Hazard Identification and Risk Assessment for a Refrigerated Propane Storage Tank- Part A

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الملخص

الغرض من هذه الورقة هو تطبيق تقنيات تقييم المخاطر على خزان البروبان المبرد الذي يمثل جزءا من وحـدة استعادة الغاز الطبيعي المسال وذلك بهدف المساهمة في جعل عمليات التشغيل آمنة قدر الإمكان. تبدأ الورقة بوصف عام للعملية مع ذكر بعض الحوادث القديمة الهامة و التي هي مشابهة ومتصلة إلى حد ما إلى العملية قيد الدراسة، ومن ثم اجـراء التحليل الذي يركز على سلسلة من التقنيات التي تكشف عن أهمية عمليات السلامة.

ان الطرق المستخدمة في هذا البحث صنفت طبقا لاستخدامها، على سبيل المثال، تقنية دراسات المخاطر والتشغيل (HAZOP) وهـي تقنيـة اساسيـة لتحـديد وتقييـم المخـاطـر بالإضـافة إلى ذلك تستخدم طرق أخرى مـثل (Risk Ranking/Matrix) و(Human Errors) بينما (Fault Tree Analysis (FTA)) و (Event Tree) تكون تقنيات مركزية لتحليل احتمالية تكرار المخاطر. ولقد تم اختيار طرق أخرى مثل (Jet fire) و (Vapour Cloud Explosion (VCE)) لتوضيح العواقب وتوسيع نطاق الآثار الناجمة عن حدث غير مرغوب فيه. وتسلط الدراسة الضوء أساسا على الحاجة إلى تقييم المخاطر في الصناعات الكيميائية. وحيث انه من الصعب تغطية كل هذه الطرق و التقنيات في ورقة بحثية واحدة، لهذا قرر تقسيمها إلى جزئين. وفي هذا الجزء (أ) سوف يتم مناقشة تقنيات تقييم المخاطر بينما سيخصص الجزء الثاني (ب) لتغطية تقنيات احتمالية تكرار المخاطر والنتائج.

ABSTRACT:

The purpose of this paper is to apply risk assessment techniques on a propane refrigerated storage tank which represents a part of LNG recovery plant at Gdansk, Poland with the aim to contribute in making the operating processes as safe as possible. The paper starts with a general description of the process and considers some important past incidents that are similar and related to some extent to our process, and then conducts the analysis which is focused on a series of techniques that reveal the importance of safety and safety analysis.

These methods were grouped according to the issues that they are investigating. For example, Hazard and Operability Studies (HAZOP) is the basic applied hazard identification technique in addition to Risk Ranking/Matrix and Human Errors whereas Fault Tree Analysis (FTA) and Event Tree are central techniques for a frequency analysis. Other methods such as Vapour Cloud Explosion (VCE) and Jet fire are chosen to illustrate the consequences and extend of impacts due to an undesired event. The study basically highlights the need for risk assessment in chemical process industries. However, since it is impractical to cover all these techniques at once, it has been decided to group them into two parts. In this part A, the hazard identification techniques are discussed whereas part B will be devoted for covering frequency and consequence analysis techniques.
Keywords: Hazard Identification; Hazard and Operability Studies; Risk Ranking/Matrix; Human Errors.

1. INTRODUCTION

The history of chemical process industries has reported several major incidents that ended up with major hazards. These major hazards came mainly to include fire, explosion and toxic release. Although fire is found to be the most common type among the others, explosion is particularly significant in terms of fatalities and loss. Toxic release, however, has perhaps the greatest severity as it can kill a large number of people and lead to long-term toxic impact on the area. The tragedy scenario at Bhopal, India 1984 works as a achieve example for such a release. The avoiding of such disasters, therefore, is basically dependent on avoiding loss of containment [1].

The causes of such loss of containment, however, can be direct as in rupture in lines, vessels or valves left open, or indirect as in a release due to runaway reaction caused by a release through piping and vessel rupture or pressure relief devices. All these issues put safety and its importance into great account. Generally, most industries consider workers safety while operating on-site, nevertheless a good management policy should also take off-site safety and general public into account[2].

Therefore, lessons from past incidents can be of great assistance in identifying major factors leading to accidents. A survey of these disasters showed that 1744 significant incidents were occurred during the period 1928-1997, with 441 accident (5%) involved fires and explosions, and 1247 (71%) involved toxic release. Most of these accidents dealt with LPG and LNG operations. Propane, in particular, have found to be the chemical product in around 12 accidents resulting in many deaths and injured. Table (1) illustrates the locations and the details of propane accidents occurred worldwide [3].

Table (1): List of major propane accidents.

