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# Hazard Identification and Accident Analysis on City Gate Station in Natural Gas Industry

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## Abstract
In spite of all the efforts in different industries to reduce the number of undesirable accidents, a lot of events always threat industrial societies. These events often cause huge damages to the environment, facilities and even in some cases, fatalities and disabilities for people. Therefore, it is important to predict these probable accidents and plan to prevent them. Hence, this research proposed to analysis hazards in one of the most important components of natural gas distribution network which is city gate station (C.G.S). In this analysis firstly, critical hazards are identified and classified based on HSE standards. Then for decreasing risk of selected hazards, a survey is done on a specific C.G.S according to previous accidents. Finally, some suggestions are offered to improve existing preventive activities.

## Keywords
Hazard, Health, Safety, City gate station, Natural gas

## INTRODUCTION
One of the major responsibilities of each management is increasing productivity through reducing costs [2]. On the other hand Accidents are very expensive for companies. Human injuries, finance losses and environmental damages can influence organization, directly and indirectly. Therefore, prediction and prevention of harmful accidents are very important for organizations [3]. The companies and factories which do not have an effective HSE management may cause accidents. These accidents can make huge problems that complex planning is required to control them. In management systems and safety and health standards like OSHA, OHSAS 18000 prediction and prevention of accidents have a valuable position [4].
This paper is aimed to study H.S.E management of a sensitive part of Gas Company. These days natural gas is considered as a potentially feasible and environmental preferred fuel, compared to other liquid fossil fuels [11]. In other words natural gas use has risen dramatically and replace to ordinary fuels and electricity power for both environmental and economical reasons. As a result, new storage units are constructed and larger amounts of petroleum and especially natural gas are stored and transported worldwide [12]. Furthermore as gas is a flammable material, and it is transferred by pipes which are installed on the land, safety and health management play a very important role to avoid accidents [5]. Even though there have been a lot of efforts in the gas industry but it is still felt that new safety and health managing methods are necessary. According to the literature most of the statistical analysis has done too long ago and hazards were identified on the basis of those days technology while there is a significant change in facilities of Gas industry from 25 years ago [9]. Furthermore the majority of researches didn't offer a practical solution for preventing the incidents therefore although the problems were assessed but still exist.
To show the situation of CGS in gas network, the procedure of natural gas distribution networks is introduced as follows: Extracted natural gas from gas & oil wells enters refinery with 4000 psi pressure and exit with 1000 psi. The continuity of gas flow is kept by compressor stations. Refined gas enters City Gate Station (C.G.S) through main pipelines. After reducing pressure to 250 psi by C.G.S, gas enters big cities and Town Board Station (T.B.S). TBS reduces gas pressure again to 60 psi and then it enters to main distributor. Via this network, gas enters regulators for reducing its pressure to 1/4 psi which is suitable for domestic & commercial subscribers' use. One of the vital components of gas network is city gate station (C.G.S). The duties of C.G.S are: 1-To reduce the pressure of gas and, 2-To add smell to it.
Although from almost 20 years ago until now regulatory structures are widely used for controlling major accident hazards , lows and regulations failed to recognize fully the importance of risk burdens of safety issues at even the most simplistic level [13].

As this huge network which consists of many hazardous sites, crosses from urban and rural areas and many people are living close to it and furthermore many workers are working around it as maintenance team or other technical crew, safety, health and environment management is considered as a crucial issue to investigate.
By reviewing historical heart-rending incident we can feel the severity of possible consequences of gas explosion better than before. One of the target accident about gas pipeline occurred in 1984 at Bhopal, India, where over 2000 people were killed by exposure to methyl isocyanine, which was accidentally released from a pesticide-manufacturing plant [7].

## LITERATURE REVIEW

There are few efforts for identifying the hazards in oil and gas pipeline network but the majority of researches are focusing on assessing and analyzing risk of hazards from different point of view, especially on assessing the safety risk of pipeline for man and environment.
Generally risk assessments can be implicit or explicit, qualitative or quantitative, and it may not always be a complex process. Sometimes only a simple risk ranking, for example combining the likelihood of an event and the severity of its outcome, may be adequate for purposes of prioritisation [10].
One of the quantitative approaches in this area is to identify and estimate risks to pipeline based on human and financial cost of each incident. But most of the traditional techniques in this field are deterministic. Hence Brito et al., presented a probabilistic model for risk ranking model assessment to calculate the more realistic risk assessment [1].
On the other hand there are some researches that identify the consequences of a specific hazard for a specific condition. For example Jo et al., believe that the most dangerous consequents of an explosion in gas pipe urban area are, the collapse of buildings, and the heat effect of thermal radiation from a sustained jet fire, which may be preceded by a short-lived fireball [5]. These elements cause death for people who are near to the pipeline. Thereby the distance of pipe to people has a significant role in assessing the individual risk assessment. Based on this they presented a simple method of risk assessment for individuals depend on the distance of person to natural gas pipelines. It worth to mention that individual risk is defined as: The probability of death for a person in a specific distance from gas pipeline in one year [5].
An example of qualitative assessment of hazard for pipeline can be the research that explores safety of pipelines from legislation point of view. Georgios, Papadakis examined whether sufficient controls already exist within the European Union _EU. Member States, considering the control philosophy of the ‘Seveso II’ Directive and the need to support development of pipeline networks across the EU taking into account the principles of sustainability [9].
On the other hand some of researchers investigated the HSE issues of natural gas network from another aspect which is calculating the dimension of consequences of oil and gas pipeline accident. For example Jo et al., presented a mathematical model to estimate ground area potentially affected by the failure of a high-pressure pipeline carrying natural gas [6]. In fact the area of hazard associated with the damage will depend on the mode of pipeline failure, time to ignition, environmental condition at failure point, and meteorological condition. In this research the causes of incidents are divided in two major groups: Time independent and Time dependent. Time dependent occurrences such as external mechanical interference are mostly caused by third party like earthquake, or overpressure while others are time dependent such as corrosion or fatigue failures. According to this research failure rate of gas pipeline is different significantly with design factors, construction conditions, maintenance techniques, and the environmental situation.
Another approach for identifying and preventing the causes of incidents is historical analysis of accidents. Montiel et al., did a survey of 185 accidents taken mainly from the database MHIDAS to identify the main features of accidents occurring in the transportation and distribution of natural gas [8].
Although In the last twenty years the network of oil and gas and also the criteria for collecting statistical data has changed significantly, the extent of consequences following gas releases and oil spillages have not shown any change in the last fifteen years. The frequency of incidents in gas transmission with many casualties increased world-wide over the last fifteen years. Based on surveys the casualties in gas transmission are strongly depend on the operation of the equipment like valves and other parts associated with the line [9].
One of the most sensitive parts of a gas network is City gate station. Hence this study is purposed to analyze this part from safety management point of view. In this research converse to the previous studies it is attempted to focus on one specific part of natural gas network and identify almost all hazards which are possible to happen for human and environment. Afterwards then according to historical incidents through a statistical analysis and HSE standards the priorities and importance of each hazard is allocated. And finally for avoiding these hazards some preventive activities are offered.

## OBJECTIVE

Usually in natural gas Companies, hazards are identified and classified based on organization chart; it means that HSE issues are analyzed in different part of organization separately without considering the relationship between them. For example employees in each specific part of a C.G.S are not familiar with hazards and safety activities in other departments that threat them, while if an accident happens in a sensitive place such as a C.G.S, all of employees are involved with the accident and also it can cause explosion and fatalities. So it is essential that all of employees, who are working in a C.G.S, be aware of hazards of their work place. Due to this reason, hazards should be identified and analyzed with concerning the relationship between departments. In this project we are going to identify and classify some of hazards in a C.G.S that is one of important work place and vital part in natural gas network. In other words this project is done in place oriented way.

## METHODOLOGY

A natural gas company has many C.G.Ss. As the systems of C.G.Ss are similar to each other this study can be used for all of C.G.Ss. For achieving to goals of this study in C.G.S this research can be divided into three main steps:

- Identify hazards and their consequences
- Analyze previous accidents in C.G.S
  - To classify hazards based on OSHA and 10-point standards.
- Improve prevention activities
  - Statistical analysis is done on the basis of accidents during recent three years ago.

**To identify hazards and their consequences**

The following hazards are identified according to the experiences of specialists and the reports of incidents in C.G.Ss. Since these hazards cause more important losses, they are considered more critical and are analyzed with more sensitivity (see Table1).

Table 1: Kinds of hazards

| Row | Hazard | Description & Consequences |
|---|---|---|
| 1 | Falling and hitting Joints, valves and tools | Joints, valves and tools are likely to fall and hit the workers on their installation or repairing in the stations which may bring about injuries or the fracture bone. |
| 2 | Gas leakage from joints and valves | The gas leakage is likely to happen on controlling operations, lubrication of valves, changing the station filter and because of the corrosion of the foundations which may cause suffocation, physical injuries and even conflagration and explosion. |
| 3 | Diffuse of evacuated gas | For installation and repairing in the C.G.S, gas should be evacuated. The evacuation is to be done in a proper depth in the earth, otherwise if the gas diffuse, it may cause poisoning and conflagration. |
| 4 | Noise pollution | A lot of noise is produced because of gas running, the reduction of its pressure at the station, gas evacuation and periodical checking of gas measuring instruments which may cause injuries for the hearing system of the workers if no safety instruments are used. |
| 5 | Propagation of odorant in environment | As the natural gas doesn't have odor and color, if it is propagated in the air, it can't be recognized by human senses. That is way; it is made smelly to provide the customers with more safety. The substance used in the process belongs to Mercaptanes and its general formula is R-SH. The substance has an unpleasing odor and is combustible. It is carried to C.G.S in the metal barrels and is injected into the gas in the exit of the station through an odorizer. It will be damage for skin, digestive and aspiration system if it leaks and touches to human body. It may cause conflagration, explosion and pollution of water, air and soil. |
| 6 | Falling and Slipping | The workers are likely to slip and fall while repairing, checking the station, changing the filter, working in the height, moving in the working place and transporting the instruments which can cause injuries and fracture bone and even heads injury. |

| | | |
|---|---|---|
| 7 | Welding radiance in repairing procedures | While welding the pipes and joints and installing the stations, the produced radiance may damage the visual system and the skin and cause the osteoporosis and chronic diseases. |
| 8 | Frostbite and Heatstroke at work place | Working in the open, the unpleasing climate and under the direct sunbeam, in the long term, will cause the diseases for the skin, respiratory system, the kidney and other physical ailments. |
| 9 | Unsuitable lighting | Unsuitable lighting in the office and long repairing activities at night will cause problems for the visual system. |
| 10 | Fire in C.G.S | To make any fire in the C.G.S campus like burning weed, smoking, uncontrolled welding wastage for repairing and the unsuitable use of electrical devices may cause explosion and gas interruption. |
| 11 | Electric shock | While working with electrical devices, installing the station and during the repairing there is the possibility of injuries, burn, shock and the physical damages caused by electric shock. |
| 12 | Pig hitting during pig operation | Pig is an instrument to clean the main pipeline, evacuated water and the liquid in pipe beds. The entry and exit of which into the pipes is done through C.G.S. As the driving power of the pig is produced by gas pressure, there is the possibility of hitting and causing injuries by pig when it exits the pipe. |
| 13 | Tear of Joints during testing in high pressure | During the test operations in high pressure, there is the possibility of pipe and joint tear which may cause the shooting of the pieces and joints and hitting to workers and facilities. |
| 14 | Leakage of industrial antifreeze | To prevent gas freezing in the winter, it is heated in C.G.Ss using special heaters. Heat transition to gas in such heaters is done through water. So to prevent water freezing, synthetic antifreeze is used. Leakage and effusion of this substance during transfusion, evacuation and maintenance causes' water and soil pollution. |
| 15 | Wastage filters | As the gas entering C.G.Ss includes impurities and pollution particles so filters are designed in the C.G.S entrance to isolate the particles. The filters are checked and the sediments evacuated and the internal elements changed periodically. The elements are to be used once and dangerous for environment because of their polluted particles. |
| 16 | Stack gas | As a result of the fuel combustion in heaters, a kind of gas with no odour and colour exits from the heaters chimneys which will pollute the environment if it exceeds the standard rate. |

**To analyze previous accidents**

In this section, the identified Hazards are classified and scored based on OSHA and 10-Point standards. Through this classification it is possible to define hazards with more severity and risk (see Table 2).

According to this table it can be seen that the most crucial hazard in a CGS is "firing in nearby of CGS facilities" which may cause explosion, while "Unsuitable lighting in official environment" with only 3 point in 10 point standard and the lowest level in OSHA (De minimize violations) is situated in lowest priority among others.

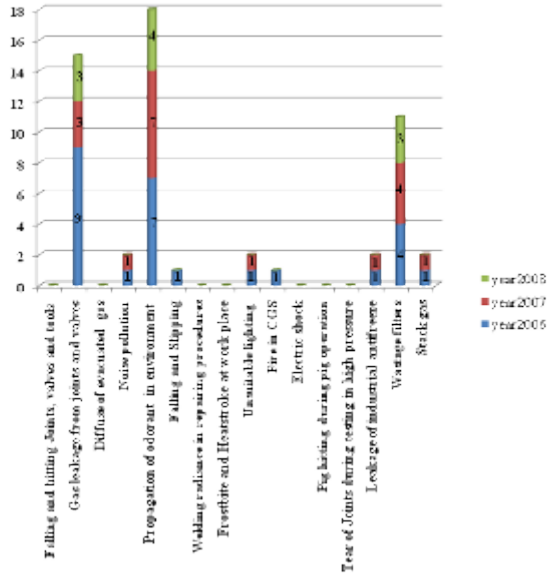
On the other hand here is a statistical analysis on the classified hazards to show that which hazard causes higher number of incident in a CGS environment. Figure 1 show the numbers of accidents refer to each specific hazard during year 2006 to 2008.

According to Figure1 among the hazards, noise pollution, unsuitable lighting and stack gas have standard pollution levels. So the amount of these factors should be measured periodically to avoid long term negative consequences. Usually ergonomic and environmental hazards are neglected in industrial places while these hazards in long time will cause non compensable health consequences for workers. Hence the measurement of these factors has a significant importance. Figure 2, 3 and 4 show the last measurement of pollution level in investigated C.G.S.

Table 2: Hazards classification

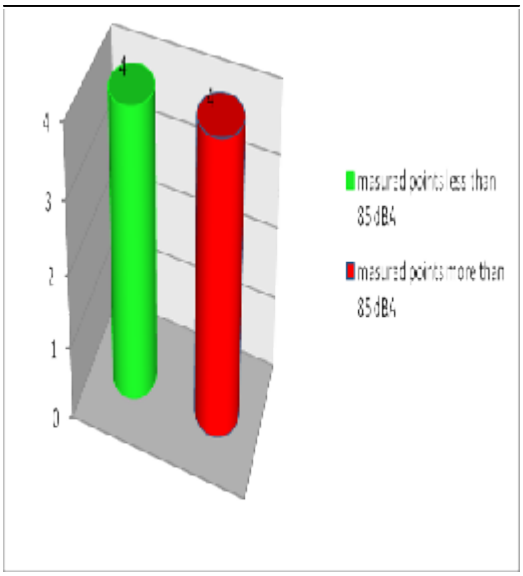
| Row | Hazard name | OSHA | 10-Point | Reasons |
|---|---|---|---|---|
| 1 | Falling and hitting Joints, valves and tools | Non-serious violations | 5 | Personal protective equipment is required and major injuries not very likely |
| 2 | Gas leakage from joints and valves | Serious violations | 8 | It has never produced fatality, but fatality easily could occur at any time |
| 3 | Diffuse of evacuated gas | Non-serious violations | 6 | Major injury not very likely but definitely could occur |
| 4 | Noise pollution | Non-serious violations | 5 | Hearing damage may be permanent without controls ore protection ( 95-100 dBA) |
| 5 | Propagation of odorant in environment | Serious violations | 7 | Using special cloth is essential and major injury could easily occur |
| 6 | Falling and Slipping | Serious violations | 7 | PPE is essential to prevent serious injury .Falling could cause hitting worker's head to joints and valves |
| 7 | Welding radiance in repairing procedures | Non-serious violations | 5 | Eye damage maybe permanent without protective equipment |
| 8 | Frostbite and Heatstroke at work place | Non-serious violations | 5 | If workers exposure in this condition for long time healthy problems will happen |
| 9 | Unsuitable lighting | De minimise violations | 3 | Major injury not very likely |
| 10 | Firing in CGS | Imminent danger | 9 | Making each kind of fire in CGS environment, smoking, and melted wastage of welding could cause explosion, this explosion could cause fatality and gas interruption |
| 11 | Electric shock | Non-serious violations | 6 | During CGS installation and repairing operation electric shock is probable that could cause injury ,burning and shock |
| 12 | Pig hitting during pig operation | Non-serious violations | 5 | During exiting pig from gas pipe, it could hit to workers or fall on their body |
| 13 | Tear of Joints during testing in high pressure | Non-serious violations | 5 | Sometimes high pressure could tear the incorrect joints that could cause hitting pieces to workers. And major injury not very likely |
| 14 | Leakage of industrial antifreeze | Non-serious violations | 5 | Leakage of this chemical substance could cause water and soil pollution |
| 15 | Wastage filters | Serious violations | 7 | These filters are disposable and they have poison materials that are very dangerous for environment |
| 16 | Stack gas | Non-serious violations | 5 | This gas consists of a few harmful gases like CO that is dangerous for environment |

