. (3) For large rooms only. May replace point smoke detectors if deemed too many. (4) Point High Sensitivity Smoke Detectors (H SSD) are preferred over air-aspirating type. In electrical rooms / E&I buildings | E&P / RC / MS | | (5) | | | X | (1, 2) | (3) | (4) |
## Areas

<table>
<thead>
<tr>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Room</td>
<td>E&amp;P</td>
<td>X</td>
<td>Fusible plugs</td>
<td>Heat sensitive cables</td>
<td>Flame detectors</td>
<td>Imaging based flame detection</td>
<td>Point smoke detectors</td>
<td>Linear smoke detectors</td>
<td>Early warning smoke detection</td>
</tr>
<tr>
<td>E&amp;P</td>
<td>X (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Instrumentation rooms + within critical cabinets. Not to be used for executive actions except for initiation of active fire protection system with use of point HSSD. (5) Can be used inside switchboard (busbar).</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E&amp;P</td>
<td>X (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) 3 non addressable type smoke detectors.</td>
</tr>
<tr>
<td>RC</td>
<td>X (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) 3 Rate of rise Heat detectors. (2) UV/IR flame detectors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabin crane</td>
<td>E&amp;P</td>
<td>X (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) One smoke detector, for alarm only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analyzer Shelter (enclosed area)</td>
<td>E&amp;P</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not applicable</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformers</td>
<td>E&amp;P/MS</td>
<td>X</td>
<td>(1)</td>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) One thermostatic heat detector above each transformer (oil immersed transformer). For large transformers, additional heat detectors shall be provided. (2) Only if transformer is deluged and if pneumatic fusible plug is connected to deluge system in replacement of heat detectors upon Company approval.</td>
</tr>
<tr>
<td>RC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RC will apply the local regulation.</td>
</tr>
<tr>
<td>Temporary refuge</td>
<td>E&amp;P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>(1, 2)</td>
<td></td>
<td>(1) Only within building if artificially ventilated area. In ambient and raised floors, if any. (2) 3 non addressable smoke detectors in ventilation air intake.</td>
</tr>
<tr>
<td>Living Quarters (LQ) /</td>
<td>E&amp;P/RC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>(1, 2)</td>
<td></td>
<td>(1) 3 non addressable smoke detectors at LQ and/or administration buildings air inlet. (2) In all rooms (ambient). For E&amp;P branch, smoke detectors shall also be installed in floors voids. (3) to be assessed on a case by case basis.</td>
</tr>
<tr>
<td>Administration buildings / Offices / Archives / Storeroom</td>
<td></td>
<td>(3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

X: Type of detection mandatory where flammable / combustible product identified.

☐ Type of detection allowed if the need arises

☐ Not applicable

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Page 20/48
The following tables show the recommended location and spacing for both heat and smoke detectors which shall be validated according to Vendors specifications.

**Table 2 - Siting of heat point detectors (Company Concept)**

<table>
<thead>
<tr>
<th>Detectors placed in naturally ventilated open spaces</th>
<th>Maximum Ground Area Covered by a Detector</th>
<th>Maximum Distance Between Detectors</th>
<th>Distance from a Continuous Obstruction (wall, etc.)</th>
<th>Maximum Height Above the Potential Hazard Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 m²</td>
<td>5 m</td>
<td>Min: 0.5 m - max: 2.5 m</td>
<td>4.5 m</td>
</tr>
<tr>
<td>Detectors placed in mechanically ventilated closed spaces (air change rate &lt; 12)</td>
<td>20 m²</td>
<td>6 m</td>
<td>Min: 0.5 m - max: 3 m</td>
<td>5 m</td>
</tr>
</tbody>
</table>

**Table 3 - Siting of smoke detectors (Company Concept)**

<table>
<thead>
<tr>
<th>Maximum ground area covered by a detector</th>
<th>Maximum Distance Between Detectors</th>
<th>Maximum Distance from Continuous Obstructions (wall, etc.)</th>
<th>Maximum Height Above the Potential Hazard Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 m²</td>
<td>9 m</td>
<td>Min: 0.5 m - max: 5 m</td>
<td>7.5 m</td>
</tr>
<tr>
<td>20 m² in false floor and false ceiling</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 7.2 Selection and Location of Gas Detectors

#### 7.2.1 Gas Detectors Location

**7.2.1.1 General Principles**

As a general rule, when locating gas detectors, the following points shall be assessed to ensure that detection is effective:

- Product composition phase (liquid/ vapour);
- Operating pressure;
- Density of gas;
- Location of release sources;
- Congestion;
- Potential for accumulation;
- Detection distance away from the release source (detectors close to release sources cannot be as effective as detectors places at a distance away);
- Poisoning materials which can affect the detector technology;
- Area coverage.

**Preliminary Grid Pattern / Location of Flammable and Toxic Gas Detectors for E&P Installations**
As a preliminary approach and pending the results from the 3D F&G Detector mapping study to be performed during basic engineering or in the absence of such study (refer to section 8), the following principles shall be used:

**Table 4 - Flammable Point Detectors spacing target for E&P Installations**
(Based on UK HSE Research Report 1123 for Offshore Installations)

<table>
<thead>
<tr>
<th>Area</th>
<th>Point detectors spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Uncongested Area&quot; (1): Uncongested open volumes with low blockage ratios</td>
<td>≤ 10 m</td>
</tr>
<tr>
<td>Congested Area (2): Large, enclosed or partly enclosed volumes with high ratios</td>
<td>≤ 5 m</td>
</tr>
</tbody>
</table>

Notes:

1. Open area slightly congested without walls (e.g. upper plated deck of modules/ platforms or process onshore trains - LNG trains excluded).
2. Highly congested area with or without walls (e.g. process areas in modules/ platforms).
3. Beam/ open path detectors to be located at edge of platform/ module / process train, when applicable, shall be taken into account for the mapping of point gas detectors to optimise their Grid Pattern / siting.

**Table 5 - Toxic (H₂S) Point Detectors spacing target for E&P Installations**

<table>
<thead>
<tr>
<th>Area</th>
<th>Point detectors spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore Installations (1)(2) (Based on API RP 14C)</td>
<td>≤ 6 m</td>
</tr>
<tr>
<td>Onshore Installations (1)(2) (Company Concept)</td>
<td>≤ 10 m</td>
</tr>
</tbody>
</table>

The Spacing may be optimised based on detailed design analysis (e.g. dispersion modelling).

Toxic (H₂S) gas detectors shall also be installed in vicinity of platform access or module/ zone entrance.