Year	Location	Chemical	Event	Death/ injured
1962	Ras Taruna, Suadi Arabia	Propane	Fire	1/11
1966	Feyzin, Farnce	Propane	Fire & Explosion	18/83
1972	Lynchburg, VA	Propane	Fire	2/3
1973	Kingman, AZ	Propane	Fire	13/89
1973	St. Amand. L'Eaux, France	Propane	Explosion	5/45
1974	Decatur, IL	Propane	Explosion	7/152
1975	Eagle. Pass, TX	Propane	Fire	16/7
1978	Waverly, TN	Propane	Explosion	12/21
1984	Roeoville, IL	Propane	Explosion	15/76
1985	Mont Bolyiey, TX	Propane	Fire	4/13
1988	Narco, LA	Propane	Explosion	7/48
1990	Porto de Leixoes, Portugal	Propane	Fire & Explosion	14/76

Based on reported data in the literature of process industry, operations which involve storing hydrocarbons in refrigerated storage tanks are less potential for fire or explosion. Most of the past incidents, on the other hand, were associated with materials stored within pressurized storage tanks. Accordingly, it could be argued that refrigerated tanks are more practicable since they are capable to store large quantities of hydrocarbons at low temperature and atmospheric pressure.

This conclusion, however, draw the reader to state that the proposed storage tank is "*inherently safer*", but hence does not mean that hazards are unlikely to arise from such tanks. The reported incidents for major leak fro a 20,000 m^3 liquefied propane tank in Qatar in 1977 is an achieve example of incidents involved refrigerated storage tanks. The consequences of the leakage, as reported, were seven deaths and extensive damage to the rest of the plant due to the fire and explosion that were raised after the leak has been ignited. It was also reported that the propane leak has occurred twice at the same tank but in the earlier year it did not ignite.

The learnt lesson from Qatar incident is that instead of having a company policy which mainly focuses on how to prevent cracks; a rather sufficient policy can be reached by relying on the crack-arresting properties of the tank material. Hence, it has been recommended that refrigerated LPG tanks should be constructed from materials, such 9% nickel steel, which do not allow for crack propagation. Moreover, the force which allowed liquefied propane to escape from the crack led to its spillage over the dike wall. One of the limitations of conventional dike walls is that large amount of material can be exposed to the atmosphere once leakage occurs. Due to these limitations, the modern adopted practice is to support the cryogenic storage tanks with a circular concrete wall jacket built about 1m away from the main wall. These walls, however, should be designed to be constructed from materials that can withstand any sudden release. Such findings, in turn, would give plausible justifications for the selection of double containment as the proposed storage tank of this study [4].

2. SYSTEM DESCRIPTION

The current storage system that is in investigation represents a part of an LNG natural gas recovery plant located in Gdansk, Poland. In this plant hydrocarbons; methane, ethane, propane, butane and gasoline are recovered separately by introducing these materials through three main stages where certain treatment producers are applied to them in each stage. A simple block diagram illustrates these sections is given in Figure (1) [5].

