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# Hazard and Operability (HAZOP) Study on LNG Skid

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***Abstract*: This study aims to investigate the potential hazards and Incidents that might occur in the LNG skid and to assess existing safeguards and recommends effective solutions if required to enhance the overall safety standards at the LNG skid area. This research is based on a qualitative Hazard Identification and Risk Assessment (HIRA) method called as Hazard and Operability Studies (HAZOP). This risk assessment technique was performed to identify the various potential accidental events and worst case scenarios in the LNG skid area which is a structured and systematic technique that provides an identification of the hazards and the operability problems using logical sequences of deviation-cause-consequence of process parameters, it analyses all the existing critical equipment using process flow diagrams (PFD) and piping and instrumentation diagrams (P&ID) to pin point and identify the source of hazards that can cause harm to personnel, assets and the environment. The results were to identify causes, consequences and safeguards for the hazards related to all the possible ways of accident in the LNG skid. This approach has been applied to the analysis the existing safety features in the LNG skid which is under construction. The results showed that HAZOP is a useful technique to identify the potential sources of human errors, machine faults, multiple or common cause failures and correlation of cause-consequence of hazards during the HAZOP process and proper preventive measures were suggested in the required areas of the LNG skid.**

***Keywords*: LNG, HIRA, HAZOP, PFD, P&ID.**

## 1. Introduction

Hazard Identification and Risk Analysis (HIRA) is an investigation method to study the need of risk management and to identify risk at an early stage and take the necessary steps or measures to mitigate its harmful effects. HIRA is a process of defining and describing hazards by characterizing their probability, frequency and severity and evaluating adverse consequences, including potential loses and injuries. For any industry to be successful the production requirements are not only sufficient but also maintain a safer working environment. The industry has to identify the hazards, assess the associated risks to tolerate level on a continuous basis, risk assessment has been performed based on risk assessment guidelines and standards.

### *A. Objective*

The main objective of the study is

- To analyse the process and find its drawbacks.
- To identify potential hazards in LNG skid area.
- To identify operability problems in the process.
- To review the existing safeguards measures for the identified hazard event.
- To recommend additional safeguards for skid if required.

## 2. Methodology

HAZOP stands for Hazard and Operability study, which was first introduced in the chemical industries. HAZOP is a very popular Risk Assessment Technique that is used in many industries, but mainly in the Process Industries, such as Oil and Gas, Chemical, Petrochemical, Fertilizers, Power generation and so on. Thus, HAZOP is primarily used as a Risk Assessment technique, even though it has the word “operability”. It is also used to test the operability aspects of a plant, but it is more used for analysing safety.

HAZOP can be defined as a structured qualitative risk assessment technique, that uses “guide words” along with “parameters” to analyse the possible deviations in a process node. These deviations are then analysed based on its existing safeguards and proposed additional preventive measures to reduce the risk if current safeguards are insufficient.

- Piping and instrumentation diagram (P&ID)
- Selection of nodes
- Identify design intent
- Identify process deviation
- Identify Cause of deviation
- Assess all consequences of every cause
- Assess with existing safeguards
- Recommend additional measures if required

### *A. Process Flow*

The purpose of the LNG skid is to Supply the process plant with pure LNG at required pressure level without any interruption or down time, the process starts with a 6” pipe to the skid area via underground which delivers LNG gas at 60 – 90 bar pressure to the skid. The pipeline rises above ground inside the skid and directed to the GOV which acts as the gateway for the LNG to the skid area. Then the gas is directed to the filtration unit to remove unwanted solid or liquid particles

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Table 1
Common causes

| S.No. | Causes | Safeguards |
|---|---|---|
| 1 | Machine, Material and equipment's failure | • Use of Machines and equipment's based on PESO and OISD standards and guidelines.<br>• The pipeline and equipment's materials are selected according to the LNG properties and design intent.<br>• Installation of all required safety devices in required areas according to the safety standards. |
| 2 | Corrosion | • Use of cathodic protection to prevent corrosion<br>• Use of corrosion coupon to monitor the pipeline corrosion condition |
| 3 | Incorrect operation | • Use of proper standard operating procedures and methodologies,<br>• Proper audit and maintenance of skid on regular intervals. |
| 4 | Excavation damage | • Markings of underground pipelines,<br>• Selection of trained machine operators,<br>• Addition of supervisors to monitor workers. |
| 5 | Poor construction | • Selection of location and Construction of skid based on OISD and PESO guidelines and standards. |
| 6 | Vandalism | • The entire skid is completely fenced<br>• Installation of 360-degree Motion sensing camera in the skid |
| 7 | Others | • Used only for design intent<br>• No Residual pipelines<br>• Proper training for workers |