**Preliminary Grid Pattern / Location of Flammable and Toxic Gas Detectors for RC & MS Installations**

Company considers that the risks to and vulnerability of people is lower on onshore sites than on offshore installations, and therefore does not require the same level of Grid Pattern than defined by the [UK HSE](https://www.hse.gov.uk) above. As per Company Concept, the maximum spacing for point detectors shall be as follows:
Table 6 - Flammable and Toxic (H2S) Point Detectors spacing target for RC & MS Installations (Company Concept)

<table>
<thead>
<tr>
<th>Area</th>
<th>Point detectors spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Area</td>
<td>≤ 20 m</td>
</tr>
<tr>
<td>Pumps and Compressors</td>
<td>≤ 10 m</td>
</tr>
<tr>
<td>Storage</td>
<td>≤ 20 m</td>
</tr>
</tbody>
</table>
| Pipeline above ground (6 m high and above) handling flammable and/or H2S product (i.e. piperacks) | Under rack ≤ 30 m  
|                                                           | Radial axe ≤ 20 m |
| Note 1: Based on Company Approval, point gas detectors located in surrounding units can be used to meet the spacing requirements. |
| Note 2: Based on Company Approval, point gas detectors can be replaced by linear detectors and/or by some point gas detectors only located around flanges / valves / manifolds (potential sources of leakage). |
| Pipeline on the ground (i.e. pipeway)                     | ≤ 50 m                  |
| Note: Based on Company Approval, point gas detectors can be replaced by linear detectors and/or by some point gas detectors only located around flanges / valves / manifolds (potential sources of leakage). |

Beam / open path detectors to be located at edge of process unit, when applicable shall be taken into account for the mapping of point gas detectors to optimise their Grid Pattern / siting.

7.2.1.2 Flammable and Toxic Point Gas Detectors

When gas detectors will be installed, the following criteria shall be considered:

- Type of gas to be detected;
- Density of gas: detector is to be positioned under the expected leak source for heavier than air gases and above the expected leak source for lighter than air gases.

A gas or vapour that has a relative density below 1 is regarded as being lighter than air.

H2S detectors shall be provided when H2S concentration is higher than 1000 ppm in the well or process stream. For lower than 1000 ppm concentration within well or process stream, HC gas detectors is deemed sufficient.

When the calibration gas is not the same as the gas to be detected, or when the gas to be detected is chosen among different gas, particular attention shall be provided for the calibration of the sensor and for the choice of the calibration gas according to the different Lower Flammability Limit (LFL) of the different gas.

7.2.1.3 Flammable and Toxic Linear Gas Detectors

The maximum distance between transmitter and receiver shall not exceed 50 m.

Linear gas detectors for natural gas shall be installed parallel to the ground floor and above the height of most of the valves and flanges in the vicinity.

Linear gas detectors require a clear and open (i.e. unobstructed) path approximately 0.3 m in diameter and therefore shall be applied with caution in congested areas.

To prevent temporary obstruction, floor markings shall be applied to show the location of open paths.

Alarm filtering and time delay shall also be available to avoid spurious alarms with human obstructions.
Furthermore, to avoid damage by ingress of splash water, linear gas detectors shall not be installed lower than 1 m above grade or ground level.

For more details, refer to GS RC INS 552, GS MS INS 401.

7.2.1.4 Oil Mist Detectors

Oil mist detectors shall be used in machinery enclosures where the fire may be preceded of high-pressure flammable liquid, such as diesel or lubrication oil.

They shall be provided based on package vendor recommendations.

If to be provided, oil mist detectors shall be located above the equipment they are protecting.

In case of strong forced ventilation, oil mist detection may also be installed in the enclosures exhaust ducting, however, this should be subject to aeraulic test verification.

7.2.1.5 Acoustic Gas Leak Detectors

The following requirements shall be followed when acoustic gas leak detection is to be used:

• Acoustic gas detectors are installed above the equipment / areas they are covering;
• Acoustic gas detectors are not suitable for multiphase leaks and are only used to monitor high pressure gas (i.e above 70 barg). The use of Acoustic gas detectors for a lower pressure will be based on supplier’s recommendations and approved by Company;
• Acoustic gas detectors are very sensitive to acoustic reflection which can generate false alarms, therefore a noise study is required to find the proper location of the detector and to hence avoid spurious detection due to acoustic reflection on metal.

7.2.2 Gas Detectors Selection

Gas detectors shall be selected as per the table below.

Note that the following represents the minimum requirements in terms of gas detection to be applied. In the absence of requirements on a specific topic in the below table from the relevant branch of the project, then similar requirements from another branch shall be used.

Similar approach applies for GRP branch, with due consideration on the section 2 - Scope of Application.
### Table 7 - Selection and implementation of HC, Toxic Gas and Liquid Spill Detectors

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process areas / wellheads areas (manned installations)</td>
<td>E&amp;P</td>
<td>X</td>
<td>(3)</td>
<td>X</td>
<td>(4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(5)</td>
</tr>
</tbody>
</table>

(1) For preliminary number and sitting, refer to Table 4, 5 and 6.
(2) To monitor process areas + seals / flanges of gas compressors and pumps handling flammable liquids or combustible liquids with temperature above their flash point + gas metering skid + Slug catcher ends + flanges of fuel gas lines feeding gas turbines in utility areas + inside pits within Restricted Areas + near direct fired heater for incoming gas detection.
(3) At edges of modules, or Escalation Zones, or Restricted Areas or above large manifolds. Shall only be used as a complementary detection to point gas detectors in a voting configuration. Otherwise may be used for alarm only.
(4) Mandatory only when H₂S concentration is higher than 1000 ppm in the well or process stream. For lower than 1000 ppm concentration within well or process stream, HC gas detectors is deemed sufficient. In process areas and along escape routes; at platform access or module / zone entrance. Semi-conductor Thin film type H₂S detector shall be used.
(5) May be used as a complementary detection to point gas detectors and for alarm only in areas with high pressure gas (i.e. above 70 barg). Will require a dedicated noise and vibration study to choose location of detector taking into consideration acoustic reflection. Detection of 10 dB above ultrasonic...
### Areas Branch

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
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</tr>
<tr>
<td>RC</td>
<td>X (1, 2)</td>
<td>X (6)</td>
<td>X (3)</td>
<td>X (7)</td>
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</tbody>
</table>

Comment:
- Background noise level during a time delay of 15 s, if confirmed by noise and vibration study shall be used as alarm set point. Shall not be used for multiphasic streams.
- (6) In closed area with H₂ compressor.
- (7) When H₂S concentration is higher than 1000 ppm in process stream.
- (8) Shall only be used as a complementary detection to point toxic gas detectors in a voting configuration. Otherwise may be used for alarm only.

For special fluids refer to RC philosophy.