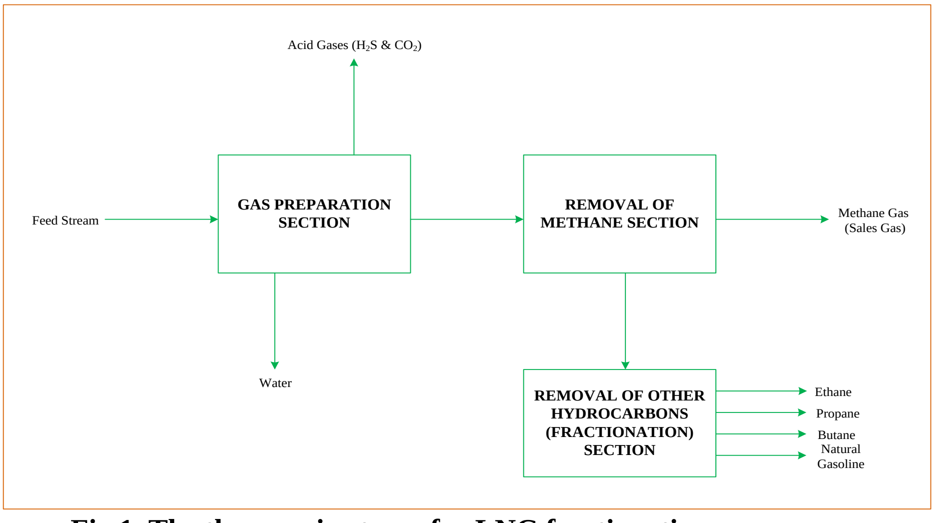


Fig.1. The three main stages for LNG fractionation

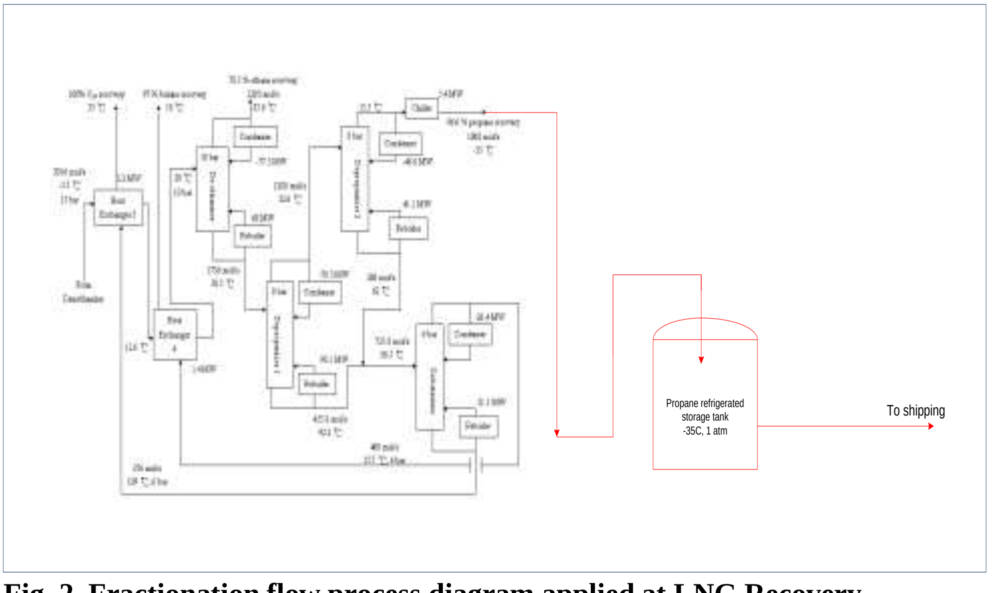


Fig. 2. Fractionation flow process diagram applied at LNG Recovery Plant.

The propane is stored within double containment tanks which are designed and constructed so that both the inner and outer tanks are capable to independently contain the stored refrigerated liquid. Such type of tanks store the refrigerated liquid in the inner tank under normal operation conditions, whereas the outer tank is designed to contain the refrigerated propane that may leak from the inner tank. But the outer tank is not capable to contain any vapour resulting from propane leakage from the inner tank.

Furthermore and based on the flow rate of liquid propane from the chiller (1000 mole/s), the tank needs around two days to be fully filled, and accordingly the shipping comes every two days to unload the tank where another spare tank is also provided [7].

3. STORAGE HAZARDS

Prior to start the safety analysis, it would be beneficial to have a glance over the potential storage hazards in the chemical industries. That is to say determining the kind of hazards associating with storage tanks is mainly depending on the nature of the stored materials as well as the type of the storage. A vessel or a tank can experience failures of different degrees extending from overpressure and underpressure failures to catastrophes due to mechanical or metallurgical defects. Filling storage tanks too rapidly can also cause overpressure conditions whereas underpressure conditions are potential when tanks are emptied too rapidly [8].

However, a release is another credible hazardous scenario associated with storage tanks that has the potential to cause fatalities. Such a problem may occur as a result of failures in equipment, pipework and/or fittings. In terms of equipment, pumps are seemed as a type of equipment with a great tendency to leak. On the other hand, a release from pipework can be a consequence of crack pipehole, a full bore rupture, or a failure or a leak at a flange, valve or gasket.

Release may also occur due to major incidents such as explosions which are potential at different scenarios as in the case where a tank that may burst due to being exposed to overpressure that cannot withstand. Nevertheless, explosion may also happen due to the ignition of flammable mixture or evolution of gas due to the reaction of different components such as impurity and material of construction. The other cause of release that should be considered is having a runaway reaction with the vessel or the tank. Additionally, fire is another important factor that should be considered as one of the factors leading to tank failures. This might involve a jet fire or a fire beneath the tank [9].

Although overfilling is another operational activity during which a release can occur, draining, sampling operations and maintenance practices are other operational activities which are regarded as potential causes of release. Moreover, loss of containment from storage can happen due to impact events such as the impact from a carried item, a dropped load, or a vehicle. However, natural events such as high winds, flooding, rainstorms and earthquakes may also lead to loss of containment whilst lighting may be a source of fire. In what follows, there will be a discussion of the importance of the applied methods in this study.

4. JUSTIFICATION FOR THE APPLIED TECHNIQUES

Hazard and Operability Studies (HAZOP) was chosen to be the primary used method for hazard identification through which a list of problems were identified and accompanied with suggestions for system improvement. And because of this important role, it was thought necessary to start our analysis with this technique which has the privilege of flexibility and allows freedom for creativity. Another valuable advantage of using HAZOP method is that its results can form the input to a probabilistic safety assessment, as the input to develop operating procedures, and as the basis for design change. Also, conducting a HAZOP study improves the safety quality by making people more aware of potential hazards and by keeping up-to-date instructions [10].

Besides, despite the similarities between HAZOP, FMEA and What-if techniques, HAZOP is preferred as it involves a vessel by vessel and pipe by pipe review of the plant. In this study, HAZOP is used to identify a major flammable release of propane from the tank as the most serious hazard. This release, in turn, represents the top event that will be developed in Fault Tree Analysis (FTA) in Part B of this study.

Moreover, Risk Matrix is adopted after HAZOP as a means to rank the potential hazards according to their severity. Based on

Risk Matrix results, proper and reliable mitigation measures have to be considered for events with high severity and likelihood.

