Review Paper

IDENTIFICATION OF MAJOR ACCIDENTS HAZARDS, PREVENTION & RECOVERY CONTROL MEASURES FOR CENTRAL GATHERING FACILITY

Karthikeyan S[1], Dr. Nihal Anwar Siddiqui[1]

Address for Correspondence

[1]Department of Health and Safety & Environment, University of Petroleum and Energy Studies, Dehradun, India.

ABSTRACT

This project is intended to present a practical approach to Identification of Major Accident Hazard, Prevention & Recovery Control Measures for Central gathering facility. To providing adequate control & recovery measure to eliminate the fixed fire protection system requirement for identified MHA area in order to minimize the Capital expenditures (CAPEX) and operating expenses (OPEX) for Central Gathering Facilities.

Wellhead area & Crude gathering involving flammable or combustible materials may hazardous environment which leads to major accident. To prevent such accident, various prevention and control measure are implemented as part of inherent safety system design.

The detailed Hazard Risk Assessment for Central Gathering Facility has been performed and suitable prevention measure such as Passive Fire Protection System and Hazardous Area Zone Classification are provided. Fire & Gas Detection system & Firefighting Equipment shall be providing as recovery control measures.

Hence, Central Gathering Facilities, ensured that a safe design is achieved which minimizes the damage caused to personnel, facilities, equipment, structures and the environment in case of an accidental event; and Reduced the likelihood of occurrence of an accidental event.

Keywords: Fire Protection, Wellhead, Risk Assessment, safe design, Central Gathering Facility.

INTRODUCTION

Central gathering facility belongs to the upstream activity to describe the production unit performing the first transformation of the crude oil after the production wells. The CPF is going to be installed as closed as possible to the production wells or offshore platform. The crude oil just collected from the wellheads can be directed by the shortest way to the CGF. If the main production of the field is crude oil, the purpose of the CGF is to separate the oil from the associated gas, the water, the sand and solvents or additives. The oil will be stored in tanks farm if onshore or floating storage unit (FSU) if offshore, before being carried out by pipeline or shipped by tanker. The water may be treated and disposed or re-injected to enhance the production.

SCOPE AND OBJECTIVE

The main aims and objectives of this research paper are:

☞ The scope of this study is to identification of possible fire scenarios that may occur at the central gathering facilities and to define the necessary prevention & recovery control measures.

☞ To identify expected major accidents hazards (MAH's) involved in central gathering facilities.

☞ To identify required fire prevention, detection and protection measures such as passive fire proofing requirement & Hazardous area classification for central gathering facilities.

☞ Ensured that a safe design is achieved which minimizes the damage caused to personnel, facilities, equipment, structures and the environment in case of an accidental event; and Reduced the likelihood of occurrence of an accidental event.

☞ To identify & ensure the fire safety system are in line the international codes and client standards are meeting.

DESCRIPTION OF CENTRAL GATHERING FACILTIES (CGF)

The production from the CGF will be achieved through 41 oil producer wells. The facilities at the CGF will not have any gathering capability. The Production from CGF will be transferred using Multiphase Pumps through an approximately 60 Km pipeline to Existing gathering before onward transfer into the main oil line.

