

Evaluation of Fire Protection & Emergency Response and Disaster Management Plan for natural Gas Pipeline Installation

Sarath Kumar V¹ Dr. Nihal Anwar Siddiqui²

¹M. Tech Student ²Associate Professor

^{1,2}Department of Humanities and Science Engineering

^{1,2}University of Petroleum and Energy Studies

Abstract— The natural gas processing and distributing industry operates widely distributed huge pipeline installations over large geographical areas. Loss of containment of natural gas from any point in this pipeline supply network may have disastrous consequences on life safety and investment. The industry currently has considerable experience gathered from such incidents in the past in the country. Learning lessons from such incidents, modern installations for natural gas distribution need to be better designed and equipped to address the risks involved. In order to prevent disastrous incidents that leave behind painful loss statistics of precious lives and public wealth, a thorough review of the fire protection philosophy and up gradation of both hardware and software control measures are required. This work critically analyzes natural gas supply network from the perspectives of fire safety and reviews the adequacy of protective measures against codes and applicable standards. Recommendations have been formulated for improved safety of the installation in line with industry best practices.

Key words: Fire Protection, Emergency Response, Disaster Management

I. INTRODUCTION

This project aims to evaluate the Fire protection systems available at the different facilities of a natural gas pipeline network viz Compressor Station, Main Line valve Station, Metering & Regulating Station transporting natural gas with the existing applicable national codes ,standards and regulations .This project also evaluates the emergency response and disaster management plan prepared for handling the emergency comparing it with the existing applicable national codes ,standards and regulations . The evaluation has been carried out by reviewing the available system and the control measures put in place on site and analyzing its effectiveness.

Evaluating the following aspects of one of the Compressor Station laid along the pipeline network.

- a) Fire protection system effectiveness
- b) Emergency response preparedness and its effectiveness.

The objective of this project is to study the existing Fire protection systems and emergency preparedness system as these systems are critical and vital for the protection of life, property and damage to the environment and explore practically feasible improvement options for the available system by a better fire protection and an emergency management practices with the help of applicable codes, standards and law and also in the light of experiences learnt from different similar industries across.

The overall objectives of ERDMP are

- a) Preserving life, assets and environment from the emergency incident.

- b) Ensuring availability of adequate resources including trained & competent manpower
- c) Systematically coordinate the emergency to prevent escalation to minimize impact on company assets, public property and environment.
- d) Provide clear line of authorities & responsibilities to Emergency Response Team and Emergency Management Teams.
- e) Controlling emergency in a shortest possible time and restoring the operation.
- f) Assist Government authorities in preparation of off-site emergency / Emergency Response Plan and co-ordinate during off-site Emergency /Disaster if requested.
- g) Notification of incident as per statutory compliances wherever applicable

In spite of sound design and engineering methods and practices followed if proper care is not taken during operation, maintenance and inspection, the facilities & pipeline can pose major threat to people, workers, assets, environment and public due to major emergency. Emergency Response & Disaster Management Plan (ERDMP) transforms the chaos of an emergency into well managed response. If implemented correctly, the ERDMP minimizes the consequences of an emergency through rapid, effective and coordinated response of all team members.

ERDMP works well in emergency response situations because it organizes essential information and resources into a logical structure in order to plan and carry out the required actions. It also provides an Emergency Response, Emergency Management and Crisis Management organizational structure that can handle any type or size of emergency.

The project work methodology adopted for information gathering and site specific study included the followings.

- a) A detailed study of the latest existing trend in the fire protection systems for the natural gas pipeline installations by reviewing the Fire design basis, fire protection philosophy documents.
- b) A detailed evaluation of the existing Emergency Response plan and Mock drills conducted at the site.
- c) A sample Site visit to the one of the Compressor Station located in the pipeline network for assessing the physical situation and, to understand and assess ground level conditions and on-site fire protection and emergency preparedness arrangements.