However, since undesired hazardous events are still potential even when equipment and control systems are working properly, human errors is thought to be another important hazard identification technique which may lead to undesired events and hence will be covered here [11].

5. HAZOP TECHNIQUE

One of the advantages of HAZOP technique is that it considers all possible ways through which hazards and operating problems may occur. The conduction of HAZOP study on the process was based on the proposed flow diagram for a refrigerated storage tank which is shown in Figure 3 below.

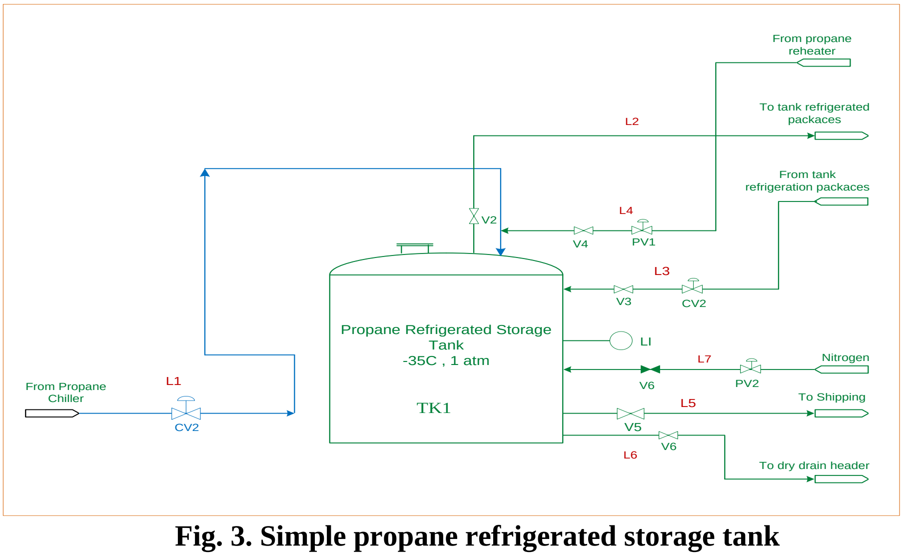


Fig. 3. Simple propane refrigerated storage tank

The modification has involved the installation of additional instrument as follows:

A. Line 1 (L1)

1. Local pressure gauge
2. Install isolation valves and bypass at CV1
3. Provide integrating flow meter

4. Install high high level alarm linked to CV1.
5. Install nonreturn valve
6. Install propane reheated line (L4) with pressure controller and ressure low low linked to pressure valve.

B. Propane storage tank (TK1)

1. Pressure indicator with high/low alarm linked to control room.
2. Local pressure gauge.
3. Level indicator with high/low alarm linked to control room.
4. Temperature indicator with high/low alarm linked to control room.
5. Local temperature gauge.
6. Vacuum relief valve.
7. Electrical heat at the base of TK1.
8. Pressure relief valve.
9. Outer tank or wall.

C. Line 2 (L2)

1. Pressure controller with high/low.
2. Pressure valve.
3. Isolation valves and bypass at PV2.

D. Line two (L3)

1. Isolation valves and bypass at CV2.
2. High level control linked to CV2.
3. Nonreturn valve.

E. Line 4 (L4)

1. Isolation valves and bypass at PV1.
2. Install pressure controller (PC1) and low low pressure (PLL) linked to PV1.

F. Line 5 (L5)

1. Sampling point.

G. Line 7 (L7)

1. Pressure controller linked to pressure valve.
2. Nonreturn valve.

Reasons for the modifications

- Having integrating flow meter installed on the liquid line (FQ).
  The installation of the integrated flow meter on liquid propane feeding line (L1) should be done in a systematic way; it should not be installed prior to installing CV1. This is because in the

event of having closed control valve, different reading will be recorded on the meter. Therefore, in the scenario of having FQ deviation such as low/no flow, it will be possible to detect the leakage source, equipment failure, and blockage and/or pipe rupture. It is also a good practice to ensure regular checking of FQ readings by the operator and this is normally stated within the operating procedure of the company.

- Installing remote pressure indicator to the TK1.

The installed pressure indicator should be linked to the control room to ensure it will be monitored by the operator and will not exceed the allowed range. But it is also required to install high and low pressure alarms beside the pressure gauge to ensure any undesired conditions will be observed in the event of operator's incautiousness.

- Installing remote temperature indicator to TK1.

The installation of this equipment will enable the operator to monitor the inlet temperature of liquid propane and detect any deviations that are about to occur. For example, the temperature for liquid propane should be kept at $-35C^0$.Therefore any increase or decrease in the temperature may cause problem.

- Installing local pressure indicator in TK1 and L1.

The point behind having local pressure indicator is to observe how exactly the operation is running in the storage tank. It makes it possible for the operator to monitor the pressure inside L1 and TK1, and takes the appropriate actions once changes in the pressure are detected. Regular checking of the pressure should be clearly stated in the safe operating procedures.

- Installing local temperature indicator.

Local temperature indicator is the means by which the operator ensures that the temperature of the tank shows compliance with the planned operation modes. There will be a record for any deviation to ensure it will not obstruct the system.

- Isolation valve and bypass at each valve (CVs) or (PVs).

The point of having isolation valve is more to do with the scenario of control valves and/or pressure valves failures and where maintenance work is required. Bypass should be provided at each valve to be used once failures occurred.

- Sampling connection.

Checking the quality of the stored liquid propane cannot be done without having analyzer and sample connection fitted on the tanks. Sample connection should be installed on line 6 (L6) to detect any potential problems such as leakage that may occur during operation and detect any damage inside the tank.

- Install pressure controller and pressure low on propane reheated line.

The aim beyond having this action is to ensure control of the storage pressure and temperature once they dropped more than the required level. In the event of having low operation conditions due to the chiller impact, the pressure controller, as it is designed to work as low low pressure, will send a signal to open pressure valve and allow propane reheated to escape with liquid propane feed.

- Vacuum relief valve.

It means of a final vacuum protection. But if the pressure of the tank dropped further, nitrogen and reheated propane are injected into the tank.

- Relief valve.

A BOG compressor re-liquefying the BOG from the tank is mostly used during normal operations to ensure the pressure of the tank does not exceed the desired range. But in the event of tank unloading, it is possible to record an increase in the pressure where the pressure relief valve is opened to the atmosphere as a final protection method.

- Electrical heat at the base of TK1.

This heat is installed to avoid ice formation in the earth especially that the temperature of the liquid propane is low.

- Outer tank or wall.

It is important to ensure that any leakage of the liquid will not accumulate under the tanks. Hence, outer tank or wall is fitted to contain the refrigerated liquid product leakage from inner tank.

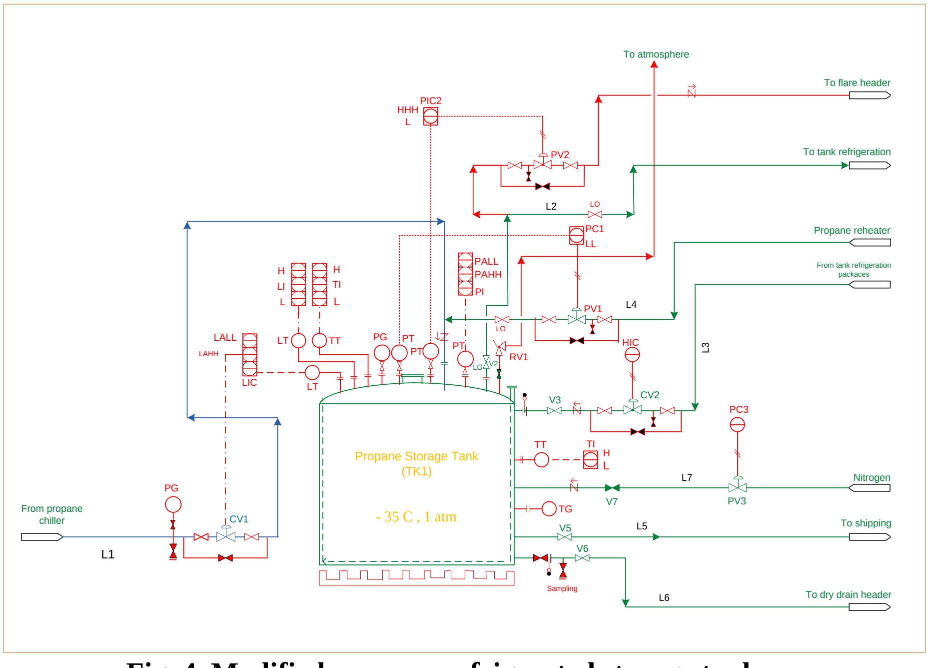


Fig. 4. Modified propane refrigerated storage tank

As a result of HAZOP, several modifications were proposed to the storage tank diagram in order to make it safer. A modified diagram is given in Figure (4).

6. Risk Ranking/Matrix

Risk matrix is another hazard identification method which reflects the importance of risk management strategies during conducting risk assessment for any particular company. It works by rating the levels of risk of all potential events. Risk value is determined by estimating of the potential severity of hazardous event and the likelihood that it will occur. Risk value is formulated as:

$$R = P * S$$

Where:

P= Likelihood of occurrence

S= Potential severity of harm

Table (2): Categories for Likelihood

Frequent	E	5
Probable	D	4
Remote	C	3
Not likely	B	2
Improbable	A	1

Table (3): Categories for Severity

Severe	V	5
Very serious	IV	4
Serious	III	3
Moderate	II	2
Minor	I	1

Table (4): Risk Rating Criteria

Category of Risk	Evaluation of tolerability
Low (Level 3,4)	Risks that should be reduced so that they are tolerable or acceptable (unwanted)
Medium (Level 6,8,9,10)	Risks that should be reduced so that they are tolerable or acceptable (unwanted)
High (Level 12,16)	unacceptable

Applying the risk rating for Leak from L1, CV1

R= P * S

R= 4 * 4 = 16 (The risk level is unacceptable).

Risk matrix was applied for the propane refrigerated storage tank in this process and the technique was conducted following the way stated in [12] and this can be seen bellow.

Table (5): Risk Ranking Calculation

	Cause	**Likelihood**	**Severity**	Risk	**Number**	**Severity**
1	Equipment failure before L1	C	I	Low	3	I
2	L1 blockage/ rupture	C	IV	High	12	IV
3	CV1 fails shut	D	II	Medium	8	II
4	Operator incorrectly closed CV1	C	II	Medium	6	II
5	CV1 fully open	D	IV	High	16	IV
6	Excess flow of propane from chiller	C	IV	High	12	IV
7	CV1 partially open	D	I	Low	4	I
8	Leak from L1, CV1	D	IV	High	16	IV
9	Partial blockage in L1	C	II	Medium	6	II
10	Same as 5					
11	External fire	B	V	Medium	10	V
12	Same as 8					
13	Same as 11					
14	More temperature from supply	C	III	Medium	9	III
15	Ingress of impurities into L1 such as butane or pentane	B	III	Medium	6	III
16	Solids in line 1such as (wax, sand scale, salt and hydrate)	B	II	Low	4	II
17	Rupture due to lightning, earthquake or impact of aircraft).	C	IV	High	12	IV
18	Same as 1					
19	Same as 2					
20	Same as 3					

21	Same as 4					
22	Same as 5					
23	Storage tank leakage or partially blockage	C	IV	High	12	IV
24	TK1 not filled properly- Human error	C	I	Low	3	I
25	Drain header valve (V6) fails open.	C	II	Medium	6	II
26	Operator leaves V6 open	C	II	Medium	6	II
27	Same as 8					
28	Increase level in the storage tank and V2 not opening	B	III	Medium	6	III
29	CV2 fails shut	D	II	Medium	8	II
30	L2 blockage or V2 fails to open	C	III	Medium	9	III
31	Same as 5					
32	Same as 11					
33	Low pressure from chiller	C	III	Medium	9	III
34	Less temperature from chiller	C	III	Medium	9	III
35	Less temperature at TK1 bottom	C	III	Medium	9	III
36	Same as 15					
37	Nitrogen valve (V6) leaks to liquid propane inside TK1	C	II	Medium	6	II
38	Poor construction material selection	C	IV	High	12	IV
39	Loss of electrical power	C	II	Medium	6	II
40	Loss of air	C	II	Medium	6	II

The table illustrates the variation in scoring amongst different incidents. The most hazardous events are those which recorded the highest scores in the index. Although the incidents no 2, 5, 6, 8, 10, 12, 17, 19, 22, 23, 27, 31 and 38 have the highest scores, incidents no 11, 13 and 32 will have the highest consequences.

However, despite having "severe" consequences for the incidents no 11, 13 and 32, they represent low risk since they are unlikely to occur. The scores have been plotted on the risk matrix diagram as follows:

Plotting the incidents on risk matrix diagram enabled us to speculate that five incidents (1, 7, 16, 18 and 24) are in the acceptable region (the green part). Apart from these particular incidents, all the other incidents are subject to analysis to draw those in acceptable region or as low as reasonably possible (ALARP) region. So after conducting risk matrix, one can say that some of the operations associated with propane storage tank are severe and potential to cause serious fatalities. Therefore, it is worthy applying safety analysis to this part of the process to avoid any undesired scenarios.

	Broadly acceptable region. Need to maintain assurance that the risk remains in the region.
	Tolerable only if risk reductions are impracticable or cost is disproportionate to improvement gained
	Unacceptable region. Risk cannot be justified except in extraordinary circumstances.

V	Severe		11, 13, 32			
IV	Very serious			2, 6, 17,19, 23, 38	5, 8,10,12, 22, 27, 31	
III	Serious		15, 28, 36	14, 30, 33, 34, 35		
II	Moderate		16	4, 9, 21, 25, 26, 37, 39, 40	3, 20, 29	
I	Minor			1, 18, 24,	7	
		Improbable	Not likely	Remote	Probable	Frequent
		A	B	C	D	E

Fig. 5. The risk matrix diagram of the propane storage tank.

In addition to equipment failure, operator's incautiousness or failure may lead to undesired events.

1. HUMAN ERROR

Most of the literature on human error has cited it as a main cause and contributing factor in the past incidents. Three Mile Island, Bhopal, Flixborough and Chernobyl are examples of such incidents that occurred due to latent errors. Bhopal tragedy, in particular, involved multiple errors and human act of neglect, misunderstanding and omission as work supervisor observed a leak in one of the storage tanks but mistakenly they assumed it water leak and accordingly the required action was delayed which led to some problematic events.

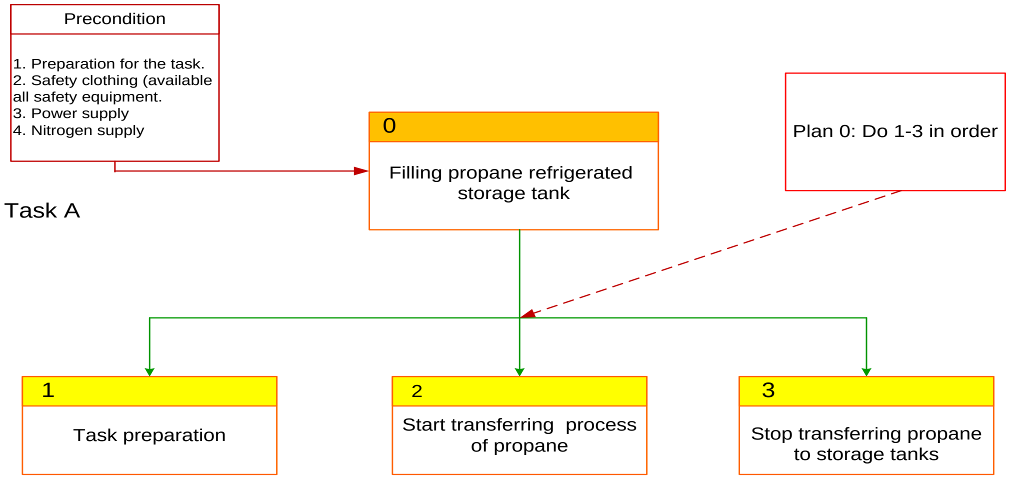
Also, improper cleaning of water from the tank led to an exothermic reaction. Therefore, human awareness and knowledge is critical issue that should be considered to ensure safe operating systems.

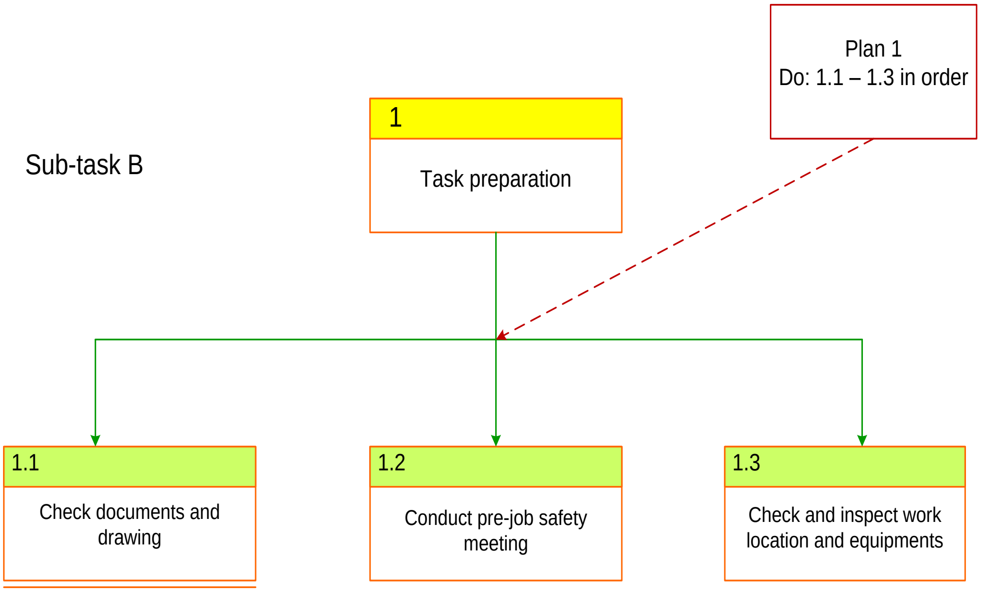
However, determining the causes and contributing factors in human errors is something of equal importance [13]. A table shows the contribution of human performance problems is provided below:

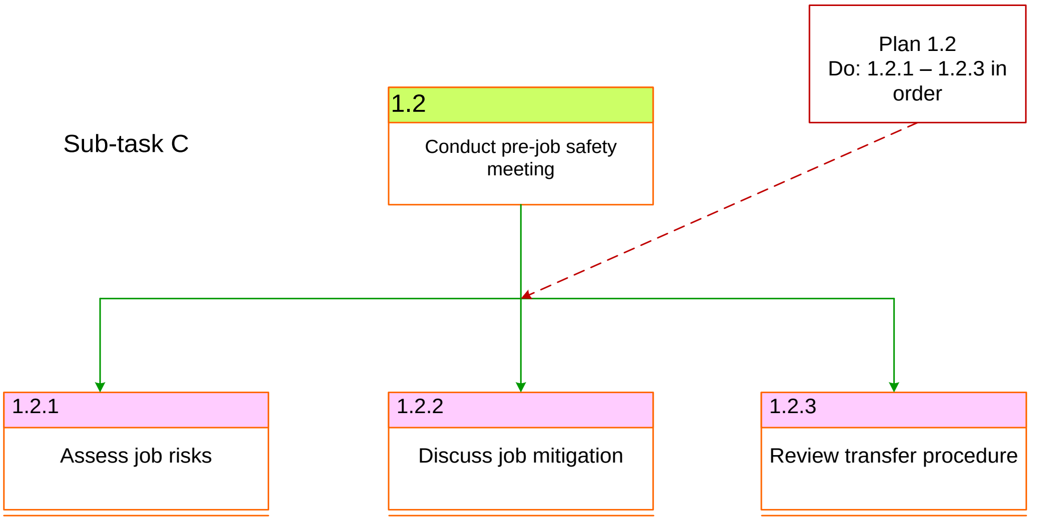
Table (6): Breakdown of human performance problem