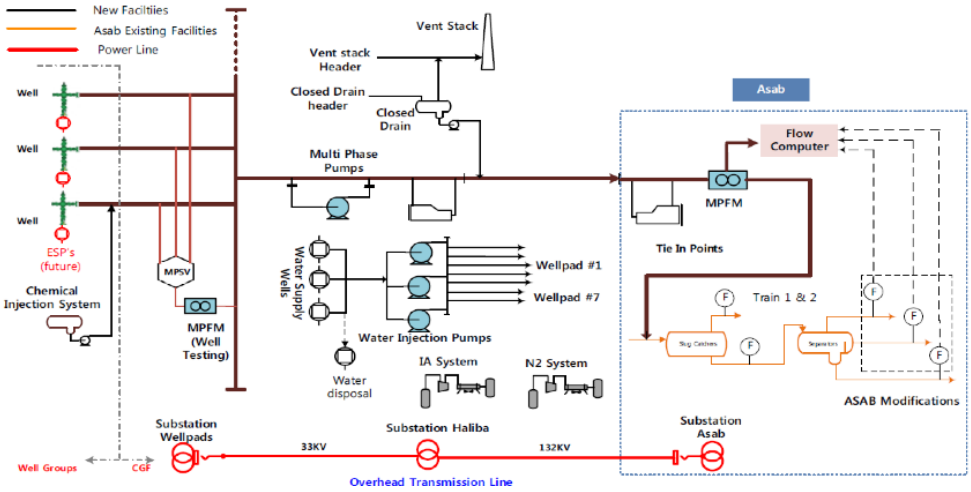


FIGURE 1: FLOR DIAGRAM – CENTRAL GATHERING FACILITIES

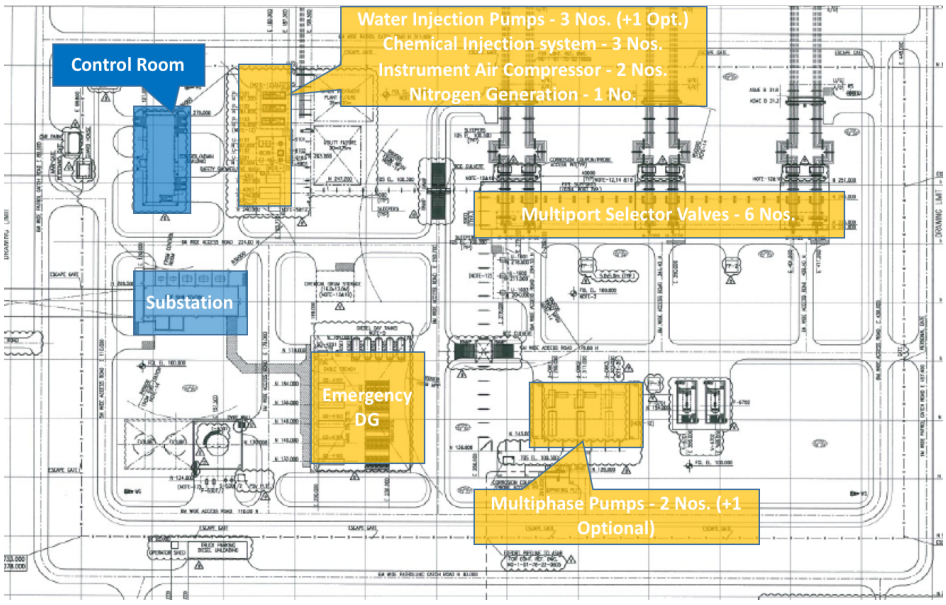


FIGURE 2: PLOT PLAN – CENTRAL GATHERING FACILITIES

The term "Central Gathering Facilities" (CGF) is used for facilities in CGF, which includes manifold, metering, pig launcher for export pipeline, water injection system, chemical injection system, Instrument air and nitrogen systems, closed drain and Vent/Flare stack, DG power generation, control building, substation etc.

METHODOLOGIES FOR FIRE PROTECTION ASSESSMENT STUDY

☞ The methodology adopted for this Fire Protection Assessment is summarized below;

STEP-01: Hazard Identification Based On Plot Area

STEP-02: Assess Area Wise Potential Fire & Explosion Hazards and Threats.

STEP-03: Identify the Suitable Mitigation Measure.

STEP-04: Implement the suitable detection and fire prevention measure.

STUDY ASSUMPTION AND DESIGN CRITERIA

☞ **Process Parameters:** The operating pressure and temperature for failure case scenarios were taken from Heat and Mass Material balance sheet.

☞ Design Temperature & Pressure.

☞ **Release Direction:** The releases from the above ground equipment and piping were modelled as horizontal. 1m height has been considered for release location.

☞ **Hole Size Parameters:** 25mm hole size has been used for modelling purpose for the basis of vessel spacing /fire protection requirements in accordance with Project HSE Philosophy.

☞ **Fluid Composition:** Design case material composition has been considered from H&MB to assess thermal radiation impact for CGF facilities.