Discussions and brainstorming with various related discipline specialists and professionals on site to arrive at final conclusions

II. STATUTORY, LEGAL ASPECTS, APPLICABLE CODES & STANDARDS

A. General

The overall design of natural gas distribution network and provision of safety systems for operation as well as maintenance practices rely upon applicable local laws, national as well international standards & codes and industry best practices.

B. Fire Protection System

The following codes and standards have been considered for design and installation of fire protection systems. Any conflict between codes shall be resolved by applying the most stringent requirement

- Indian Insurance Regulations (formerly known as TAC Rules).
- National Fire Protection Association (NFPA)
- Oil Industries Safety directorate (OISD)
- Internal (Organizational) Standard on Fire Safety Management
- Internal (Organizational) Standard on Fire Protection Equipment and System

C. Emergency Response and Disaster Management Plan

The following codes and standards have been considered for developing Emergency Response and Disaster Management Plan along with the best practices followed in the industry.

As per the Section 41-B (4) of the Factories Act, 1948 and Rule 13 (1) of the Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rule- 1989, PNGRB (Codes Practices for ERDMP, Regulations 2010, Environment (Protection) Act, 1986, National Disaster Management Guidelines for Chemical Disaster-2007, Explosives act 1884, Petroleum Act 1934, PLI 1991, National Environmental Tribunal Act-1993 it is mandatory for the occupier to:

- Prepare on-site and off-site Emergency Response and Disaster Management Plan,
- Provide information of on-site emergency plan to all employees liable to be affected by the major emergency,
- Conduct emergency mock drills to train the employees, review the emergency preparedness and response to handle the major emergency.

III. METHODOLOGY

The methodology adopted for information gathering and site specific study included the followings.

- A detailed study of the latest existing trend in the fire protection systems for the natural gas pipeline installations by reviewing the Fire design basis, fire protection philosophy documents.
- A detailed evaluation of the existing Emergency Response plan and Mock drills conducted at the site.
- A sample Site visit to the one of the Compressor Station located in the pipeline network for assessing the physical situation and, to understand and assess ground level conditions and on-site fire protection and emergency preparedness arrangements.

- Discussions and brainstorming with various related discipline specialists and professionals on site to arrive at final conclusions.

IV. DESCRIPTION OF PROCESS

A. Compressor Station

Compressor stations are provided at strategic points to boost the pressure of gas being transported through the pipeline from one compressor station to the next compressor station. The compressor station has following facilities:

- Gas Turbine (GT) driven gas compressors
- Gas Engine Generators (GEG) for power generation
- Diesel Engine Generator (DEG) for emergency power generation.
- Gas After Coolers
- Scrubbers
- Electric Sub-substation
- Pig launcher and receiver
- Local Control Centre
- Emergency Shut-Down (ESD) and Emergency Blow-Down (EBD) system

Natural Gas (NG) enters the compressor station through the main pipeline. The gas is then directed to the station suction valve. Station by-pass is located between the suction & discharge valve of compressors which is closed during normal operation and opened when the station is shut down and to be by passed. From the station suction valve, the gas enters the scrubber inlet and enters the suction side of the compressor. NG is then compressed through centrifugal compressors and pushed into the compressor station discharge lines connected to the discharge header, which then goes to the gas after cooler unit.

Natural gas is a highly flammable, odorless, colorless gas. It is non-toxic but it asphyxiates if present in excess concentrations in the atmosphere.

B. Pipeline

The main NG pipeline of X-70 grade is constructed and laid as per OISD standard OISD-141 from Off-Shore Terminal in Andhra Pradesh to the compressor station in Gujarat. Minimum one meter depth top soil cover from the top of the pipeline is ensured throughout the length to prevent damages due to third party interference. Pipeline is cathodically protected to prevent the pipeline from external corrosion.

