Topics Of Discussion

- Why Fire and Gas Systems?
- Performance based Fire and Gas concepts
- Process FGS Hazard Assessment and Detector mapping
- Process FGS Loop Effectiveness
- Why Honeywell?
Why Fire and Gas Systems?

FGS implementation can be a result of

- Any risk assessment recommendation
- Previous incidents involving gas release/fires
- Insurance companies audit
- Insurance premium reduction
- Green field project or plant expansion
- Ineffective existing fire and gas systems

What happens with an ineffective FGS

- Fines from AHJ
- High insurance premiums
- Nuisance false alarms
- Loss of property
- Loss of lives
- Environmental Damage
- Reputation Damage

Petrofac Kittiwake Platform Northsea

March 20, 2015
– Major gas leak undetected for 84 mins

Leak detected by worker after ~1500 kg of gas leak

Prescriptive and Performance Based Standards

• Prescriptive standards specify the requirement to meet the code while Performance based standards only give a guideline to the designer / end user.

• NFPA 72 and EN 54 codes are Prescriptive standards, primarily intended for Fire protection in enclosed areas.

• IEC 61511 and ISA 84.00.01 are Performance based standards, which have been written to help analyze, design, realize, install, commission and maintain SIL loops for the Process industry.

• The ISA 84.00.01 committee has released a F&G guideline for the process industry in 2010 and is up for a new edition in 2017 (TR 84.00.07)
Why Prescriptive Standards Do Not Always Work

Irrespective of where the mouth of the HVAC duct opens, Prescriptive standards will specify the same number of Gas Detectors inside the building.
Performance Based FGS Design Process

- Design and implementation of a FGS can be performed in a manner that is consistent with the underlying principles of both ANSI/ISA-84.00.01-2004 and IEC 61511.
- The fundamental approach is to examine the hazard and risk in order to establish required FGS performance, and then to specify a design that achieves that performance.
- This performance-based FGS design process integrates into the relevant portions of a Safety Lifecycle for safety functions.
Fire and Gas Systems for Process Industry

A combination of both prescriptive and performance-based methods

F&G components for the process area (1, 2, 3)
- ISA TR 84.00.07

Detect
- Gas detectors
- Flame detectors
- Pull stations/Call points

Control
- Example - Safety Manager,
  - Suppression & Releasing

Respond
- Dry Powder
- Expansion foam
- Water Curtains
- Annunciation Devices

F&G components for the process area 4
Control room and Admin building – NFPA 72

Detect
- Smoke detectors
- Aspiration detectors
- Pull stations/Call points

Control
- Example – XLS/Notifier
  - Suppression & Releasing

Respond
- Speakers
  - Beacons & Horns,
- ESD
- LED Signs
- Graphic Package
FGS Loops Design Criteria as per ISA TR 84.00.07

• ISA TR 84.00.07 focuses on the implementation of FGS to protect people and the environment when the process is operating normally, but loss of containment has occurred due to such factors as corrosion, erosion, leaking gasket, and tubing failure.

• Consider a scenario where the pressure in the vessel is within tolerable limits (e.g., not high) and loss of containment has occurred. In this scenario, a FGS function is an appropriate choice for reducing the risk, because there is no potential for implementing a preventive safety instrumented function to prevent loss of containment.
Event Tree Analysis

**Process Events** leading to Failure of vessel and release to environment – (4) and (7)

Equip / pipe failures like corrosion, flange leaks etc. and release to environment – (8)
The Bow Tie Representation

**Prevention**
(reduces frequency)

- BPCS
- ESD (SIS)
- PSV
- Operator procedure

**Hazardous event**
(Loss of Containment)

**Mitigation**
(reduces severity)

- Fire and Gas
- Fire suppression systems
- Emergency Procedures
Can I Take Credit for a FGS Loop in a LOPA?

- In a Layers Of Protection Analysis (LOPA) the intent is to prevent a Loss Of Containment (LOC) from occurring.

- FGS loops are generally NOT preventive layers and normally do NOT qualify as an Independent Protection Layer (IPL) in a LOPA.

- Additionally, gas leaks are generally not caused by the process but by equipment / pipe failure and no additional layers of protection can prevent these failures (note - regular maintenance and life of equipment is already considered in the initiating event frequency of 1 x 10^-5 in our example).