Table 2
Existing safeguards

| S.No. | Location | Device | Functions |
|---|---|---|---|
| 1 | LNG Skid area | Open path gas detector | Gas detector |
| 2 | | Point gas detector (LEL) | Gas detector |
| 3 | | Pressure relief valve | Relives gas if pressure reaches above the range |
| 4 | | Creep relief valve | Relieves high creep pressure in pipeline |
| 5 | | Non return valve | Stops reverse flow of fluids in pipeline |
| 6 | | Pressure transmitter | Transmits gas pressure to SCADA |
| 7 | | Temperature transmitter | Transmits gas temperature to SCADA |
| 8 | | Flame arrestor | Quenches Vent gas flame if ignited |
| 9 | | Lightning arrestor | Attracts and captures lightning in its range area |
| 10 | | Earth pit | Enclosure to access and maintain electrodes |
| 11 | | Corrosion coupon | Sacrificial metal used to detect corrosion condition |
| 12 | | Flame proof devices | If Ignited, sparks will not transmit outside enclosure. |
| 13 | | Surveillance camera | To monitor or observe a particular area constantly |
| 14 | | 360º Camera with motion sensor | If the sensor detects motion, it start recording immediately |
| 15 | | Manual calling point | Device to manually initiate the alarm |
| 16 | | Emergency stopping device | Device to manually stop all the devices |
| 17 | | Beacon | A light set up in a visible position as a warning signal. |
| 18 | | Hooter | Device to alert workers to an emergency using sound |
| 19 | Control room | Manual Call Point | Device to manually initiate the alarm |
| 20 | | Smoke detector | Device to detects smoke in a particular area |
| 21 | | Temperature sensor | Device used to measure the temperature of MC or area. |
| 22 | | Hooter | Device to alert workers to an emergency using sound |
| 23 | | Beacon | A light set up in a visible position as a warning signal. |

(<3 microns) such as rust, dust particles, ice formation, particulate matter, oil, water, and other unwanted substance in the LNG. Once filtered the gas is then sent to metering unit to measure the amount of gas consumed or received by the plant, then the gas reaches the pressure regulator area where the gas pressure is reduced from (60-90 bar) to (2.5 – 4 bar). The gas now reaches a flow control unit to which is used to regulate the flow or pressure of a fluid and sends it to the process shops via pipeline.

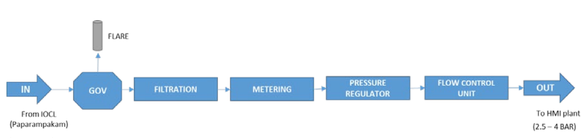


Fig. 1. Process flow

## B. Piping and Instrumentation

It is important to identify the processes in operations, be familiar with the process/piping and instrumentation diagram (P&ID). P&ID are drawings or diagrams that provide the visual representation of interconnected processes, equipment, and controls in the physical plan

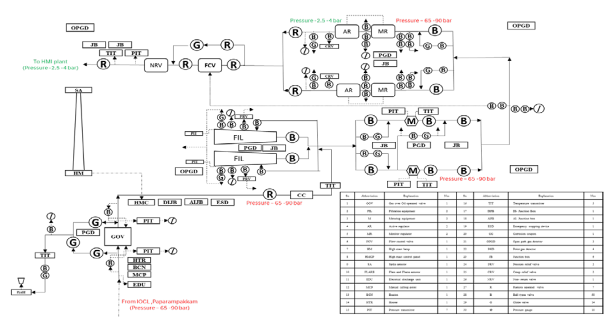

Fig. 2. Piping and Instrumentation

Table 3
HAZOP worksheet

| S. No. | Deviation | Cause | Consequences | Safe guard | Recommendations |
|---|---|---|---|---|---|
| 1 | No Flow | 1.1 Pipeline leak<br>1.2 Pipeline leak before GOV<br>1.3 GOV Stuck close<br>1.4 ROV Stuck close<br>1.5 Valves Stuck close | 1.1 Gas leak leads to fire and explosion.<br>1.2 Builds up over pressure inside pipeline.<br>1.3 Down time at various shops | 1.1 Use of gas detectors (PGD) interlocked with SCADA<br>1.2 ESD installed<br>1.3 Bypass line provided for GOV<br>1.4 N2 cylinder backup provided or can be operated manually.<br>1.5 Use of pressure transmitter to monitor incoming pressure<br>1.6 Manually operatable ROV and globe valves<br>1.7 Regular maintenance and periodic inspection<br>1.8 Isolation valves provided | 1.1 Installation of ROV in a pit near the HMI plant compound interlocked with SCADA. |
| | Low flow | 1.1 Pipeline leak<br>1.2 GOV partially open<br>1.3 ROV partially open<br>1.4 Valves partially open | 1.1 Gas leak leads to fire and explosion.<br>1.2 Builds up over pressure inside pipeline.<br>1.3 Process upsets at various shops | 1.1 Use of gas detectors (PGD) interlocked with SCADA<br>1.2 ESD installed<br>1.3 Bypass line provided for GOV<br>1.4 N2 cylinder provided in GOV as failsafe unit.<br>1.5 Use of pressure transmitter to monitor incoming pressure<br>1.6 Manually operatable ROV and globe valves<br>1.7 Regular maintenance and periodic inspection<br>1.8 Isolation valves provided | |
| | High flow | -NO CONCERN as skid is designed for maximum flow rate 120bar and intel pressure is capped at 90bar- | | | |
| | Back flow | Pressure difference in skid is lower than supply. | - NO CONCERN- | | |
| 2 | Low pressure | -Refer less flow- | | | |
| | High pressure | -Refer no flow- | | | |
| 3 | Low temp | 3.1 Low ambient temperature | -No concern as skid is designed and built for Cryogenic gas- | | |
| | High temp | 3.1 High ambient temperature<br>3.2 External fire/ heat source | 3.1 No Hazard present as the skid is designed for maximum ambient temperature.<br><br>3.2 Possible crack or rupture to pipeline and leads to explosion | 3.1 PGD provided<br>3.2Temperature transmitters provided<br>3.3 Use of Flame proof devices<br>3.4 ESD installed<br>3.5 Hooter and beacon to indicate emergency<br>3.6 Continuous monitoring via SCADA<br>3.7 Isolation valve at multiple points<br>3.8 Fire monitors<br>3.9 Portable firefighting equipment<br>3.10 Use of non-sparking tools (Brass) | 3.1 Use of mist type fire monitors instead of jet type monitors |
| 4 | Rust | 4.1 Poor selection of pipeline material<br>4.2 Environment conditions.<br>4.3 Poor Weather<br>4.4 Moist atmosphere<br>4.5 Reaction of pipeline with LNG<br>4.6 Underground pipeline reaction. | 4.1 Pipeline corrosion leads to gas leak<br>4.2 Possible equipments corrosion results in malfunction. | 4.1 Pipeline and equipment materials are selected based on PESO and OISD standards.<br>4.2 Use of corrosion coupon<br>4.3 Use of corrosion protective paint over pipeline<br>4.4 Preventive inspection and Regular maintenance<br>4.5 Pipeline NDT test annually<br>4.6 Pipeline audit on regular intervals. | 4.1 Installation of Cathodic protection equipment in pipeline |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Impurities | - NO CONCERN- | | | |
| 6 | Failure/ Electric spark | 6.1 Electrical discharge unit fails<br>6.2 MCP failure<br>6.3 BCN malfunction<br>6.4 HTR malfunction<br>6.5 PIT or TIT failure<br>6.6 GOV Failure<br>6.7 PGD failure<br>6.8 Flame arrestor failure.<br>6.9 Electrical ignition | 6.1 Electrocution occurs<br>6.2 Fails to initiate alarm signal<br>6.3 Fails to alert the emergency situation<br>6.4 Incorrect reading on pressure transmitter.<br>6.5 Unable to detect gas leak if PGD fails.<br>6.6 Ignited gas backflow leads to pipeline explosion<br>6.5 During gas leak a spark from any equipment might trigger an explosion. | 6.1 Interlocked with SCADA and notifies if fails<br>6.2 All the equipment's were inspected and maintained periodically.<br>6.3. Functional test done every six months<br>6.4 Use of pressure gauge as a failsafe system.<br>6.5 N2 backup provided or can be operated manually.<br>6.6 PGD is interlocked with SCADA which notifies if fails.<br>6.7 Secondary MCP provided in control room<br>6.8 All the devices and equipments used were Flame proof devices | 6.1 Installation of MCP near the secondary exit.<br>6.2 Addition of In-line flame arrestor in flare line as a fail-safe system for flare.<br>6.3 Installation of level gauge for GOV oil cylinders<br>6.4 Installation of pressure gauge for N2 cylinder n GOV |
| 7 | | 7.1 Possible electrical discharge in pipeline<br>7.2 Electrical discharge in equipments and devices | 7.1 During gas leak electrical discharge from any equipment acts as an ignition source. | 7.1 All the pipelines, equipments, devices and flare unit were earthed properly.<br>7.2 Bonding of flanges and joints in pipeline. | |
| 8 | Gas leak via equipments | 8.1 Pressure transmitter failure<br>8.2 Temperature transmitter failure<br>8.3 Pressure gauge failure | 8.1 Any leak from equipment failure leads to fire and explosion | 8.1 All equipments are installed with isolation valves. | 8.1 Isolation valves flow chart must be provided. |
| 9 | Flare failure | 9.1 Ignition of flare vent gas<br>9.2 Electrical discharge in flare pipe, | 9.1 Vent gag ignition flashbacks in pipeline and leads to explosion.<br>9.2 Electrical discharge might become a potential ignition source | 9.1 End type flame arrestor installed on flare.<br>9.2 The flare pipe is earthed properly | |

