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Health, Safety and Environmental Risk of a Gas Pipeline in an Oil Exploring Area of Gachsaran

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Abstract: The purpose of this study was assessing health, safety and environmental risk of a gas transfer pipeline in an oily area of Gachsaran. In this method, we used the Kent's pipeline risk assessment method except that to facilitate using the method more practically some changes were exerted into Kent's method. A pipeline with 16 kilometers length was selected considering surrounding nature of the pipeline. It was divided into two sections. Analogous to Kent's method, in this method, parameters included: interested party's injuries, corrosion, design factor, incorrect operation index and consequence scoring. The difference here was that for consequence scoring we used ALOHA 5.6 software instead of Kent's pattern. Results showed that health, safety and environmental risks of section 2 (the next 13 kilometers of outgoing pipeline from gas station after the first 3 kilometers) were greater. It seems the main cause of gaining a bigger risk number was related to more activities of interested parties around section 2. Because all figures gathered from indexes are almost close to gather except third parties activity.

Key words: Pipeline, Risk assessment, Health, Safety, Environment, ALOHA

Introduction

Today, pipelines have found an important role in the transportation systems. Pipelines transport many considerable volumes of raw materials and products. This application is bolded in oil, gas and petrochemical industries. Right operation and handling of pipelines, regarding its confinement is one of the safest methods of transportation[1]. Then why is it necessary to identify and assess the pipeline hazards?

Nevertheless safety and ease of pipeline transportations, we should note that most length of pipelines are located out of our sight, they have high volume and pressure inside them, and hazardous entity of some chemicals, long distances which these pipelines pass and other factors, should be considered. On the other hand, due to wide range of pipelines integrity threatening factors, this system of transportation, seems vulnerable.

Between 1970s and 2001, 34 major accidents happened in the United States Oil and petrochemical pipelines, which leaded to death of at least 105 people.

Average financial loss for every accident has been 34 million dollars. Mean volume of release for every case was about 10 million gallons[2]. In the year 2000 only one accident in a pipeline resulted to death of 12 people[3]. With regard to wide hazards of pipelines, it is very critical that some features or tools be applied to manage the hazards.

Unfortunately, nevertheless of this importance, many legal agencies ignore health, safety and environmental requirements of pipelines[4]. One of the best tools for managing HSE (health, safety, Environment) hazards is Risk Assessment procedure. This is wise to consider a mixture of social and personal risks[5] because pipelines accidents could have social and personal, infrastructural

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and environmental consequences[6].

Hence, it should be tried to form and keep a comprehensive intuition about pipeline risk assessment. As the population increases around pipelines, vulnerability of pipelines are raised[7] therefore; social risks can be affected by consequences and probable hazards of pipelines.

Indeed, which factors can influence integrity of pipelines? Which items are the HSE hazards of a pipeline? Which approaches can enhance reliability of pipelines?

These questions and many others about pipeline hazards were issues that have engaged the mind of this paper's executors. Execution of this study was an endeavor to solve some of those problems. In this paper, using amended Kent's method for pipeline risk assessment, objections are identified and managerial and technical solutions are presented for control of related risks.

Materials and Methods

One of the most common methods in pipeline risk assessment is Kent's method. This method has been taken from the book "*Pipeline Risk Management Manual – W.Kent –third edition- 2004*". In this method, *Relative Risk Rating* is the final measure for estimating the risk level of the selected pipeline. Unlike many other methods that are deterministic, Kent's method is a probabilistic method. This feature is important, especially in management of corrosion risks[8]. However importance of deterministic methods should not be ignored.

The main objective of this paper was the identification of potential risks of the selected pipeline and offering preventive approaches. Using such a system, we could improve weak points of the pipeline greatly[9].

This improvement would rise the lifetime of the system. If threatening risk's identification and assessment are well done, probably we could use the outputs of the method in Risk Based Inspections (RBI)[10]. The formula used in "Relative Risk Rating" is:

Relative Risk Rating = (Index sum) / (Leak Impact Factor)

Index sum = (Third party) + (Corrosion) + (Design) + (Incorrect operation)

Leak Impact Factor = Threat area + Product hazards + Target

Index sum is achieved by the summation of interested parties, corrosion, design, and incorrect operation parameters. Each of these parameters, themselves have some sub clauses or parameters. The third parties' index includes: minimum depth of soil, activity level, above ground facilities, line location, public education, right-of-way condition and patrolling frequency.

Corrosion index includes: atmospheric corrosion, internal corrosion and surface corrosion. Design index comprises safety factor, fatigue, surge potential, integrity verification, and land movement. And finally incorrect operation index has clauses including design, construction, operation and maintenance.