C. Main Line Valve (MLV) and Metering & Regulating (M&R) Station

Main Line Valve (MLV) stations are installed along the pipeline route at appropriate spacing in accordance with the requirements of design codes, OISD 141/ASME B 31.8, for isolation of a pipeline section in case of any emergency or repair/maintenance work.

Each M&R station is provided at strategic locations based on the customers along the pipeline route. Each M&R has mainline block valves and blow down piping fitted with QOEC (Quick Opening End Closure) for evacuation of gas.

D. Main Pipeline Operations Centre

Process parameters of compressor station facilities, Remote MLVs and Metering and Regulating stations are continuously monitored, analysed and controlled using

SCADA (Supervisory Control and Data Acquisition) system. SCADA system is monitored on 24x7 by the main pipeline operation centre at Head office.

Emergency Control Centre at Site

Each site has an Emergency Control Centre (ECC) in Local Control Centre building.

E. Process Safety and Shut-Down Systems

Safe de-pressuring of station piping in the event of a unit upset or when the station requires maintenance is achieved by directing the gas pressure to a blow down vent. A blow down vent is a vertical pipe, equipped with sound-reducing equipment that is open to the atmosphere and connected to the compressor piping by both manual and automatic valves. In an emergency, the station and unit inlet and discharge valves close, the emergency vent valve opens, and gas releases to the atmosphere, reducing station pressure. All vents are designed to stand safely and discharge the gas at a level of 3 m above washing platform.

1) Emergency Shutdown (ESD) System

The ESD system is independent from the process control system, but arranged to receive signals from process control parameters and fire and gas system to generate alarms to the other systems for display of shutdown alarms on screen.

V. IDENTIFICATION OF FIRE & EXPLOSION HAZARDS

An important part of understanding the effectiveness and credibility of the existing fire protection system as well as the emergency response system is by identifying a potential worst case emergency scenario which include a gas leak leading to a major fire leading to a major emergency scenario that can occur at the site.

VI. RISK ASSESSMENT

Detailed Risk Analysis of the entire installation are carried out identifying the major risks and threats that could happen along the pipeline installations as well as Quantitative Risk Assessment (QRA) and On-site & Off-site Disaster Management Plan are also prepared.

The Individual Risk per Annum (IRPA) levels discussed in IS-15656 and in EP95-0352 leads to a risk region approach called as "ALARP". The Individual Risk per Annum as per the QRA output of the pipeline System is 9.17567×10^{-6} /Year, which on comparison with the below ALARP triangle represents the region lower than 10^{-5} & above 10^{-6} . This region is the "Broadly Acceptable risk region".

Hence the IRPA of the pipeline System is "Broadly Acceptable Risk Region". Risks including existing control measures and additional control measures required during operations and maintenance and construction phases are identified and documented in the Risk Register.

A. Risk Mitigation and Emergency Prevention Measures

The pipeline is designed as per ASME B 31.8 and PNGRB T4S regulations 2009. Following risk mitigation measures have been implemented to ensure integrity and safety of the pipeline operations.

B. HSE Management System

Systematic application of management policies, good safety practices & guidelines, safety procedures and

implementation of the investigation findings are ensured through Health, Safety and Environment Management System.

- a) Health Safety and Environment (HSE) Policy & HSE organization set-up.
- b) Proper site lay out and inter facility distances & operation of facilities using SOP / SMPs.
- c) Safety Committees with fair participation of employees and contract workers.
- d) Safety audits and Inspections carried out with the help of prescribed checklists. The periodicity and guidelines for inspection as per regulations of Petroleum and Natural Gas Regulatory Board on process / procedure / methodology are followed for ensuring adherence and its protocol for third party confirmatory assessment.
- e) Work permit system (including confined space and entry permit)
- f) Investigation of all incidents including minor ones and near miss cases followed by implementation of corrective actions.
- g) Fire Prevention and Fire Protection System.
- h) Emergency Mock Drill for Employees, Contractors/Visitors including assembly points and Escape route.
- i) Safety briefing in regional and English language to all visitors and safety induction training to all contractor worker (Audio /Visual Aid).
- j) Training and evaluating employees & contractors on health and safety practices.