- Note – It depends on what one is trying to prevent. If the Hazardous event is considered as “serious personnel injury” instead of LOC, then FGS may qualify as a Prevention layer.
Performance Based FGS Design Process

ISA TR 84.00.07 – Guidance on the evaluation of Fire, Combustible Gas and Toxic Gas System effectiveness

Fire and Gas Hazard Assessment
1. Identify Areas of Concern
2. Identify Hazard/Risk Scenarios
3. Analyze Consequences
4. Analyze Hazard Frequency
5. Analyze Unmitigated Hazard/Risk

Requirement Specification
6. Identify FGS Performance Requirements
7. FGS Conceptual Design

Performance Verification
8. Verify Detector Coverage
9. Verify FGS Safety Availability
10. FGS Effectiveness of Actions
11. FGS loop effectiveness
Process Fire and Gas

Process unit in a refinery

Area of Concern Assessment
Ineffective Gas Detection Due to Inappropriate Detector Placement
Fire and Gas Detection Philosophy

• Ideally detect Fire or Gas leak at an incipient stage. By taking action based on early detection, the mitigation effectiveness of a F&G function also increases. Early detection is possible if:
  - Leak sources are identified by a good PHA / QRA study
  - Gas detectors are installed at locations close to the leak sources
• If a Fire or Gas leak develops into a major hazardous event, then the FGS mitigation system plays an important factor to reduce the severity of the harm.
Detector Coverage Assessment – Semi-Quantitative Method

**Scoring/Ranking System**

- Process Equipment
- Consequences
- Likelihood
- Occupancy
- Ignition Probability
- Pressure
- Congestion and Confinement

<table>
<thead>
<tr>
<th>Risk Grade</th>
<th>Exposure Definition</th>
<th>Hazard Rank</th>
<th>Gas Coverage Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Hydrocarbon processing, with high exposure</td>
<td>5 to &lt;7</td>
<td>90%</td>
</tr>
<tr>
<td>B</td>
<td>Hydrocarbon processing, with moderate exposure</td>
<td>2 to &lt; 5</td>
<td>80%</td>
</tr>
<tr>
<td>C</td>
<td>Hydrocarbon processing, with low or very low exposure</td>
<td>0.5 to 2</td>
<td>60%</td>
</tr>
<tr>
<td>No FGS</td>
<td>Risk is tolerable w/o benefits of FGS</td>
<td>&lt;0.5</td>
<td>No Target Coverage</td>
</tr>
</tbody>
</table>
Semi-Quantitative Method – Geographic Requirements

Methodology similar for gas and flame detection

<table>
<thead>
<tr>
<th>Risk Grade</th>
<th>Coverage Targets</th>
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<tbody>
<tr>
<td>A</td>
<td>&gt;90%</td>
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<td>B</td>
<td>80%</td>
</tr>
<tr>
<td>C</td>
<td>60%</td>
</tr>
</tbody>
</table>

Grade A:  
Grade B:  
Grade C:  

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Geographic Coverage Verification – Results

After placement of detectors in Appropriate locations
Detector Coverage Assessment – Scenario Based, Fully Quantitative Method

1. Identify Areas of Concern
2. Determine Extent of Hazards
3. Determine Undetected Hazard Frequency
4. Compare with Company’s Tolerable Frequency
5. Identify Hazard Escalation Reduction Requirements

Gas Release
- Wind blowing towards facility
- IE - 0.003/year
- Gas ignited
  - S1=0.6
  - F1=0.4
- Gas ignited
  - S2=0.3
  - F2=0.7

Undetected hazard frequency – Fire – 0.00054/year
Undetected hazard frequency – Gas – 0.00126/year
Residual Risk -0.012/year

Undetected Fire Hazard Frequency (HF) = 0.00054
End user Tolerable Frequency (TF) = 0.00001
Hazard Escalation Reduction Factor (HF/TF) = 54

Identify Hazard Escalation Reduction Requirements
Fully Quantitative Method – Requirements

• Company’s tolerable frequency – $1 \times 10^{-5}$

• Fire and Gas mapping needs to be done to reduce undetected frequency less than the Tolerable frequency

• Methodology similar for gas and flame detection
Scenario Coverage Verification – Results

- Company’s tolerable frequency – $1 \times 10^{-5}$
- Hazard Frequency comparable to tolerable frequency after placement of detectors in appropriate locations
Optimal Detectors and Appropriate Placement Based on Mapping
Mitigation Action Effectiveness

- Water Curtain Effectiveness
- Foam Effectiveness
- Dry Powder system Effectiveness
- Valve Trip Effectiveness
- Alarm Effectiveness
- Evacuation Effectiveness
FGS Availability Assessment – Results

Availability Calculation (1-PFDavg)
Summary

- Availability of FGS elements
- Proof Test Intervals

Table 2: Spurious Trips

| MTTFS (years) | 338.26 |

Pie charts showing PFDavg Contributions and MTTFS Contributions.
FGS Instrumented Function (FIF) Effectiveness

Detector coverage
- Gas
- Fire
- Flame
- Smoke
- ...

FGS Loop availability
- SIL3 PLC for F&G
- DCS
- Fire Alarm Panel for Buildings
- ...

Mitigation action effectiveness
- Dry Powder
- Expansion foam
- Water Curtains
- Annunciation Systems
- Shutdown systems
- ...

FIF Detection Effectiveness = Detector coverage x FGS loop availability

FIF Loop Effectiveness = FIF Detection Effectiveness x Mitigation action effectiveness
FGS Instrumented Function Detection Effectiveness

<table>
<thead>
<tr>
<th>Detector Coverage</th>
<th>FGS loop Availability</th>
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<tbody>
<tr>
<td>Say 90%</td>
<td>Say 99.9%</td>
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FIF Detection Effectiveness = 0.9 x 0.99 = 0.89 (89%)

With 89% Detection Effectiveness, we can be assured that approx. 90% of the Gas leaks will be detected and action (manual or automatic) can be taken at the incipient stages before this escalates into a major leak / hazardous event.
FGS Instrumented Function (FIF) Effectiveness

FIF Effectiveness = 0.9 x 0.99 x 0.9 = 0.80 (80%)

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<th>Mitigation Effectiveness</th>
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<td>Say 99.9%</td>
<td>90%</td>
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With 80% Effectiveness, not a good idea to assign a SIL value to a FGS Instrumented Function
Summary

Risk Assessment Report (PHA, QRA etc.)

FGS Function Required?

Yes → Geographic Coverage?

FGS detectors mapping to meet geographic coverage

# of FGS detectors

Final elements for Mitigation

No, Stop

Scenario Coverage?

FGS detectors mapping to meet target risk

# of FGS detectors

Total FGS IO count
Segregated Topology – Experion
Honeywell One-Stop Shop in F&G

Human Interface
- Experion Orion
- Experion industrial security
- Digital video manager
- Other advance applications like Alarm manager, PHD, eServer, Experion collaboration station
- First responder interface

Logic Solver & Networking Technologies
- SIL-3 solutions: Honeywell safety systems
- Fire alarm panels
- Public address/voice alarm systems
- Fire Networks, Bus & Ring Topologies
- OneWireless™ Infrastructure

Field Equipment
- Gas & Flame Detectors
- Addressable Fire Sensors & Devices
- Notification Devices
- HSSD point type or Aspirating early fire detection
- Process monitoring video systems
- Suppression Systems

Services
- Safety consulting services including Safety audits, Hazop and SIL verification & Validation
- Fire system design services including detector mapping
- Project services including Design, Engineering & Commissioning
- Project management
- Lifecycle support services & training

Honeywell One-Stop F&G Supplier
Safety Engineering Applications

HPS Global Safety Center of Excellence (COE) responsibilities include:

- Execute projects
- Provide Consultancy services (SIS – ESD, BMS and FGS)
- Support Engineering Excellence
- Training – Product and Processes
- Site services - System commissioning and Audits
- TAC, provide support to the regional offices Globally
F&G Solutions – Where Do You Find Us In The Demo Area?

INTEGRATED SAFETY & SECURITY
- Command and Control Suite
- DVM and Flare Watch Solution
- Integrated Fire and Gas Solutions
- Safety Manager A.R.T.

TERMINAL SOLUTIONS
- Terminal Manager
- Central Inventory Systems

SOFTWARE
- Symphonite Production Management
- Process Safety Analytics
- DynAMO Alarm & Operations
- Profit Control & Optimization
- UniSim Competency Suite
- UniSim Design

MODULAR & GAS SOLUTIONS
- Integrated Combustion Equipment Management
- Integrated Gas Metering Solutions
- Gas Software Solutions
- Elster Precision Solutions
- Midstream Gas

WIRELESS
- OneWireless Solutions
- Universal Wireless

DATA MANAGEMENT
- Experion PKS Orion
- Industrial Cyber Security

DATA ANALYTICS
- Unifomance Insight & PHD Cloud Historian
- Unifomance Asset Sentinel and Process Performance Monitoring
- Unifomance KPI and Enterprise Collaboration
- Secure Media Exchange (SMX)
- Industrial Cyber Security

EDGE DEVICES
- Experion SCADA Solutions
- Connected Worker
- SmartLine Connection Advantage
- ControlEdge PLC
- Matrikon OPC UA and OPC Foundation
- Experion LX

EXPERION & LEAP
- Experion Virtualization Solutions
- APEX Center
- Process Solution Suites for UOP
- LEAP / Auto Device Commissioning
- C300 and Series C I/O
- Integrated Open Protocols

LIFECYCLE INVESTMENT PROTECTION
- C200 & Batch Upgrade
- Spare Parts & Service Online
- Experion LCN
- EHPM On Process Migration and FSC to Safety Manager Migration
- Trace, Track & Respond Configuration Data Management
- Assurance 360

Spotlight Area

SM Cabinets

Fusion4

Experion Cabinets

LSS Cabinets