### Process areas / wellheads areas (Remote or unmanned installations)

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>E&amp;P</td>
<td>X (1, 3)</td>
<td>X (2)</td>
<td>X (4, 5)</td>
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<td></td>
</tr>
</tbody>
</table>

Comment:
- (1) For preliminary number and siting, refer to Table 4.
- (2) At edges of modules, or Escalation Zones, or Restricted Areas. Shall only be used as a complementary detection to point gas detectors in a voting configuration. Otherwise may be used for alarm only.
- (3) To monitor process areas + pumps handling flammable liquids or combustible liquids with temperature above their flash point + gas metering skid.
- (4) Mandatory only when H₂S concentration is higher than 1000 ppm in the well or process stream. In process areas and along escape routes. Semi-conductor Thin film type H₂S detector shall be used.
- (5) In process areas, along escape routes, at
<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryogenic product Storage &amp; handling areas</td>
<td>E&amp;P / RC</td>
<td>X (1)</td>
<td>(3)</td>
<td></td>
<td>X (2)</td>
<td></td>
<td></td>
<td></td>
<td>(1) For LNG storage tanks: In vicinity of manifolds and pumps on top of tanks when applicable + valves / manifold at bottom. (2) Where spills are collected on spillage collection system on top of the LNG storage tank or in remote impounding basin if provided. (3) To supplement point flammable gas detectors (ex: at edges of storage area).</td>
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<td>MS</td>
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<td></td>
<td></td>
<td>Not applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG Storage &amp; handling areas and jetty</td>
<td>E&amp;P / RC</td>
<td>X (1)</td>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) For LPG storage tanks: In vicinity of manifolds and pumps. (2) Can be used to complete point detectors (ex: at edges of storage area). For more details, refer to GS-GR-HSE-313.</td>
<td></td>
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<tr>
<td></td>
<td>MS</td>
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<td></td>
<td></td>
<td></td>
<td>Not applicable</td>
<td></td>
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</tr>
<tr>
<td>LNG process train and jetty</td>
<td>E&amp;P</td>
<td>X (1, 4, 5)</td>
<td>X (3)</td>
<td></td>
<td>X (2)</td>
<td></td>
<td></td>
<td></td>
<td>(1) To monitor process areas + seals / flanges of gas compressors and pumps handling flammable liquids or combustible liquids with temperature above their flash point + inside pits within Restricted Areas + near direct fired heater for incoming gas detection. (2) Where spills are collected (e.g. in impounding basin). (3) To be provided at the periphery of LNG process train.</td>
<td></td>
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</tbody>
</table>
### Areas

<table>
<thead>
<tr>
<th>Branch</th>
<th>E&amp;P / RC</th>
<th>MS</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammable Liquid Hydrocarbons Storage &amp; handling areas</td>
<td>X (1)</td>
<td>X (3)</td>
<td>(1) Within bund areas and in tank double wall annular space for product class I and II (if T_{storage} ≥ flash point). Within pumps areas for product class I and II*. *Pressurized Class II (P &gt; 20 b) product can create an aerosol in the event of a leak (stabilized product only). (2) Same as above for gas detector if concentration of toxic gas deemed dangerous for workers (Concentration of H₂S higher than 1000 ppm inside the product). (3) Within bund and pumps areas as well as in tank double wall annular. For more details, refer to GS-GR-HSE-309.</td>
</tr>
</tbody>
</table>
### Fire and Gas Detection - Design Requirements

**Company General Specification**

GS-GR-HSE-314

**Rev.: 00**

**Effective date: 01/2022**

**Page: 29 of 48**

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<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
<th>Comment</th>
</tr>
</thead>
</table>
| Truck / Rail / Sea loading & unloading station | TRS | X (1) | | | | | | | X (2) | | | (1) One flame detector shall be located at the bottom of the arm for product class I. (2) One liquid spill detector shall be located within bund areas for product class II and III. (3) Same as above for gas detector if concentration of toxic gas deemed dangerous for workers (concentration of H₂S higher than 1000 ppm inside the product). For more details, refer to GS-GR-HSE-309.
| Packaged Rotating Machinery Enclosures (i.e. diesel engine, gas turbine enclosures etc.) | E&P / RC | X (1, 2) | | | | | | | | | | (1) 3 IR point gas detectors in each ventilation and combustion air intakes within “Restricted Area”. (2) Only applicable for gas turbine, gas engine and screw compressors enclosures: 3 IR point gas detectors within enclosure or ventilation air outlet. For more details, refer to GS-GR-HSE-316.
| Enclosed spaces containing hydrocarbons such as HPU, diesel engines | E&P / RC | | | | | | | | (1) | | | (1) if recommended by package vendors and for alarm only.
| HVAC Room | E&P / RC | (1) | | (1) | | | | | | | | (1) To determine the type of detectors following the type refrigerant fluid.

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## Fire and Gas Detection - Design Requirements

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop (without flammable product stored)</td>
<td>E&amp;P / RC</td>
<td>X (1)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>(1) Only if located within the Restricted Area and if fitted with an airlock and air intake: 3 IR point gas detectors inside airlock and air intake.</td>
</tr>
<tr>
<td>Warehouse (without flammable product stored)</td>
<td>E&amp;P / RC</td>
<td>X (1)</td>
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<td>Not applicable</td>
</tr>
<tr>
<td>Warehouse (with flammable product stored)</td>
<td>RC / MS</td>
<td>X (1)</td>
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<td></td>
<td>Not applicable</td>
</tr>
<tr>
<td>Electrical rooms / E&amp;I buildings</td>
<td>E&amp;P / RC</td>
<td>X (1)</td>
<td>X (2)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>(1) 3 IR point gas detectors at building air inlet + each airlock if building is located within Restricted Area. (2) One point electro-chemical type H₂S detector at building air inlet + in each air lock if building is located within Restricted Area and only when H₂S concentration is higher than 1000 ppm in the well or process stream.</td>
</tr>
<tr>
<td>Analyzer Shelter (enclosed)</td>
<td>E&amp;P</td>
<td>X (1, 2)</td>
<td>X (3)</td>
<td>X (4)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>(1) 3 IR point gas detectors at air intake, if any + IR point gas detectors to be located inside (at ceiling + at ground level).</td>
</tr>
<tr>
<td>Areas</td>
<td>Branch</td>
<td>Point flammable gas detectors</td>
<td>H₂ point gas detectors</td>
<td>Linear flammable gas detectors</td>
<td>Point toxic gas detectors</td>
<td>Linear toxic gas detectors</td>
<td>O₂ deficiency gas detectors</td>
<td>Oil mist gas detectors</td>
<td>Cryogenic &amp; Cold spill detectors</td>
<td>Liquid spill detectors</td>
<td>Acoustic gas leak detectors</td>
<td>Comment</td>
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</tr>
<tr>
<td>RC</td>
<td>X (5)</td>
<td>X (6)</td>
<td>X (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2) At the vent of analyser. (3) One point electro-chemical type H₂S detector at air intake if any + inside shelter when H₂S concentration is higher than 1000 ppm in the well or process stream. (4) If potential risk of anoxia due to presence of nitrogen.</td>
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<tr>
<td>MS</td>
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<td>(5) One in top, one in bottom, one at the air intake duct (outdoor). (6) H₂S detector at air intake if any+ inside shelter when H₂S concentration is higher than 1000 ppm in the well or process stream. (7) If N₂ inlet in the shelter.</td>
<td></td>
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</tr>
<tr>
<td>Electrochlorination package</td>
<td>E&amp;P</td>
<td>X (1)</td>
<td></td>
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<td></td>
<td>(1) 3 detectors at vicinity of vent line of degassing tank.</td>
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<tr>
<td>RC</td>
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<td></td>
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<td>Not applicable.</td>
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<tr>
<td>MS</td>
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<td></td>
<td></td>
<td>Not applicable.</td>
<td></td>
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</tr>
<tr>
<td>Laboratory</td>
<td>E&amp;P / RC / MS</td>
<td>X (2, 3)</td>
<td>X (4)</td>
<td>X (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1) One detector to be provided within room. (2) If within the Restricted Area, three IR point gas detectors to be provided in airlock and air intake. (3) Three IR point gas detectors to be provided inside laboratory.</td>
<td></td>
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</tr>
</tbody>
</table>