C. Existing Controls

1) Fire Protection System Availability at the installation

The level of fire protection systems in the site is determined by identification of fire hazards, the facility design, and the criticality of equipment, the plant layout & the plant manning. The principal objectives of fire protection systems are to

- 1) Minimize the risk and consequences of an accidental event
- 2) Minimize the potential for hazardous occurrences
- 3) Ensure a safe working environment for personnel
- 4) Ensure adequate means of escape are provided
- 5) Provide appropriate fire protection systems to rapidly bring under control and extinguish any reasonably foreseeable fire which could develop during normal operations
- 6) Minimize the potential for pollution of the environment from accidental spills, venting or flaring of hazardous materials.

D. Fixed Fire Protection Systems

Considering the hazard and the equipment to be protected, the various fixed fire protection systems and facilities provided are

1) Type of Protection System

- 1) Fire water tanks
- 2) Fire Water Pumps
- 3) Fire water network, hydrants and monitors
- 4) Deluge water spray system.
- 5) Gaseous extinguishing system
- 6) FM-200 total flooding system
- 7) CO2 total flooding system
- 8) Fire and Gas Detection system.

VII. EMERGENCY RESPONSE AND DISASTER MANAGEMENT PLAN (ERDMP)

A written Emergency Response and Disaster Management Plan is available at control center and other key locations. Mock drills are conducted to test the effectiveness of the ERDMP frequently.

A. Objectives

The overall objectives of ERDMP are:

- a) Preserving life, assets and environment from the emergency incident.
- b) Ensuring availability of adequate resources including trained & competent manpower
- c) Systematically coordinate the emergency to prevent escalation to minimize impact on company assets, public property and environment.
- d) Provide clear line of authorities & responsibilities to Emergency Response Team and Emergency Management Teams.
- e) Controlling emergency in a shortest possible time and restoring the operation.
- f) Assist Government authorities in preparation of off-site emergency / Emergency Response Plan and co-ordinate during off-site Emergency /Disaster if requested.
- g) Notification of incident as per statutory compliances wherever applicable

In spite of sound design and engineering methods and practices followed if proper care is not taken during operation, maintenance and inspection, the facilities & pipeline can pose major threat to people, workers, assets, environment and public due to major emergency. Emergency Response & Disaster Management Plan (ERDMP) transforms the chaos of an emergency into well managed response.

B. Classification of Emergencies

As per PNGRB (Code of Practices for Emergency Response and Disaster Management Plan) Regulations, 2010, emergencies are categorized into three broad levels based on seriousness and resources requirements:

The matrix for assessment of the level is given in Site.

C. Levels of Emergencies

Emergencies are categorized into three broad levels (As per PNGRB-Sec 06) on the basis of seriousness and response requirements, namely

1) Level-I

This is an emergency which-

- 1) can be effectively and safely managed and contained within the site, location or installation by the available resources
- 2) has no impact outside the site, location or installation

2) Level-II

- 1) This is an emergency or an incident which cannot be effectively and safely managed or contained at the location or installation by available resources and additional support is alerted or required;
- 2) is having or has the potential of an effect beyond the site location or installation and where external support of mutual aid partner may be involved;

- 3) is likely to be danger to life , the environment, to an industrial assets or reputation

3) Level-III

This is an emergency or an incident with-

- 1) Off-site impact which could be catastrophic and is likely to affect the population property and environment inside and outside the installation
- 2) And management and control is done by district administration

Although the level III emergency falls under the purview of District Authority but till they step in, it should be responsibility of the organization to manage the emergency.