☞ As per The Centre for Marine and Petroleum Technology (CMPT), A Guide to Quantitative risk assessment (QRA) for Offshore Installation, 1999 Edition, supports jet fire is applicable only for Ignited gas releases. However, On Conservative side, flange guards will be considered to minimizing the likelihood of a jet fire impinging an adjacent equipment/ support due to high pressure crude oil release (if any).

☞ Fluid is crude oil, pool fire events are more likely to occur in this section as the Multi-port Selector Valve (MPSV) and Multi Phase Pumps (MPP) are located at Grade level and Jet release from MPSV and MPP area will be significantly low considering flange guards, thus thermal radiation (12.5 kW/m2) effect from pool fire has been considered to finalizing minimum separation distance between multiport selector valve groupings and Multi-phase pump area.

☞ Possible jet fire due to damage of Instruments and instrument connection on HC equipment/pipes will be avoided considering no mechanical handling/ lifting carried out over instrument/ instrument connection during operation and maintenance without proper work permit system and lifting procedure/ plan to avoid dropped object hazard.

☞ Possibility of jet fire from piping leak or rupture due to corrosion will be avoided by proper material selection in design Stage. Horizontal impinged has considered for jet/pool fire as conservative approach.

☞ For obtaining conservative results, the facilities are always assumed to be in the downwind direction of the release and based on Manning philosophy details.

☞ 10 minutes release duration has been considered in accordance with HSE Technical Guidance.

☞ Inventory for consequence modelling considered based on size of the flow line, longest distance between well head area & CGF and process operating conditions.

☞ Thermal radiation criteria 12.5 kW/ m^2 will be utilised for finalizing minimum separation distances between

process equipment's.

HAZARD IDENTIFICATION AND ASSESSMENT

A Major Accident is an uncontrolled occurrence / incident that leads to Catastrophic or Severe consequences to the health and safety of people, assets, the environment and the company reputation(as defined in Code of Practice on HSE Risk Management).

☞ Identified MAH's from HAZID workshop are listed below.

- ➢ Multi-Port Selector Valve Manifold Area including MPFM
- ➢ Multi-Phase Pump (MPP) area
- ➢ Control Building and Substation
- ➢ DG Power Generation

AREA WISE HAZARD ASSESSMENT

Manifold Area Including Multi-Phase Flow Meter

- **Main Hazards:**

Potential loss of containment event involving incoming well fluid flow lines within the CPF , Multi port Selector valve (MPSV) and production manifold following ignition can result in Pool fire/ flash fire/Explosion or an unignited release may pose limited toxic release threat due to limited H2S content in the well fluid.

- **Fire Hazard:**

Jet fire – No jet fire scenario due to hydrocarbon gas is envisaged considering process fluid is crude oil and vapor fraction of mixture is very low (0.005).

Pool fire – Following a release from this section, due to rain out of the entrained liquid, a local pool formation is likely irrespective of the direction of leak and pool fire can result on its ignition. The results from consequences analysis with basis of initial release rate (33 kg/sec) with respect to available process conditions details, the pool fire arising from a 25mm hole size at Multi port Selector valve and production manifold(MSM) will leading to thermal radiation of 12.5kW/m2 to maximum distance of 40 meters.

Flash fire/explosion – As the well fluids have associated gases/vapours, on release will form a vapour cloud which will disperse and on ignition can result in flash fire or explosion. As the flow line and manifold areas will be open, explosion events generating high overpressures are not expected.

Proposed Prevention/Mitigation measures

Design Measures to minimize occurrence of such accidental releases:

Proper selection of material will help minimizing such releases.

Use of high integrity material for gaskets in flanges will assist in reducing such releases

Design to minimize the number of flange connections

Considering Flange guards for all flanges

Layout to avoid mechanical handling over live lines in order to avoid dropped object hazard

As the flow lines will be at grade, plant roads/ maintenance access should be arranged/design to prevent vehicular impact.

Ignition Control:

Hazardous area classification and use of electrical equipment and fittings suitable for use in the area will help reduce ignition risk of a flammable gas cloud.

Plant roads should be in general in unclassified area of the plant.

Unclassified equipment and facilities should be adequately separated from the process facilities. It is preferred that separation distances between these facilities is decided based on flammable gas dispersion study for credible leak sizes.

Fire & Gas Detection System:

Fire and Gas (F&G) detection in the area will facilitate an early detection and initiation of emergency response/ actions following an accidental release or fire scenario.

Proposed Recovery Control measures

Jet Fire Events

Jet fire events involving the flow lines located at Grade levels are very low likely to result in an impinged release, i.e. will result in a pool fire like scenario rather than jet fire considering following points.

No jet fire scenario due to hydrocarbon gas is envisaged considering process fluid is crude oil and vapor fraction of mixture is very low (0.005). Jet fire due to crude oil is unstable and volume / iso-inventory of hydrocarbon is small and such that pressure will reduce quickly. However, manifold area will be provided with flange guards (for all flanges located in MPSV areas) to avoid liquid jet and following fire.

Possibly of damage due to Instruments and instrument connection can cause jet fire will be avoided considering no mechanical handling will be carried out over instruments without proper work permit system and lifting procedure during operation and maintenance to avoid dropped object hazard.

Possibility of jet fire from piping leak or rupture due to corrosion will be avoided by proper material selection in design stage.

Pool Fire Events

Pool fire events are more likely to occur in this section as the flow lines are located at Grade level.

Effective control for pool fire events is through prompt isolation of the failed section to limit the inventory available for pool fire. Furthermore, in order to limit the pool fire duration and hence associated escalation, the area below Multi-port selector valves and flow lines (near production manifold area) should be paved and sloping towards a drainage system to remove the released inventory to a safe location.

In case the inventory available in the section cannot be minimized, means of depressurization/blowdown of the inventory to close drain/flare/vent should be considered.

Critical plant facilities, failure of which can result in major impact on plant operations should be located in such a manner to minimize getting impacted by credible pool fire events from this area.

In case the above measures are not feasible to be implemented and critical equipment can be subjected to high thermal radiation intensities, they would require to be protected with active fire protection means (such as fire water) or passive protection means (i.e. PFP/insulation).

In order to control and extinguish small pool fire events, mobile water foam trolley should be considered.

Passive fire protection of the critical plant structure & instrument (ESD valves etc.) subjected to high thermal radiation intensities for long enough duration to result in their failure, would also need to be provided with fire proofing of suitable rating (Jet fires and pool fire) and should survive the fire duration to minimize escalation.

Explosion

As the area is expected to be open and not confined, explosion threat is not major. However, measures such as quick shutdown & isolation of failed section on confirmed F&G detection and separation distances will help in minimizing the gas cloud size and hence the consequences.

Multi-Phase Pump Area

- **Main Hazards:**

Potential loss of containment event

involving Multi-phase pump area following ignition can result in Pool fire/flash fire/Explosion or an unignited release may pose limited toxic release threat due to limited H2S content in the well fluid.

Fire Hazard:

Jet fire – No jet fire scenario due to hydrocarbon gas is envisaged considering process fluid is crude oil and vapor fraction of mixture is very low (0.005).

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- Use of high integrity material for gaskets in flanges will assist in reducing such releases
- Design to minimize the number of flange connections
- Considering Flange guards for all flanges
- Layout to avoid mechanical handling over live lines in order to avoid dropped object hazard
- As the piping will be at grade, plant roads/ maintenance access should be arranged/design to prevent vehicular impact.

Ignition Control:

Hazardous area classification and use of electrical equipment and fittings suitable for use in the area will help reduce ignition risk of a flammable gas cloud.

Plant roads should be in general in unclassified area of the plant.

Unclassified equipment and facilities should be adequately separated from the process facilities. It is preferred that separation distances between these facilities is decided based on flammable gas dispersion study for credible leak sizes.

Fire & Gas Detection System:

Fire and Gas (F&G) detection in the area will facilitate an early detection and initiation of emergency response/ actions following an accidental release or fire scenario.

Proposed Recovery Control measures

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In case the above measures are not feasible to be implemented and critical equipment can be subjected to high thermal radiation intensities, they would require to be protected with active fire protection means (such as fire water) or passive protection means (i.e. PFP/insulation).

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Buildings (Substation and Control Building)

Main Hazards:

Flammable gas ingress from process area in case of loss of containment.

Fire Hazards inside the building.