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## Areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery room</td>
<td>E&amp;P / RC</td>
<td>(1) 3 H₂ point gas detectors as a minimum. (2) 3 detectors to be provided if the battery room is located within the Restricted Area and batteries are not shutdown in case of loss of pressurisation of building due to gas detection at building air inlet.</td>
</tr>
<tr>
<td>Temporary refuge</td>
<td>E&amp;P</td>
<td>(1) 3 IR point gas detectors at Temporary refuge air inlet + air intake if located within Restricted Area. (2) For “open” secondary muster area located in process areas.</td>
</tr>
<tr>
<td>Living Quarters / Administration buildings / Offices / Archives / Storeroom</td>
<td>E&amp;P</td>
<td>(1) 3 IR point gas detectors at LQ and/or administration buildings air inlet + each air intake if LQ / Administration buildings are located within Restricted Area. (2) Detectors can be used either to monitor an atmosphere in which operators may be present to cope with anoxia issues (use of nitrogen or of some O₂ depletant firefighting agent) or to monitor the level of oxygen of inert atmospheres. (3) One point electro-chemical type H₂S detector at LQ and/or administration buildings air inlet + in each airlock if building is located within Restricted Area and only when H₂S concentration is higher than 1000 ppm in the well or process stream.</td>
</tr>
</tbody>
</table>

(4) CO and/or H₂S detectors if risk identified (H₂S > 1000 ppm).
<table>
<thead>
<tr>
<th>Areas</th>
<th>Branch</th>
<th>Point flammable gas detectors</th>
<th>H₂ point gas detectors</th>
<th>Linear flammable gas detectors</th>
<th>Point toxic gas detectors</th>
<th>Linear toxic gas detectors</th>
<th>O₂ deficiency gas detectors</th>
<th>Oil mist gas detectors</th>
<th>Cryogenic &amp; Cold spill detectors</th>
<th>Liquid spill detectors</th>
<th>Acoustic gas leak detectors</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC</td>
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<td>Not applicable</td>
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<tr>
<td>MS</td>
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<td></td>
<td></td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

X: Type of detection mandatory where flammable / combustible product identified.

☐ Type of detection allowed if the need arises

☒ Not applicable
7.2.3 Alarm thresholds

Threshold for Flammable Gas Points Detectors:

For HC flammable gas point detectors located outdoors, indoors (when applicable), in building air intakes and airlocks, the threshold shall be set as follows:

- The first alarm threshold will be set as low as practicable and no more than 20% LFL;
- The executive actions threshold will be set at 40% LFL.

HC flammable gas points detectors in buildings shall comply with the requirements of GS-GR-HSE-302.

HC flammable gas points detectors inside machinery enclosures shall comply with the requirements of GS-GR-HSE-316:

- The alarm threshold will be set at 15% LFL;
- The executive actions threshold will be set at 25% LFL.

For H2 flammable gas point detectors, the threshold shall be set as follows:

- The alarm threshold will be set at 5% LFL in enclosed area (i.e. batteries room) and 20% outdoors;
- The executive actions threshold will be set at 10% LFL in enclosed area (i.e. batteries room) and 40% outdoors.

Threshold for Flammable Gas Open Path Detectors:

The threshold shall be set as follows:

- The low-level alarm will be set at 0.5 LFL x m (i.e. 50% LFL extended for one meter: it gives an alarm if there is a flammable gas cloud of 5% LFL over a distance of 10 m);
- The high-level alarm: 1 LFL x m.

These thresholds are defined in a lumpsum way but may be adjusted in function of the emergency actions and response strategy that could depend on this indication.

However, in all cases, these adjustments shall be subject to a formal derogation by Company.

Flammable open path gas detectors shall not be used solely for execution actions but may be used as complementary means to gas point detection in a voting logic configuration.

Flammable open path gas detectors shall not be used for rotating machines enclosures inlet ducts (neither ventilation nor combustion air).

Threshold for toxic (H2S) gas point detectors:

H2S detectors shall be used mainly for alarms purposes and personnel protection actions.

The threshold shall be set as follows:

- The alert threshold will be set at 5 ppm;
- The alarm threshold will be set at 10 ppm.

Threshold for toxic (H2S) linear gas detectors:

The threshold shall be set as follows:

- The low-level alarm will be set at 5 ppm x m;
- The high-level alarm will be set at 10 ppm x m.
As for flammable gas, linear type detectors for H₂S detection shall not be used solely for executive actions but may be used as complementary means to toxic gas point detection in a voting logic configuration and their use is subject to Company approval.

**Threshold for toxic (Hydrogen Fluoride- HF) gas point detectors:**

The threshold shall be set as follows:

- The alert threshold will be set at 3 ppm;
- The alarm threshold will be set at 5 ppm.

**Threshold for toxic (Benzene - C₆H₆) gas point detectors:**

The threshold shall be set as follows:

- The alert threshold will be set at 1 ppm;
- The alarm threshold will be set at 3 ppm.

**Threshold for toxic (Ammonia - NH₃) gas point detectors:**

The threshold shall be set as follows:

- The alert threshold will be set at 10 ppm;
- The alarm threshold will be set at 20 ppm.

**Threshold for toxic (Carbon monoxide - CO) gas point detectors:**

The threshold shall be set as follows:

- The alert threshold will be set at 20 ppm;
- The alarm threshold will be set at 100 ppm.

**Threshold for Oxygen (O₂) deficiency detectors:**

The threshold shall be set as follows:

- The alert threshold will be set at 20%;
- The alarm threshold will be set at 19%.

As a general rule, VME (Valeur Moyenne d’Exposition) and VLCT (Valeur Limite de Court Terme) may be used to define respectively first and second thresholds.

### 8. 3D Fire & Gas Detectors Mapping Study

#### 8.1 Generalities

A 3D F&G detection mapping study shall be performed on new E&P greenfield installations such as:

- New offshore platform or Floaters;
- New onshore process / LNG plants.

For all other installations, including brownfield projects, the 3D F&G detector mapping study requirement (if to be performed) shall be defined by Company in the Safety Concept / Safety Note when applicable.