D. Pre-Emergency Preparedness

Pre-emergency planning and training are essential elements of ERDMP for prompt and effective response during an emergency. Pre-emergency preparedness includes alarms evacuation plan, arrangement with local authorities, training etc. which are detailed below

E. Supports from Mutual Aid Members

During emergencies, it may be necessary to seek the support of neighbouring industries in order to provide additional quantities of safety, fire fighting materials & equipment etc. This will help in a greater way to control the emergency that may escalate beyond the capability of the site. To avail /render the help during emergency, Emergency Response Team Leader should become a member of the existing mutual aid schemes available if any in that area.

F. Arrangement with External Agencies

In order to get timely help from external agencies during the emergency which cannot be managed using available resources, Emergency Response Team Leader shall establish contacts & maintain relations through regular meetings. The expected help from external agencies are listed below

- a) Fire Services: Additional fire fighting facilities/ equipment etc.
- b) Police: Control & evacuate public and regulate the traffic during major evacuation.
- c) Private / Civil Hospitals: Ambulances, doctors for treatment of casualties.
- d) Factory Inspectorate & State Pollution Control Board- to seek information regarding the impact to surrounding environment.
- e) District Magistrate – to get support when neighboring population is affected.

G. Training and Rehearsal

Training plays an important role in enhancing the knowledge and skill of staff about their roles & responsibilities and resources available to manage the emergency. Regular rehearsals of ERDMP ensure preparedness of staff and operability of facilities to manage the emergency situations. It further enhances confidence, better understanding of individual's role & responsibilities in emergency besides improving the overall coordinated efforts.

All employees positioned at compressor stations are trained in ERDMP and basic fire prevention & fire fighting training. Training includes classroom sessions as

well as hands on training on fire fighting equipment, emergency and Evacuation exercise/ mock drills.

H. Post Emergency Action Plan

Once the emergency has been successfully handled by coordinated efforts of CS staff under the leadership of Area Manager/ RHM, the affected site shall be checked for presence of flammable gases. After confirming that no flammable gases are present, the area shall be declared as safe for re-entry. However, the CS unit start-up shall be carried out only after confirming the requirements viz. statutory authorities, ensuring healthiness of engineering equipment and utility facilities, forming investigation team and insurance claim.

I. Information to Statutory Authorities

In case of major incident involving loss of lives and property following authorities must be informed by the organisation prior to the restarting the facilities.

- a) Local police station
- b) Local Fire Brigade Services
- c) Director – Industrial safety & Health(Local)
- d) State Pollution Control Board.
- e) Petroleum and Natural Gas Regulatory Board (PNGRB)
- f) Petroleum and Explosive Safety Organization(PESO)
- g) Ministry of Petroleum and Natural Gas (MoPNG)

VIII. CONCLUSION

For the smooth and safe operation of a natural gas installation it requires to have an effective Fire protection system and an Emergency Response plan for handling the any emergency that could happen at the pipeline installation. Periodic review and updation of the plan is a must to establish and ensuring the effectiveness and this can be made sure by conducting various inspection of the systems conducting different internal and external audits .Periodic review of the risk assessments for the various operational and maintenance activities is also an important factor for ensuring the effectiveness of the system identified and control measures implemented.

REFERENCES

- [1] Indian Insurance Regulations (formerly known as TAC Rules).
- [2] National Fire Protection Association (NFPA)
- [3] Oil Industries Safety directorate (OISD)
- [4] Internal (Organizational) Standard on Fire Safety Management
- [5] Internal (Organizational) Standard on Fire Protection Equipment and System
- [6] Factories Act, 194
- [7] Manufacture, Storage and Import of Hazardous Chemicals (MSIHC) Rule- 1989
- [8] PNGRB (Codes Practices for ERDMP Regulations 2010
- [9] Environment (Protection) Act, 1986
- [10] National Disaster Management Guidelines for Chemical Disaster-2007
- [11] Explosives act 1884, Petroleum Act 1934, PLI 1991
- [12] National Environmental Tribunal Act-1993 it is mandatory for the occupier to: