Analysis and Modeling of Emerging Risks In The Domestic Gas Industry

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Abstract- *Pipelines are among the safest methods to transport oil and gas, but when an incident occurs, it can lead to disaster. Pipeline failures often cause injuries, fatalities, explosions and fires due to product ignition, property damage, and spills that can lead to environmental impact risk assessment is adequate methods followed by oil and gas industries in functioning of gas pipelines helps limits the results of disasters. Risk assessments are administered at various phases of the strategy industry from conceptual stage, design stage, construction stage, operational stage, decommissioning stage. The likelihood and consequence analyses of pipeline failures from past events are necessary for the development of realistic risk models. Relationships between the pipeline failure consequences and the basic pipeline design variables are investigated. They provide a valuable contribution to pipeline risk modelling. Recently installed hazardous liquid pipelines of large diameters and high operating pressure are more likely to cause ignitions. In contrast, older installed hazardous liquid pipelines of small diameters cause larger release volumes and more expensive property damages. The portion of fatalities and injuries that is caused by distribution pipeline accidents is higher for the public than workers compared to other pipeline types.*

Keywords- Risk analysis; Domestic gas distribution; Risk assessment; ERDMP

I. INTRODUCTION

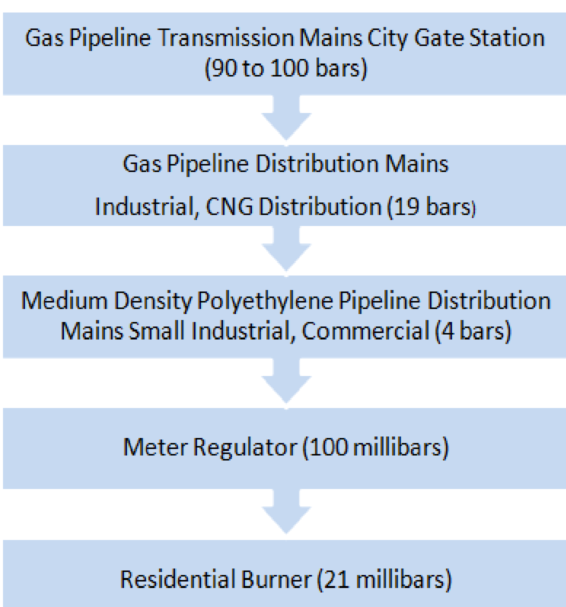
Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly including varying amounts of other higher alkenes, and sometimes a small percentage of carbon dioxide, nitrogen, hydrogen, or helium. It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure supplied by existing under the surface of the Earth over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas. Natural gas is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. It is a non-renewable resource. Natural gas is found in deep underground rock formations or associated with other hydrocarbon reservoirs in coal beds and asmethane clathrates. Petroleum is another resource and fossil fuel found in close proximity to, and with natural gas. Most natural gas was created over time by two mechanisms: biogenic and thermogenic. Biogenic gas is created by methanogenic organisms in marshes, bogs, landfills, and shallow sediments. Deeper in the earth, at greater temperature and pressure, thermogenic gas is created from buried organic material. The lower explosive limit of natural gas is 5% and the upper explosive limit of natural gas is 15%. The density of natural gas is 0.65 kg/m3 whereas the density of air is1.2 kg/m3.Natural gas is used worldwide for different applications such as it is used for electrical power generation, domestics, making fertilizer, industrial, commercial and alternative fuel to diesel as aviation fuel. Many countries are being used natural gas as a fuel for transportation and feedstock for chemical and petrochemical industries. Natural gas is a clean and eco-friendly fuel as an advantage results in usage is in increasing trend. Natural gas use in increased more and replacing the ordinary fuel for production electricity due to environmental as well as economic reasons. Natural gas is extremely flammable and form explosive mixture with air. It is highly reactive with oxidizers and halogen compounds. Transmission of natural gas from oil well heads to storage tanks and exporting terminals are carried out through pipelines. It is transmitted either in Natural Gaseous (NG) or Liquefied Natural Gas (LNG) form. Transmission pipelines are carried out across country or in between busy cities or network of super high ways.

II. METHODOLOGY

The following methodology use for the risk assessment:

- Use a what-if analysis to identify threats and hazards. What-if questions are asked about what could go wrong and about what would happen if things do go wrong. This type of analysis is a brainstorming activity and is carried out by people who have knowledge about the areas, operations, and processes that may be exposed to hazardous events and conditions.

- Use a checklist of known threats and hazards to identify your threats and hazards. The value of this type of analysis depends upon the quality of the checklist and the experience of the user.
- Use a combination of checklists and what-if analysis to identify your threats and hazards. Checklists are used to ensure that all relevant what-if questions are asked and discussed, and to encourage a creative approach to risk assessment.
- Use a hazard and operability study (HAZOP) to identify your threats and hazards. If you need to do a thorough analysis, this method is for you. However, it requires strong leadership and is costly and time consuming. It also assumes that you have a very knowledgeable interdisciplinary team available to you, one with detailed knowledge about the areas, operations, and processes that may be exposed to hazardous events and conditions
- Use a failure mode and effect analysis (FMEA) to identify potential failures and to figure out what effect failures would have. This method begins by selecting a system for analysis and then looks at each element within the system. It then tries to predict what would happen to the system as a whole when each element fails. This method is often used to predict hardware failures and is best suited for this purpose.
- Use a fault tree analysis (FTA) to identify all the things that could potentially cause a hazardous event. It starts with a particular type of hazardous event and then tries to identify every possible cause.



City Gas Distribution Pressure Flow Chart

- Listing out key Operation and Maintenance activities.
- Identification of possible/potential hazards in these identified activities.
- Analysis of these hazards using a dedicated Hazard Identification Sheet covering the hazard, severity, probability and overall risk.
- Decide Control Measures and check if existing control measures are adequate or additional control measures are required.
- Check the residual risk level after considering all control measures.

III. MODELINGAND ANALYSIS

Risk Assessment Methodology:

The risk assessment process is primarily based on likelihood of occurrence of the risks identified and their possible hazard consequences particularly being evaluated through hypothetical accident scenarios. With respect to the proposed project, the major risks viz. jet fire resulting from natural gas pipeline failure have been assessed and evaluated through a risk matrix generated to combine the risk severity and likelihood factor. Risk associated with the natural gas distribution network have been determined semi-quantitatively as the product of likelihood/probability and severity/consequence by using order of magnitude data (**risk ranking = severity/consequence factor X likelihood / probability factor).** Significance of such project related risks was then established through their classification as high, medium, low, very low depending upon risk ranking. Thereare five step of hazard identification and risk assessment are-

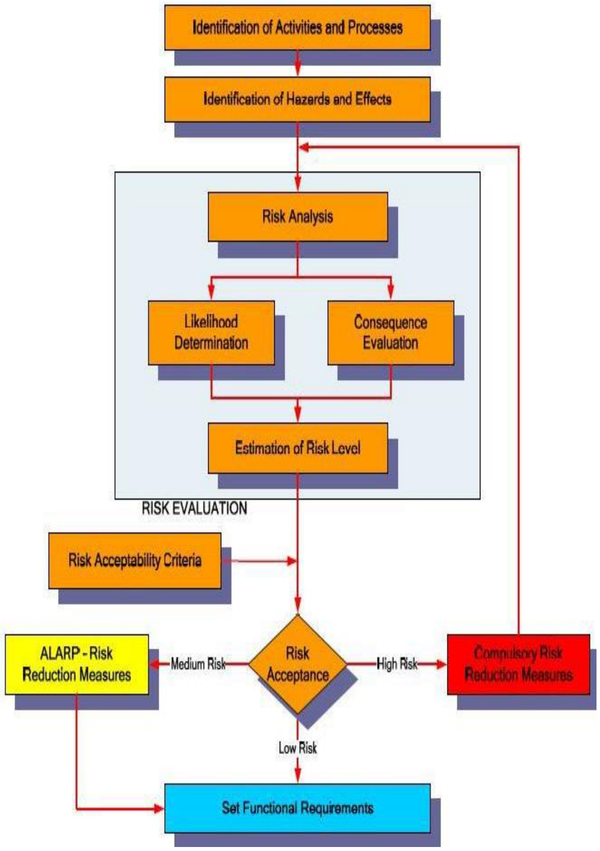
Step1: Establish the context: Define the internal, external and the risk management context and their process and operations.