The following areas are excluded:

- Storage areas;
- Internal areas of building/enclosures;
- Airlocks and air intakes.
The 3D F&G detection mapping study shall hence be limited to outdoors F&G detectors.

8.2 Coverage Review and Potential Optimisation

The 3D F&G detectors mapping study shall be performed to ensure that the F&G detectors coverage satisfies an adequate level of safety.

The mapping study using the 3D model shall be performed based on 2D F&G detectors drawings developed using requirements specified in section 7.

Each detector shall be considered both individually and as part of a group of detectors in line with preliminary project F&G Cause & Effects charts.

In each “fire/gas zone/volume of interest”, as defined in section 8.3, the number and location of the detectors shall be set such that the combined coverage of all the detectors in the “fire/gas zone/volume” meets the requirements defined in section 8.3.

The software used shall be submitted to Company Approval.

Note: For gas detection, benefits from grated decks, where applicable shall be taken into account, especially if gas detectors on the different levels are included in the same voter as per the project F&G Cause and Effects charts.

8.3 Detection Performance Criteria

8.3.1 Detection Coverage Criteria

Prior to performing the study, dedicated “fire zone(s) / volume(s)” of interest and dedicated “gas zone(s) / volume(s)” of interest where HC fires / leaks could occur shall be defined within the 3D model.

The 3D F&G detectors mapping study shall then only be performed within the “fire zone(s) / volume(s)” and “gas zone(s)/volume(s)” of interest.

For both fire and gas coverage studies, the following target coverage within the defined “Zone / Volume of interest” shall be verified:

- 90% of the volume / zone of interest to be detected by 100N detector;
- 80% of the volume / zone of interest to be detected by 200N detectors.

For fire coverage @200N detectors, coverage target may be lowered providing all areas within the dedicated “fire zone / volume” of interest are covered by fusible plugs and upon Company approval.

8.3.2 Minimum Fire Size

A fire with flame of 2 m length shall be used for the fire coverage study.

Outcomes of the project Fire Risk Analysis with size of fire corresponding to 0.1 kg/s release rate (i.e. corresponding to small fire event) may be used if data is available at start of study and with the approval of the Company.

A correction factor on the flame detector vision shall also be specified within the software used for the study.

This correction factor shall be specified within an assumption register and validated by Company.
8.3.3 Maximum Flammable Gas Cloud Size

The following gas cloud size shall be used for the gas coverage:

- 6 m gas cloud for the “gas zone(s) / volume(s)” of interest within congested areas;
- 10 m gas cloud for the “gas zone(s) / volume(s)” of interest within uncongested areas.

Note: The size of a gas cloud generating an overpressure of 150 mbar coming from the project Explosion Risk Analysis may be used providing Company approval.

8.3.4 Maximum Toxic (H2S) Gas Cloud Size

A 6 m diameter sphere shall be used as default toxic (H2S) cloud size. Other, cloud size based on the project gas dispersion study may be used providing Company approval.

In the absence of specific requirements from the Safety Concept, the toxic coverage study shall only focus on ensuring that 90% of the “volume / zone” of interest is detected by 1ooN detector.

Note: 3D toxic gas coverage study shall only be performed if project strategy defined in the Safety Concept is to locate toxic gas detectors within process areas. Should strategy be to provide toxic gas detection only at periphery of process areas or at entrance, then no 3D toxic gas mapping study is required.

9. Detection Logic Principle

9.1 Detection Logic Matrix

The safety logic to be implemented in the FGS, shall be specified in a dedicated document called ‘F&G Cause & Effect Matrix’.

The interaction with other systems (ESD, HVAC, packages, F&G Programmable Logic Controller (PLC), Human Machine Interface (HMI) etc.) shall be clearly addressed using tag/ equipment numbers, interconnection signal tags, ESD safety bar references, and listing associated reference documents.

Particular functions such as the manual activation push button (field and CCR), MACs, manual deluge/foam start/stop etc. being related to programming the F&G safety logic shall clearly appear on the F&G Cause & Effect matrix.

9.2 Detection Logic for E&P Installations

9.2.1 Detection and Voting Principles for Executive Actions

Alarms or executive actions linked to F&G single or confirmed detection shall comply with GS-GR-HSE-304 requirements.

All F&G detectors which can cause a main process or platform shutdown (i.e. ESD-1 or essential SD-2) shall be redundant or have triplicate sensors in accordance with the Table 8, in order to obtain both reliability as well as availability.

The voting principles of Table 8 shall be implemented in accordance with GS EP INS 198.
### Table 8 - Voting Configuration Principles

<table>
<thead>
<tr>
<th>ESD-1</th>
<th>2ooN (N≥3)</th>
<th>All F&amp;G detection used for ESD-1 level executive actions shall be installed in a 2ooN (with N≥3) voting configuration minimum.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2oo2</td>
<td>The use of a 2oo2 voting configuration for ESD-1 level executive actions is not permitted for gas detection applications. It is only permitted for smoke detection if it is done between 2 separate loops and if each loop has multiple (3 or more) detectors (Reminder: as per GS-GR-HSE-304 requirement, ESD-1 in technical rooms is not allowed on fire detection).</td>
</tr>
<tr>
<td></td>
<td>1oo2</td>
<td>The use of a 1oo2 voting configuration for ESD-1 level executive actions is not permitted in any case, because the degraded mode in case of one faulty or inhibited detector would increase the risk of spurious shutdowns due to the reduced number of healthy detectors, and it would also reduce the effective safety integrity level (SIL) of the entire loop.</td>
</tr>
<tr>
<td></td>
<td>1oo1</td>
<td>The use of a single fire or gas detector for ESD-1 level executive actions is not permitted because it is considered too unreliable to avoid a spurious ESD-1 activation.</td>
</tr>
<tr>
<td>SD-2/3</td>
<td></td>
<td>Single detectors are permitted upon Company approval, but voting configurations shall be installed when an increased reliability and/or availability is required for a particular (essential) equipment, package, area or zone (e.g. following SIL review, etc.).</td>
</tr>
</tbody>
</table>

The maximum number of detectors used in a single voting block shall be assessed, following GS EP INS 134.

### 9.2.2 Fault and Inhibits Handling Principles for Voting Configurations

A detector fault (detector breakdown) is not considered as the equivalent of exceeding a trip threshold value (except for 2oo2 configuration), otherwise a detector fault would reduce unnecessary the availability of the SIF and it would increase the risk of spurious shutdowns due to the reduced number of healthy detectors.

Maintenance inhibits can be set for reasons of periodic calibration or during planned and controlled operations (welding, etc). They shall only inhibit the particular detector.

For F&G coverage, they are considered as a non-availability of the detector. However, they are not considered as a fault or detection as the inhibitions are done intentionally, in a temporary manner and via a formal process of inhibitions management (risks assessment carried-out with adequate mitigation measures in place and appropriate actions to be generated if needed).

Therefore, in case of faulty or inhibited detectors, the voting configuration shall follow principles mentioned in the Tables 9, 10 and 11 hereafter.

The 'executive action' means the trip activation as per F&G Cause & Effect matrix for the initial voting configuration, while 'alarm' means a CCR operator workstation announcement with event recording by the Instrumented Control and Safety System (ICSS).

A fault alarm shall only be removable from the ICSS alarm pages once that fault has been restored to healthy conditions.
### Table 9 - Fault Handling Principles for 2oo2 Configurations (Smoke Detection Only)

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>Normal</th>
<th>Detection</th>
<th>Fault</th>
<th>Inhibit</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>Normal</td>
<td>Normal</td>
<td>Detection Alarm</td>
<td>Fault Alarm</td>
<td>No Action</td>
</tr>
<tr>
<td>Detection</td>
<td>Detection Alarm</td>
<td>Executive actions</td>
<td>Executive actions</td>
<td>Executive actions</td>
<td></td>
</tr>
<tr>
<td>Fault</td>
<td>Fault Alarm</td>
<td>Executive actions</td>
<td>Executive actions</td>
<td>Fault Alarm</td>
<td></td>
</tr>
<tr>
<td>Inhibit</td>
<td>No Action</td>
<td>Executive actions</td>
<td>Fault Alarm</td>
<td>Inhibit Alarm</td>
<td></td>
</tr>
</tbody>
</table>

### Table 10 - Fault Handling Principles for F&G 2ooN with N=3 Configurations

<table>
<thead>
<tr>
<th></th>
<th>D1 (Normal (N))</th>
<th>Detection (D)</th>
<th>Fault (F)</th>
<th>Inhibit (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D2</td>
<td>Normal</td>
<td>N</td>
<td>DA</td>
<td>FA</td>
</tr>
<tr>
<td>Detection</td>
<td>DA</td>
<td>EA</td>
<td>EA</td>
<td>EA</td>
</tr>
<tr>
<td>Fault</td>
<td>FA</td>
<td>EA</td>
<td>FA</td>
<td>FA</td>
</tr>
<tr>
<td>Inhibit</td>
<td>NA</td>
<td>EA</td>
<td>FA</td>
<td>NA</td>
</tr>
<tr>
<td>D2</td>
<td>N</td>
<td>D</td>
<td>F</td>
<td>I</td>
</tr>
</tbody>
</table>
### Table 11 - Fault Handling Principles for F&G 2ooN with N>3 Configurations

<table>
<thead>
<tr>
<th>D1</th>
<th>Normal (N)</th>
<th>Detection (D)</th>
<th>Fault (F)</th>
<th>Inhibit (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>DA + FA</td>
<td>FA + DA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>DA + FA</td>
<td>FA + DA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>DA + FA</td>
<td>FA + DA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>DA + FA</td>
<td>FA + DA</td>
<td>NA</td>
</tr>
</tbody>
</table>


**Rule for 2ooN with N>3:**

- 1 fault or 1 inhibit = degrade to 2oo(N-1);
- 2 faults/inhibits or combination thereof = degrade to 1oo(N-2);
- X inhibits = degrade to 1oo(N-X) with 1<X<N;
- 2 faults + (N-2) inhibits = FA;
- 1 fault + (N-1) inhibits = FA;
- ≥ 3 faults = EA;
- N inhibits = IA.

A sufficient number of spare detectors and spare parts shall be kept locally at the production facility to ensure that the duration of any default is reduced as much as possible (i.e. less than 1 day).

### 9.2.3 Smoke Detection Requirements for Technical Rooms

Multiple (two or more) loops, with a voting configuration between loops shall be used.

In case multiple loops are applied, each loop shall have ‘mixed’ locations within the technical room, meaning that each loop will have at least one detector under the false floor, one detector in the room and (when applicable) one detector above the false ceiling, hence creating a total room coverage by each loop.

Voting shall then be between the loops.

This requirement may be altered when individual cabinets are equipped with individual smoke detectors and/or individual fire extinguishing (e.g. electrical switchboards).

This requirement may also be modified for very large rooms where a very large number of smoke detectors per loop would be required, in which case a room partition approach is more practical.

In any case, the fire detection philosophy for technical rooms shall be clearly identified in the Safety Concept or the dedicated project F&G detection philosophy.
9.3 Detection Logic for RC & MS Installations

9.3.1 Detection and Voting Principles for Executive Actions

9.3.1.1 Basic Principles for Executive Actions

The use of a single F&G detector for alarm or evacuation actuators activation (Flash fired, siren, horn, etc) shall be the standard of installation.

For liquid HC installations process shut down and other actions, a confirmed detection may be required, which requires a second F&G detector, or a visual confirmation by an operator or through Closed Circuit TeleVision (CCTV).

9.3.1.2 Other Voting Principles

When detection is based on more than one detector for process shut down, the following principles shall be followed:

- By default, all F&G detection used for emergency shutdown actions are installed in a 2ooN (with N≥3) voting configuration minimum;
- The use of a 1oo2 voting configuration for emergency shutdown actions is not permitted in any case, because the degraded mode in case of one faulty or inhibited detector would increase the risk of spurious shutdowns;
- The use of a 2oo2 voting configuration for emergency shutdown actions is not permitted for gas detection applications. It is only permitted for smoke detection if it is done between 2 separate loops and if each loop has multiple (3 or more) detectors (e.g. 2 separate smoke detection loops for a technical room).

For fired heaters, flammable gas detectors shall be installed around the heaters in a 2ooN (with N≥3) voting configuration in order to trigger automatically the water / vapour curtain located around the heater and to shut down the Heater & Unit.

The choice of shutting down the Heater & Unit manually or automatically shall be assessed during a risk analysis and approved by Company.

9.3.1.3 Personnel Evacuation

General:

If a fire or a flammable / toxic gas dispersion is detected (alarm threshold) in a zone, the F&G alarm system shall:

- Warn the personnel in the zone to evacuate and go to the muster point,
- Prevent the unauthorized personnel from entering into the zone.

There are two types of alarm system in units:

- Audible (air horn or electric siren) which can be stopped after a certain time and is common to all risks;
- Visual (flashing lights) which remain on as long as the risk detection is active and have a colour dedicated to the risk:
  - Blue: risks of flammable gases (explosivity) and fire;
  - Orange: toxic risks;
  - White: O₂ deficiency (in analyser shelters only).
When a toxic risk is identified, the confinement rules of workers in nearby buildings shall be studied by a risk analysis and validated by Company.

**Location of Audible and Visual Alarms:**

There shall be sufficient audible warning devices, arranged in such a way as to be extended over all of the area affected by the detection.

The sound level required shall always be greater than the average sound level of the zone.

Visual alarm shall be positioned so as to prevent any entry into the zone when they are activated (generally, on access ways), and also to be visible to personnel in the zone (generally, on the main through routes).

For more details, refer to GS RC INS 550 and GS MS INS 012.

### 9.3.2 Maintenance Inhibits

Maintenance inhibits may be set for reasons of periodic calibration or faulty detectors.

Maintenance inhibits shall be considered the equivalent of a detector fault, meaning a non-availability of that detector.

In case of voting configurations:

- It results into a degraded mode with reduced availability;
- It shall only inhibit the particular detector, hence not the output of the voting block.

A sufficient number of spare detectors and spare parts shall be kept locally on site to ensure that the duration of any maintenance inhibit is reduced as much a possible (i.e. less than 1 day).

### 9.4 F&G Human-Machine Interface (HMI)

F&G events and alarms shall be reported from the F&G Safety System to the operator using 2 distinct methods:

**Via the PCS Operator Workstations:**

The principle operator interface shall be the PCS Operator workstation.

The workstation shall display F&G information in a series of overview and detailed mimics where the operator will be given a detailed status of the fire and gas system.

Additionally, alarms shall be presented to the operator on chronological alarm displays.

All F&G alarms shall be alerted to operator visibly and audibly.

The mimics shall allow the operator to carry out reset functions as necessary.

However, executive actions shall not be initiated from the PCS Operator Workstation.

**Direct to a F&G matrix with appropriate indicators and pushbuttons**

The F&G hardwired matrix shall be direct hardwired from F&G Safety System to a set of status lamps and buttons.
The matrix shall:

- Show a fixed overview of the installation;
- Provide indication of any Fire, Toxic Gas or Flammable gas alarm per fire zone.

Therefore, in case of failure of the PCS the operator will still have a status of the F&G detection.

The matrix may also provide pushbuttons direct to the F&G Safety System to initiate executive actions.

10. Typical Actions Upon F&G Detection for E&P Installations

As a minimum, the following basic principles shall be implemented and/or complemented by actions specified in GS-GR-HSE-304 and specified within the project F&G Cause and Effects matrix (see section 12.2).

Note: For rotating machineries, refer to GS EP MEC 051 and GS-GR-HSE-316.

10.1 Process Areas / Open Areas

Fire Detection

1ooN flame detector or 1oo3 PT on the fusible loop shall initiate an alarm in the CCR and on the F&G matrix panel.

As a minimum, confirmed fire detection in an escalation area (i.e. corresponding to either 2ooN flame detectors or 2oo3 PTs) shall:

- Initiate alarms in the CCR + on the F&G Matrix Panel;
- Initiate PAGA;
- Initiate concerned escalation area ESD-1/F;
- Initiate firewater pump start-up sequence;
- Open deluge valve(s) when applicable as per fire scenario defined in F&G Cause and effects matrix.

Flammable Gas Detection

The following configurations shall initiate an alarm in the CCR and on the F&G matrix panel:

- 1ooN gas detector @ 20%LFL or 1ooN gas detector @ 40%LFL;
- 1ooN open path beam gas detector @ 0.5 LFL x m or @ 1 LFL x m.

As a minimum, confirmed gas detection in an escalation area (i.e. corresponding to either 2ooN gas detectors @ 40% LFL or a combination of 1ooN gas detector @ 40% LFL + 1ooN open path beam gas detector @ 1 LFL x m) shall:

- Initiate alarms in the CCR + on the F&G Matrix Panel;
- Initiate PAGA;
- Initiate concerned escalation area ESD-1/G;
- Initiate electrical isolation of all electrical equipment not certified for use in Zone 1 within the concerned escalation area (Note 3).

In addition, on offshore installations, since confirmed gas detection at the firewater pump air intake will inhibit to start the pump, start of one firewater pump upon confirmed gas detection outdoors may be implemented; this will ensure that at least one firewater pump is available in case of fire post blast event. This shall be defined within the Safety Concept or the project dedicated F&G detection philosophy.
Should acoustic detection be provided, as specified in section 7.2.2, detection of 10 dB above ultrasonic background noise level during a time delay of 15s, if confirmed by noise and vibration study shall be used as alarm set point. In addition, acoustic gas detection may be used as a complementary detection to point and open path beam gas detectors in a voting configuration for automatic executive action.

For FPSO, electrical isolation of all electrical equipment not certified for use in Zone 1 within the Restricted Area shall be initiated.

**Toxic Gas Detection**

1ooN H₂S toxic gas detector @ 5 ppm or 1ooN H₂S toxic gas open path detector @ 5 ppm x m shall initiate an alarm in the CCR and on the F&G matrix panel.

1ooN H₂S toxic gas detector @ 10 ppm or 1ooN H₂S toxic gas open path detector @ 10 ppm x m shall initiate an alarm in the CCR and on the F&G matrix panel and PAGA.

In some cases (mainly depending on country requirements), H₂S detection may be used for automatic executive actions upon a 2ooN voting basis.

This shall be defined within the Safety Concept or the project dedicated F&G detection philosophy.

**10.2 Buildings**

**Fire Detection in Manned Rooms**

Early smoke detection signal from 1ooN point HSSD or 1ooN smoke/heat detector in a room shall initiate an alarm in the CCR and on the F&G matrix panel.

As a minimum, confirmed fire detection in a room (i.e. corresponding to either 2ooN smoke/heat detectors from two loops or high smoke detection signal from 1ooN point HSSD) shall:

- Initiate alarms in the CCR + on the F&G Matrix Panel;
- Initiate PAGA;
- Close F&G dampers within the room where fire is detected;
- Initiate automatic extinguishing system within room/false floors, when applicable.

For more details refer to GS-GR-HSE-302.

**Fire Detection in Buildings Air Intake**

1oo3 smoke detector in building air duct shall initiate an alarm in the CCR and on the F&G matrix panel.

As a minimum, confirmed smoke detection a building air intake (i.e. corresponding to either 2oo3 smoke detectors) shall:

- Initiate alarms in the CCR + on the F&G Matrix Panel;
- Initiate PAGA;
- Close the building boundary F&G dampers;
- Stop the building HVAC system.

In case of multiple air intakes, upon confirmed smoke detection in one single air intake, only the F&G damper of the concerned air intake shall be closed.

**Flammable Gas Detection in Buildings Air Intakes or Air Locks**

1oo3 gas detector @ 20% LFL or 40% LFL in a building air intake or airlock shall initiate an alarm in the CCR and on the F&G matrix panel.
As a minimum, confirmed gas detection at building air intake or airlock (i.e. corresponding to 2003 gas detectors @ 40% LFL) shall:

- Initiate alarms in the CCR + on the F&G Matrix Panel;
- Close the building boundary F&G dampers;
- Stop the building HVAC system;
- Initiate Building ESD-1/G;
- Initiate PAGA;
- Initiate electrical isolation of all electrical equipment not certified for use in Zone 1 within the building.

In case of multiple air intakes, upon confirmed smoke detection in one single air intake, only the F&G damper of the concerned air intake shall be closed.


A manual alarm system (e.g. telephones, pushbuttons clearly marked and identified) shall be available within each escalation area to enable a person discovering a fire to initiate the operation of a fire alarm system so that appropriate measures can be taken.

Reference shall be made to ISO 7240-11, or NFPA 72 for more details on MACs.

12. Documentation

12.1 F&G Layouts and 3-D Model

During basic engineering phases of new projects, specific lay-outs (e.g. F&G detectors drawings) showing the location of the detectors shall be made and give all necessary indications for the installation of the detectors including their positions (2-D and elevation).

For each detector located on the layouts, the following information shall be given:

- Type of gas detectors and technologies selected (depending on gas to be detected) or type of technologies chosen for fire detectors (e.g. heat detector, smoke detector, fusible plugs…). Usually this information is included in the symbolization of the detector;
- The exact sitting of the detector on the 2-D drawings including information on their elevations. This is generally indicated with an arrow or a point showing where the detector is located and supplemented by notes giving more information on elevations.

When available, 3-D model of the facility shall point out F&G detectors to ensure that any obstruction is avoided and installation as required is feasible.

12.2 F&G Causes and Effects Matrix

The F&G Causes and Effects matrix shall consist of a set of tables with one set for each escalation zone (refer to GS-GR-HSE-301).

For EP, for the purpose of initiating specific alarms and actions upon detection, the segregation of each escalation zone into several F&G Area (FGA) may be applied.
FGAs shall be physically limited by active or passive fire protection such as fire rated and or blast rated walls, bulkheads or decks, dedicated protection systems, and areas that will be segregated for the facilitation of fire and/ or gas detection cause and effect logic implementation.

The F&G Cause and Effects matrix shall then be developed for each escalation zone and each FGA, when applicable, during the basic engineering phase and updated during the Detail Engineering.

They shall be compiled on the basis of detector/MAC/etc. layout drawings and be organised in line with API RP 14C as follows:

- On the vertical axis: the causes or initiating events, e.g. all the different detectors in the zone (sub-divided area/unit) including possible combinations (voting blocks), alarm/trip threshold values, faults, or signals from other matrices/systems;
- On the horizontal axis: the effects or consequences divided clearly in three main groups, i.e. alarms (local and remote), extinguishing and emergency shutdown actions (process, electrical, ICSS, packages, refer to GS-GR-HSE-304 and section 10.1 for E&P).

In case of separate FGS, multiple dedicated matrices are typically created, for example:

- A FGS for floating production facility is typically split up in a topsides and a hull FGS, with an additional dedicated IMO-certified fire detection system for LQ;
- Packaged equipment can be supplied with their own F&G system;
- Onshore facilities are split up in process units, buildings, geographic areas, etc.

Although the F&G Causes and Effects matrix for package equipment is typically in the scope of work of the package Vendor, the evaluation and approval remains the responsibility of Company.

An example is available in Appendix 1.

13. Bibliography

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title of the Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>API RP 14G</td>
<td>Recommended Practice for Fire Prevention and Control on Fixed Open type Offshore Production Platform</td>
</tr>
<tr>
<td>Health and Safety Executive (published 2017)</td>
<td>Fixed flammable gas detector systems on offshore installations: Optimization and assessment of effectiveness</td>
</tr>
</tbody>
</table>
Appendix 1. Example of a Causes and Effects Matrix

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>LOCATION</th>
<th>INSTRUMENT TYPE</th>
<th>DESCRIPTION</th>
<th>SET POINT</th>
<th>VOTING</th>
<th>NOTE</th>
<th>ALARMS</th>
<th>USE</th>
<th>EXECUTION ACTIONS</th>
<th>EXECUTION ACTIONS</th>
<th>EXECUTION ACTIONS</th>
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</thead>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| FIRE ZONE: |         |                |             |           |         |      |        |     |                   |                   |                   |
| FZ-0       |         |                |             |           |         |      |        |     |                   |                   |                   |

| FIRE AND GAS AREA: |         |                |             |           |         |      |        |     |                   |                   |                   |
| FGA-30C     |         |                |             |           |         |      |        |     |                   |                   |                   |

| LOCATION: |         |                |             |           |         |      |        |     |                   |                   |                   |
| COT 1 (PORTSIDE) |         |                |             |           |         |      |        |     |                   |                   |                   |

| SYSTEM: |         |                |             |           |         |      |        |     |                   |                   |                   |
| FIRE AND GAS DETECTION ON CARGO TANKS |         |                |             |           |         |      |        |     |                   |                   |                   |
Appendix 2. Guidelines for Fusible-Plug Selection and Installation (E&P Installations)

A fusible element consists of a metal alloy installed on a stainless steel loop (generally ½” AISI 316L or 904 as per GS EP INS 143) pressurized with instrument air (or nitrogen) and melting at a pre-set temperature (79°C to 96°C). The low loop pressure is used to initiate various actions. At least 3 PT (analogue pressure transmitters) are installed on the fusible plug system to provide a 2oo3 voting logic which automatically activates ESD-1 actions (as per section 10).

### Table - Guidelines for Fusible-Plug Selection and Installation (Extract from API RP 14C)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Fusible Plug Arrangement</th>
<th>Minimum Number of Plugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellheads</td>
<td>3 around each wellhead at 120°</td>
<td>3</td>
</tr>
<tr>
<td>Headers</td>
<td>one for each 3 m of header length or: ( n = \frac{L}{3} ) (1)</td>
<td>2</td>
</tr>
<tr>
<td>Pressure vessels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OD: Outside diameter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L: Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (E)SDVs at battery limit</td>
<td>3 around each ESDV at 120°</td>
<td>3</td>
</tr>
<tr>
<td>Vertical Vessel</td>
<td>( n = \frac{OD}{0.3} ) with a maximum of 5 plugs</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal vessel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If OD ≤ 1.2 m</td>
<td>( n = \frac{L}{1.5} )</td>
<td>2</td>
</tr>
<tr>
<td>If OD ≥ 1.2 m</td>
<td>( n = 2 \times \frac{L}{1.5} ) in 2 parallel rows</td>
<td>4</td>
</tr>
<tr>
<td>Atmospheric vessels</td>
<td>1 for each process inlet, outlet and hatch</td>
<td>-</td>
</tr>
<tr>
<td>Heat exchangers (shell-tube)</td>
<td>1 for each end of heat exchanger</td>
<td>2</td>
</tr>
<tr>
<td>Pumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reciprocating</td>
<td>1 over rod packing</td>
<td>-</td>
</tr>
<tr>
<td>Centrifugal</td>
<td>1 over each packing box</td>
<td>-</td>
</tr>
</tbody>
</table>

**General note:** When fusible tubing or other devices (such as UV/IR flame detectors, etc.) are used instead of fusible plugs, it is recommended that they provide at least the same coverage as outlined above.

**Note 1:** Not applicable to underwater wellheads or headers.

**Note 2:** Plugs shall be installed at maximum 2 m above the equipment they are monitoring; For vessels, fusible plugs shall be installed along the lowest deluge ring. In case of maintenance purposes and potential interference with the fusible plugs network, this requirement may be reviewed upon Company approval.

End of document.
Original signed.