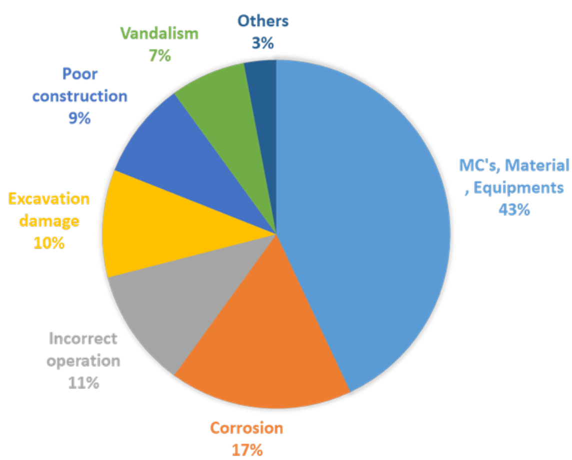

Fig. 3.

## C. Recommendations

The recommendations given below are either horizontal implementation of similar hazardous areas or mandatory standards based on OISD and PESO standards and guideline.

1. De-Energizing unit
2. Additional ROV
3. Secondary Fire tender Access
4. Ex – approved devices
5. Pipeline markings
6. Control room alternate exit
7. Mist type monitor
8. In-Line flame arrestor
9. Electrical panel suppression system
10. Gas odoriser
11. Additional MCP
12. Cathodic protection

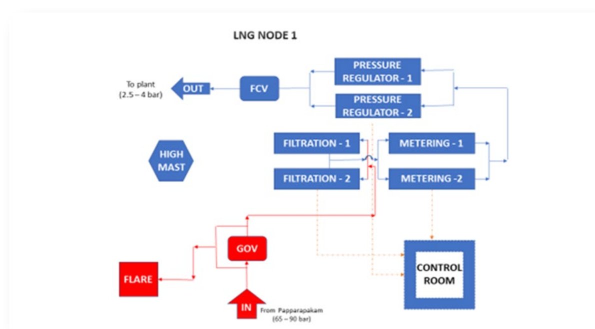

Fig. 4. LNG SKID (NODE - 1)

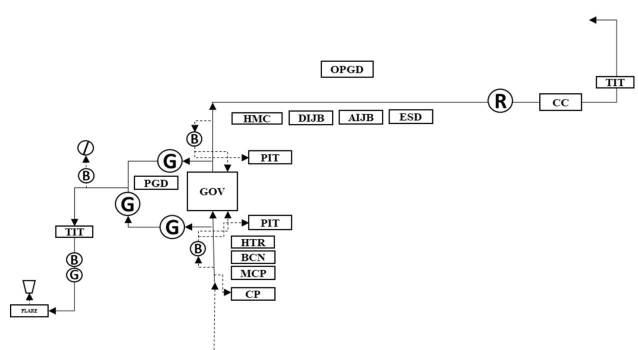

Fig. 5.

## 3. Conclusion

The present study aimed to assess the potential risk and to find ways to reduce or eliminate those hazards in the LNG skid at HYUNDAI MOTOR INDIA using the HAZOP technique. More than 50 LNG accident case studies were collected and analysed to find the common cause of accidents and drawbacks in gas pipelines.

As the safety systems assessed were evaluated as adequate for the hazards identified during this project, the results showed that the skid area is designed, built and installed with all the necessary safeguards in such a way that it counters most critical deviations that might occur in the process.

The findings also showed that the few areas with a minimum hazardous situation need to enhance the controls, with the help of this risk assessment tool, the hazards are calculated with the severity and probability in every possible location in the skid area and were recommended with suitable preventive measures where it is required. The present study's findings can be a guideline for predictive maintenance and planning requirement training programs for the skid operators and maintenance crew, therefore improving the safer environment in the LNG skid area.

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