To calculate the pipeline risk level, one should use the guideline tables of Kent's method. According to comments of the tables, one should select the suitable number and finally, per above formula, calculate *Relative Risk Rating*. Note that weights of all parameters are not equal and depending on engineering experiences, each parameter has an appropriate weight.

Also, Leak Impact Factor section is the summation of "Threat area, Product hazards and Target". The change which we exerted in this method was using ALOHA 5.4 software for estimating the threat area instead of using the traditional method. This change was to facilitate the estimations because we thought the suggested technique of Kent's method is somewhat hard and applying software can ease the use of it. We also believed using software will improve Kent's method capabilities.

The ALOHA software is a consequence analysis software which is downloadable from EPA website. To working with this software, with inserting process data and source (here pipeline), and weather conditions (wind velocity, environment roughness, humidity…), the software represents three levels of radiation at Kw/m^2. Of course regard to the nature of natural gas, noteworthy scenario for us was fire and explosion and accordingly radiation severity.

The software classification for radiation severity is as below:

- Red threat zone (10 KW/m^2- potentially lethal within 60 s)
- Orange threat zone (5 KW/m^2- second degree burns within 60 s)
- Yellow threat zone (2 KW/m^2- pain within 60 s)

Other contents of Leak Impact Factor were calculated as Kent's method. To implement risk assessment, a team was formed from our own organization experts and a consultation company. According to past experiences, a pipeline with 16 km length was selected. Considering geographical, ecological and demographical differences, this line was divided into two sections, the first 3 kilometers outgoing from the site and the next 13 km left.

Risk assessment team inspected and reviewed each section and gathered related information. Then all data were discussed in a meeting and after consensus on proper number, related measures were extracted from the guideline tables. Also threat zones were calculated by software.

Results

The overall results of our study showed that most important threatening factor of the pipeline in this study was "Third Party Damages" which had considerable impact on final risk score for each section.

For the first index, measure of *third party damages*, were 53 for section 1 and 38 for section 2 (Table 1).

Another index, the *corrosion index*, was 36.7 and 38.7, for section 1 and 2 accordingly (Table 2).

Design index for both sections was equal and it was 36.5. Design requirements and specifications for both sections were same (Table 3).

Incorrect operation index was calculated and measures of sub clauses including: design, construction, operation and maintenance were attained (Table 4).

And finally, *Leak Impact Factor* calculated for each section (Table 5).

In both sections of the pipeline, general parameters didn't have considerable differences except at "third party damage index" which there were most variations. In dominator of Relative Risk Rating equation (Leak Impact Factor), also there were some differences that had impact on final risk score.

Using the parameters and described procedure, final risk score for section1 was 8.71 and for section 2 was 5.96

Table 1. Measures of third party damage index for two sections

ID	PARAMETER	RANGE	SECTION 1	SECTION 2
Third Party Damage Index				
1–1	Depth of soil	0–20	13	13
1–2	Activity level	0–20	12	2
1–3	Above ground facilities	0–10	5	1
1–4	Line location	0–15	9	9
1–5	Public education	0–15	3	3
1–6	Right-of-way condition	0–5	3	2
1–7	Patrolling frequency	0–15	8	8
	Total	0–100	53	38

Table 2. Corrosion index measures for two sections

ID	PARAMETER	RANGE	SECTION 1	SECTION 2
Corrosion Index				
A	Atmospheric corrosion	0–10	6.7	3.7
A1	Atmospheric exposure	0–5	3	0
A2	Atmospheric Type	0–2	1.2	1.2
A3	Atmospheric Coating	0–3	2.5	2.5
B	Internal corrosion	0–20	8	8
B1	Product Corrosivity	0–10	3	3
B2	Corrosion prevention	0–10	5	5
C	Subsurface Corrosion	0–70	22	27
C1	Soil Corrosivity	0–15	8	8
C2	Mechanical corrosion	0–5	4	4
C3	Piping Coating	0–25	10	15
	Total	0–100	36.7	38.7

Table 3. Design index measures for two sections

ID	PARAMETER	RANGE	SECTION 1	SECTION 2
Design index				
1	Safety factor	0–35	3.5	3.5
2	Fatigue	0–15	13	13
3	Surge potential	0–10	5	5
4	Integrity Verification	0–25	5	5
5	Land movements	0–15	10	10
	Total	0–100	36.5	36.5

Table 4. Incorrect operation index measures for two sections

ID	PARAMETER	RANGE	SECTION 1	SECTION 2
Incorrect Operation Index				
1	Design	0–30	11	10
1–1	Hazard identification	0–4	1	0
1–2	Maximum Operating Pressure potential	0–12	0	0
1–3	Safety Systems	0–10	6	6
1–4	Material Selection	0–2	2	2
1–5	Checks	0–2	2	2
2	Construction	0–20	18	18
2–1	Inspection	0–10	8	8
2–2	Material	0–2	2	2
2–3	Joining	0–2	2	2
2–4	Backfill	0–2	2	2
2–5	Handling	0–2	2	2
2–6	Coating	0–2	2	2
3	Operation	0–35	17	15
3–1	Procedures	0–7	2	2
3–2	Communications	0–3	2	0
3–3	Drug Test	0–2	0	0
3–4	Safety Programs	0–2	1	1
3–5	Survey/Maps/Records	0–5	3	3
3–6	Training	0–10	6	6
3–7	Mechanical error preventers	0–6	3	3
4	Maintenance	0–15	2	2
4–1	Documentation	0–2	1	1
4–2	Schedule	0–3	1	1
4–3	Procedures	0–10	0	0
	Total	0–100	48	45

Table 5. Leak impact factor measures for two sections

ID	PARAMETER	RANGE	SECTION 1	SECTION 2
Leak Impact Factor				
1	Target		6	7.5
1–1	Population Density		2.5	4
1–2	High Value Area		3.5	3.5
2	Product Hazards		7	7
2–1	Acute Hazards		5	5
2–2	Chronic Hazards		2	2
3	Threat Area		7	12
	Total		20	26.5

Table 6. Measures of main parameters of two sections

Parameter	Section 1	Section 2
Third party damage index	53	38
Corrosion index	36.7	38.4
Design factor	36.5	36.5
Incorrect operation index	48	45
Index sum	174.2	157.9
Leak Impact Factor	20	26.5
Relative Risk Rating	**8.71**	**5.96**

(Table 6).
Finally, *Relative Risk Ranking* for each section:

Relative Risk Rating = (Index sum) / (Leak Impact Factor)

section1: 174.2/20 = 8.71

section2: 157.9/26.5 = 5.96

Discussion

In the Kent's method, to estimate Leak *impact factor*, evaluator needs to understand release mechanisms for assumed scenario and then model potential release for risk assessment. To score the relative dispersion area or hazard zone of a spill or release, the relative measures of quantity released and dispersion potential can be combined and then adjusted for mitigation measures.

Having knowledge of understanding and modeling of such situations need engineering and technical backgrounds and for some conditions this modeling requires complicated mathematical relations that maybe inaccurate.

To facilitate this section of *pipelines risk assessment* and to resolve complexity of consequence analysis, we applied software (ALOHA) and really we got very more straightforward results. The main content of our study was trying to solve complexity of that section.

Nevertheless, there were some limitations and difficulties in implementation of this study. Maybe the most important limitation was that due to the long life of the line there wasn't sufficient necessary documentation and where there was no enough data, expert judgments were used. The most dominant presentation of this lack was in *Design index*.

Another limitation of applying our new method is that in this type of estimation, the basic focus is on the safety and occupational health and environmental concerns lie in third rank of importance. In the other word, this method is more reliable for safety and occupational health than environmental concerns. However we can interpret environmental data and information from this method.

Evaluation of gathered data showed that increased risk of section 2 of the pipeline was due to third parties activities. This index exerts its impact in two ways: first, direct impact via *third party damage index* and indirectly via *leak impact factor* because population density has major effect on *leak impact factor* measure. Also all figures gathered from indexes are almost close to gather except third parties activity that this difference may be root of differences at the levels of these two sections.

Some assessments were made by the risk assessment team after achieving final results to find main causes of risks. This assessment suggested below reasons for increased risk level in section 1:

- More proximity and activity of native people and tribe
- Proximity to above ground facilities
- Absence or shortage of public awareness about pipeline hazards
- Cultivation around or on the buried line
- Depth of land in some point (that can lead to water accumulation)

This is obvious that most of the causes are related to third parties. However if pipeline designed appropriately and performed in pre-planned track, ecological risk will diminish[11]. But human activities and third party activities (such as contractors) have dramatic impact on integrity of pipelines.

Anyway, deduction of this study on the magnitude of third party's impact on pipeline integrity is compatible with "Iranian Pipeline and Telecommunication company" declaration about threatening factors of pipelines.

In this study we used ALOHA software to facilitate application of Kent's method, but it does deserve to endeavor more study to further facilitate some aspects of the current method.

Conclusion

In conclusion, our study shows importance of risk assessment process for pipelines in general, because conducting pipeline risk assessment can enhance system life cycle[12]. The second point was the importance of public and third parties awareness about hazards of pipelines. Increasing communication with public and training educate them can lead to decreasing level of health, safety and environment risks.

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