Proposed Prevention/Mitigation measures

F&G (flammable & toxic) detectors provided at HVAC inlet together with gas tight dampers to avoid ingress of flammable gas into the building.

Smoke detectors should be considered at HVAC ducting to avoid smoke flow due to the plume and ceiling jet produced by the anticipated fire as well as any pre-existing ambient air flows that could exist in the protected compartment.

HSSD System for early smoke detection

Automatically activated fixed Inert gas extinguishing system on confirmed fire detection should be considered for building fire hazards.

Portable CO_2/DCP extinguishers should be considered for Electrical hazards in

Control buildings and substation.

DG Power Generation

Main Hazards:

Fire Hazards due to diesel handling.

Proposed Prevention/Mitigation measures

Safe separation distances should be maintained between Diesel Generator power generation and other process areas / critical facilities to ensure no credible fire or explosion impact to the system.

Bund provision around diesel tank with capacity of 110% of tank capacity.

Fire detectors (Heat) should be considered for Diesel Generator power generation area to provide early warning to personnel of potentially dangerous situations in terms of ambient flammable gas or fire.

Portable/Wheeled Foam Fire extinguishers should be considered near Diesel storage tank area.

Automatically activated fixed Inert gas extinguishing system on confirmed fire detection should be considered for DG power generator enclosure fire hazards.

Summary

The Fire Protection Assessment Study is performed to identify expected MAH's associated with the Central gathering facilities planned under CGF field development project and assess fire prevention, detection and protection measures in case of MAH events.

Based on detailed area wise hazard assessment performed for CGF field development project, two different options (Option 1 and Option 2) are proposed without fixed firewater system.

Option-1:

ESDV with fire proofing (to Isolate inventory between Wellhead flow line and CGF facilities)

ESDV's with fire proofing (at downstream of production headers and MPP by pass line)

Each one at production line connecting to Multi-Phase Pump (MPP)

One at Multi-Phase Pump (MPP) by pass line.

Curb walls (size as per standard civil design requirements) with proper sloping to a drainage system to remove accidental spill and proper disposal.

Curb walls for Multiport selector valve grouping (Each curb wall contain 2 no's of Multi-port selector valve (MPSV))

Curb wall for Multi-phase pump area with sloping to a drainage system to remove accidental spill and proper disposal.

Minimum separation distance (approximately 40m) between Multi-port Selection Valves (MPSV's) group based on 12.5 kW/m2 thermal radiation impact.

Option-2:

Manual isolation valve (to Isolate inventory between Wellhead flow line and CGF facilities)

ESDV with fire proofing (to Isolate inventory between MPSV and MPP area)

Bund wall (Size of 20*15*0.5).

Each bund wall contain 2 Multi-Port Selector Valves (MPSV).

Curb wall (size as per standard civil design requirements) with proper sloping to a drainage system to remove accidental spill and proper disposal.

For Multi-Phase Pump (MPP) Area

Minimum separation distance (approximately 75m) between each bund wall based on 1.6 kW/m2 thermal radiation considering no impact to people present in field and without thermal radiation impact operator can take preventive action by closing manual isolation valve located at battery limit

of CGF in the event of fire.

CONCLUSION

Among two options, Option-1 is concluded considering Safety, Operational, Maintenance and Cost benefit point of view.

Option-2 has not been selected considering the following factors,

In Option-2, Multi-port Selector Valves (MPSV) and associated piping's located inside the bund wall will be completely lost in case of fire at MPSV location, whereas extent of damage is limited in Option-1 considering fire extent is limited through minimizing HC inventory by automatic closure of emergency shutdown valves on confirmed fire and gas detection, passive fire protection and separation distances within the CGF facilities.

As per SHELL DEP 80.47.10.30 (Assessment of the Fire Safety of Onshore Installations), Section 2.5.2, "As a general rule, operators and/or FIT (First Intervention Team) members should not be exposed to >2.5 kW/m2 (>800 Btu/h·ft2) when dressed in "standard" inherently fire resisting PPE (e.g., coveralls). Hence Manual intervention in the event of fire is not allowed if radiation is higher than above specified.

Operation and maintenance point of view.

Comparatively higher cost than option-1 with above risk involved.

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