Figure 1: Number of accidents during the year 2006 to 2008



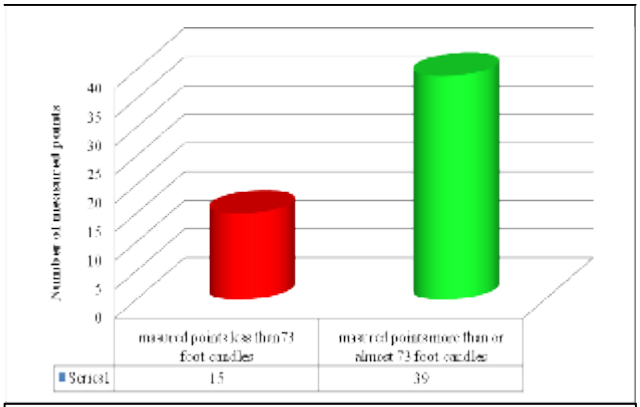

(Numbers of accidents in row 4,9,16 show the number of inspections that the measured amount of each one was more than standard level.)

Figure 2: Noise measurement



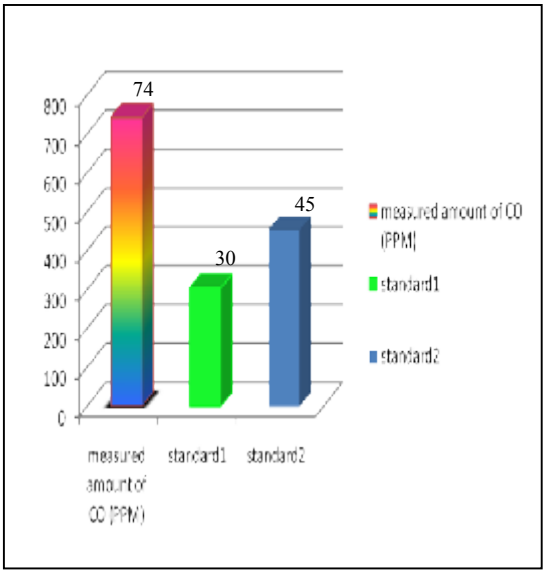

8 different places are measured in the official and facilities departments in a specific C.G.S. There are 4 points with standard level of noise and 4 places with more than standard level that related to facilities departments.

Figure 3: Lighting Measurement




54 different places are measured in the official and facilities departments in the C.G.S. There are 39 points with standard level of light and 15 places with less than standard level of light that related to facilities departments.

Figure 4: Stack gas measurement




These figures clarify that there is not enough attention for decreasing the risk of environmental and ergonomic hazards in the C.G.S. Therefore new politics should be made for paying attention to these fields.

## To improve prevention activities

According to above analyze it is obvious that despite all guidelines and regulations, accidents have occurred yet. Therefore in this section based on priorities of hazards and their severity some suggestions are offered according to CGS facilities and experts interview to reduce accident probability.

- To use installation and repairing guidelines exactly.

- To enforce workers to implement rules and regulations by training and noticing through warning sights and also punishing guilty workers.
- To rotate duties between workers who work in noisy places.
- To repairing and maintenance on time and based on preventive maintenance schedule.
- To use qualified suppliers for purchasing standards goods.
- To use gas detector for measuring amount of gas in the air.
- To use odorant loader for evacuating odorant material instead of traditional method. In traditional method, workers should empty barrels by hand; therefore this act is too risky and dangerous.
- To solve lighting problem as fast as possible.
- To use new warning systems for detecting and putting out fire.
- To use skilled workers for purring antifreeze in heaters.
- As the volume of used antifreeze is very much annually and keeping them is expensive and very harmful for environment, investigation for recovering them is necessary.
- To investigate and establish new work places for recycling filters.
- To use new gas fired heating facilities for heaters.

There isn't any effective reporting system for environmental and agronomical accidents therefore it is necessary to redesign reporting forms for the system

## CONCLUSION

According to above study which consisted of hazard identification, accident analyses and also considering to expert's experiences we conclude that:

- For decreasing rate of accidents in Gas Company, HSE study for each sensitive part of gas network like C.G.S is essential. This study should consist of all aspects of HSE about one specific place.
- The hazards that may damage environment are not paid attention enough. Therefore it is necessary that the top managers pay enough attention to this issue.
- The hazards that cause physical and mental injuries in long time like lack of light or noise pollution are not considered enough and also their guidelines and regulations need to be up to dated and reviewed more expertly.

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