Step2: Identifying Hazard: Defining and describing a hazard, including its magnitude and severity, physical characteristics and causative factors or area affected.

Step3: Analyse Risk: Analysing the consequences and likelihood and determine the risk level.

Step4: Evaluate Risk: Evaluating the risk classification table is formed and hazard or calculating the risk class gives the required safety precaution to be taken.

Step5: Treat and resolve the risk: Identifying the option, assess the option, prepare and implement, reducing or transferring the risks, by short- and long-term planning.



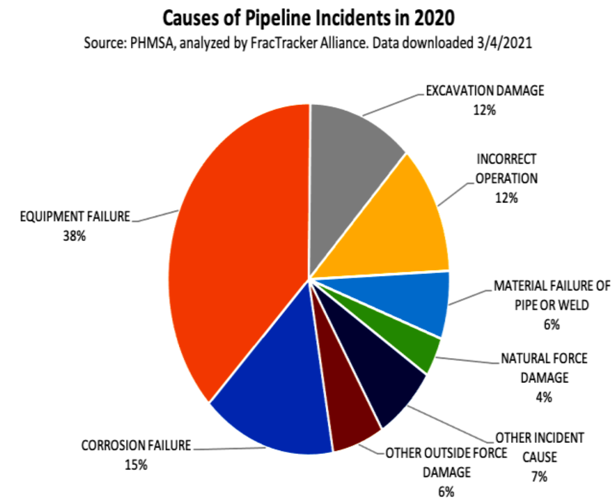
Risk Assessment Process

IV. RISK EVALUATION

Based on ranking of likelihood and frequencies, each identified hazard has been evaluated based on the likelihood of occurrence and the magnitude of consequences. The significance of the risk is expressed as the product of likelihood and the consequence of the risk event, expressed as follows:

Significance = Likelihood X Consequence

The **Table** below illustrates all possible product results for the five likelihood and consequence categories while the **Table** assigns risk significance criteria in three regions that identify the limit of risk acceptability. Depending on the position of the intersection of a column with a row in the risk matrix, hazard prone activities have been classified as low, medium and high thereby qualifying for a set of risk reduction / mitigation strategies.



In field of City Piping Networks, the problems are as followingPipeline Damaged and Gas Leakage:

City Piping Networks have three types of pipelines

(1) Steel Pipeline.
(2) MDPE (Medium Density Polyethylene) Pipeline.
(3) GI (Galvanized Iron)

Pipeline among which MDPE pipeline damaged and causes leakage such as weld Leakage in Equipment/Lines, Leak from flange, gland etc. Leak from rotary equipment, Metallurgical failure, Leakage due to improper operation, Leakage due to improper maintenance, Normal operations venting/draining, Any Other/ Third Party frequently occurred.

		Consequence				
		Negligible 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	5 Almost certain	Moderate 5	High 10	Extreme 15	Extreme 20	Extreme 25
	4 Likely	Moderate 4	High 8	High 12	Extreme 16	Extreme 20
	3 Possible	Low 3	Moderate 6	High 9	High 12	Extreme 15
	2 Unlikely	Low 2	Moderate 4	Moderate 6	High 8	High 10
	1 Rare	Low 1	Low 2	Low 3	Moderate 4	Moderate 5

Risk assessment Matrix

Risk Significance	Criteria Definition & Action Requirements
Extreme 16 – 25	Project HSE Management need to ensure that necessary mitigation is adopted to ensure that possible risk remains within acceptable limits
High 10-15	Project HSE Management needs to adopt necessary measures to prevent any change/modification of existing risk controls and ensure implementation of all practicable controls.
Moderate 5-9	Project related risks are managed by well-established controls and routine processes/procedures. Implementation of additional controls can be considered.
Low 1-4	All risks are managed by well-established controls and routine processes/procedures. Additional risk controls need not to be considered

Sr no.	Incident	Possible consequences	Risk
1	Small leakage of Natural GAS	Disperse safely or minor fire with no risk to Neighbouring land uses.	Very low
2	Medium leakage of Natural Gas	Disperse safely or ignition and flash fire, death in Within or adjacent to cloud at time of ignition.	Low
3	Pool or jet fire of Natural Gas	Thermal radiation effects at neighbouring land Uses.	Medium
4	Prolong fire at tank leading to Explosion	Intense thermal radiation affects causing deaths at Substantial distances.	Medium
5	Catastrophic leakage of Natural Gas	Safe dispersion less likely, ignition and flash fire probable over a substantial distance.	Low

For various hypothetical scenarios considered with respect to pipeline leaks and ruptures, the threat zones calculated using ALOHA for defined thermal radiation intensities have been presented in the Table below.

Table: Threat Zone Distance - Proposed Natural Gas Pipeline Failure Scenarios

Case No	Pipeline Failure Case	Hole Size (inch)	Distance to 10.0 kW/m2(m)	Distance to 5.0W/m2 (m)	Distance to 2.0 kW/m2 (m)
I	30 pipeline leaks	0.50	<10	<10	<10
II	30 pipeline leaks	1.00	<10	<10	11
III	30pipelineruptures	30	369	514	793

Thus, the risk ranking and significance of the proposed natural gas pipeline failure is rated as

"MEDIUM WITH SCORE =12"

Likelihood ranking	3	Consequence ranking	4
High risk with score of 12			

Based on the above findings it can be concluded that risk falls in ALARP zone and also given that adequate safety and emergency response measures

V. EMERGENCY RESPONSE MEASURES

Declaration of Emergency

- Level-I and Level-II Emergency- The emergency has to be declared by the Chief Incident Controller.
- Level-III Emergency- The emergency has to be declared by District Authority.

Disaster Management Plan Objective:

The primary objective of the DMP is to provide a safe, timely, effective and coordinated response by the onsite Emergency Response Team (ERT), along with the other local and government agencies/departments to prevent or minimize any major emergencies that may arise from possible failures of pipeline during operation.

Minimize the risk for human life, environment and common property resources, by means of an effective and efficient intervention; Protection of the environment; Protection of public safety; Initiate the early and efficient response throughout the utilization of all available resources.

VI. PURPOSE

The purpose of the DMP is to effectively manage and control the emergencies occurring during project operations. This DMP ensures,

- Emergency response group is effective & adequate;
- clear roles and responsibilities of key personnel & support groups;
- availability and adequacy of emergency infrastructure & resources; and efficient emergency communication.

VII. CONCLUSION

Impact assessment is the process evaluating and identifying the future consequences of current activities of gas processing industries. Dispersion model use to evaluate and consequences of fire and explosions. The purpose of dispersion and source models solve conservation of mass, momentum and energy equation, and can use to model the dispersion of clouds in presence of obstacles even of complex geometry. Moreover, they can deal with heavy, natural or light gas dispersion, then assuming preventive measures must be the main aim of the all those involved in potentially hazardous activity, from those responsible for fixing the objectives and details of a task, to the operatives that carry out the work. This includes the setting of measures to enable the operatives to avoid accidents on the job. it is recommended to specifically identify risk present in a gas transmission pipeline of city gas distribution industry. Also, it is recommended to determine whether the risks present city gas distribution industry is the same with the other city gas distribution industry in different locations in India. The conclusion of this research work investigation of the effects, cause, and safety issues in city gas distribution industry and noted recommendations to the improvement of city gas distribution industry safety.

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