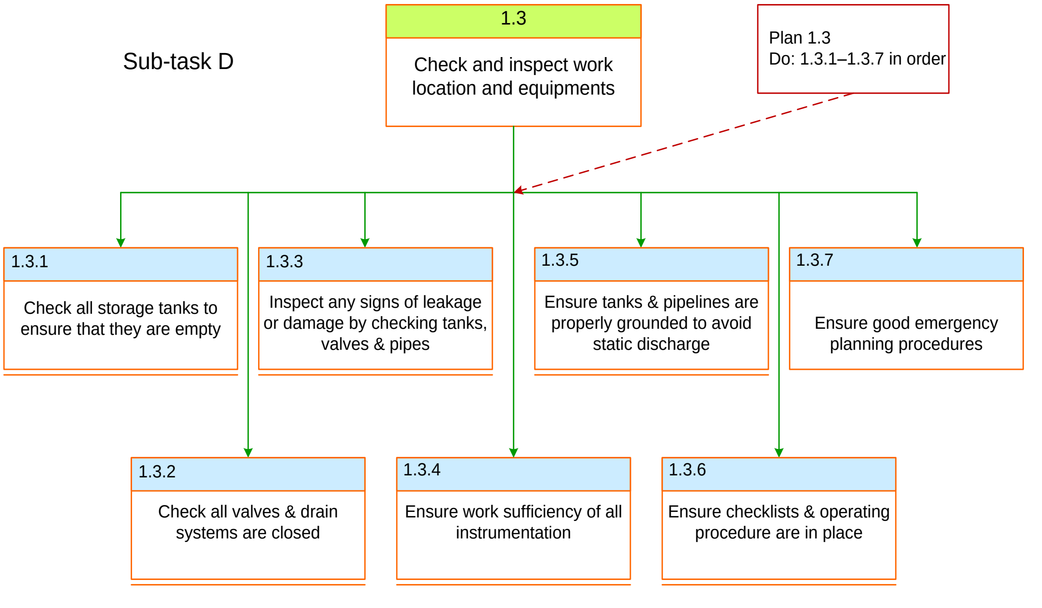
	Human performance problems
43%	Deficient procedures or documentation
18%	Lake of knowledge or training
16%	Failure to follow procedure
10%	Deficient planning or scheduling
6%	Miscommunication
3%	Deficient supervision
2%	Policy problems
2%	Other

In regards to our process (storage tank), overfilling of the tank is one of the most frequent consequences of operator error that may lead to fire or explosion. Overfilling may occur in scenarios when the operator forgets to close the manual valve after the liquid reached the required level or in the event of level measurement failure. Other mistakes associated with storage operation would have been forgetting to empty the spare holding tank and/or having inoperative refrigeration system (e.g. kept shutdown to save costs). A systematic illustration of the main and sub-tasks involved in filling the storage tank with propane is provided in what follows.


Precondition
1. Preparation for the task.
2. Safety clothing (available all safety equipment.
3. Power supply
4. Nitrogen supply
0
Filling propane refrigerated storage tank
Plan 0: Do 1-3 in order
Task A
1
Task preparation
2
Start transferring process of propane
3
Stop transferring propane to storage tanks


Plan 1
Do: 1.1 – 1.3 in order
Sub-task B
1
Task preparation
1.1
Check documents and drawing
1.2
Conduct pre-job safety meeting
1.3
Check and inspect work location and equipments


Sub-task C
1.2
Conduct pre-job safety meeting
Plan 1.2
Do: 1.2.1 – 1.2.3 in order
1.2.1
Assess job risks
1.2.2
Discuss job mitigation
1.2.3
Review transfer procedure


Sub-task D
1.3
Check and inspect work location and equipments
Plan 1.3
Do: 1.3.1–1.3.7 in order
1.3.1
Check all storage tanks to ensure that they are empty
1.3.3
Inspect any signs of leakage or damage by checking tanks, valves & pipes
1.3.5
Ensure tanks & pipelines are properly grounded to avoid static discharge
1.3.7
Ensure good emergency planning procedures
1.3.2
Check all valves & drain systems are closed
1.3.4
Ensure work sufficiency of all instrumentation
1.3.6
Ensure checklists & operating procedure are in place

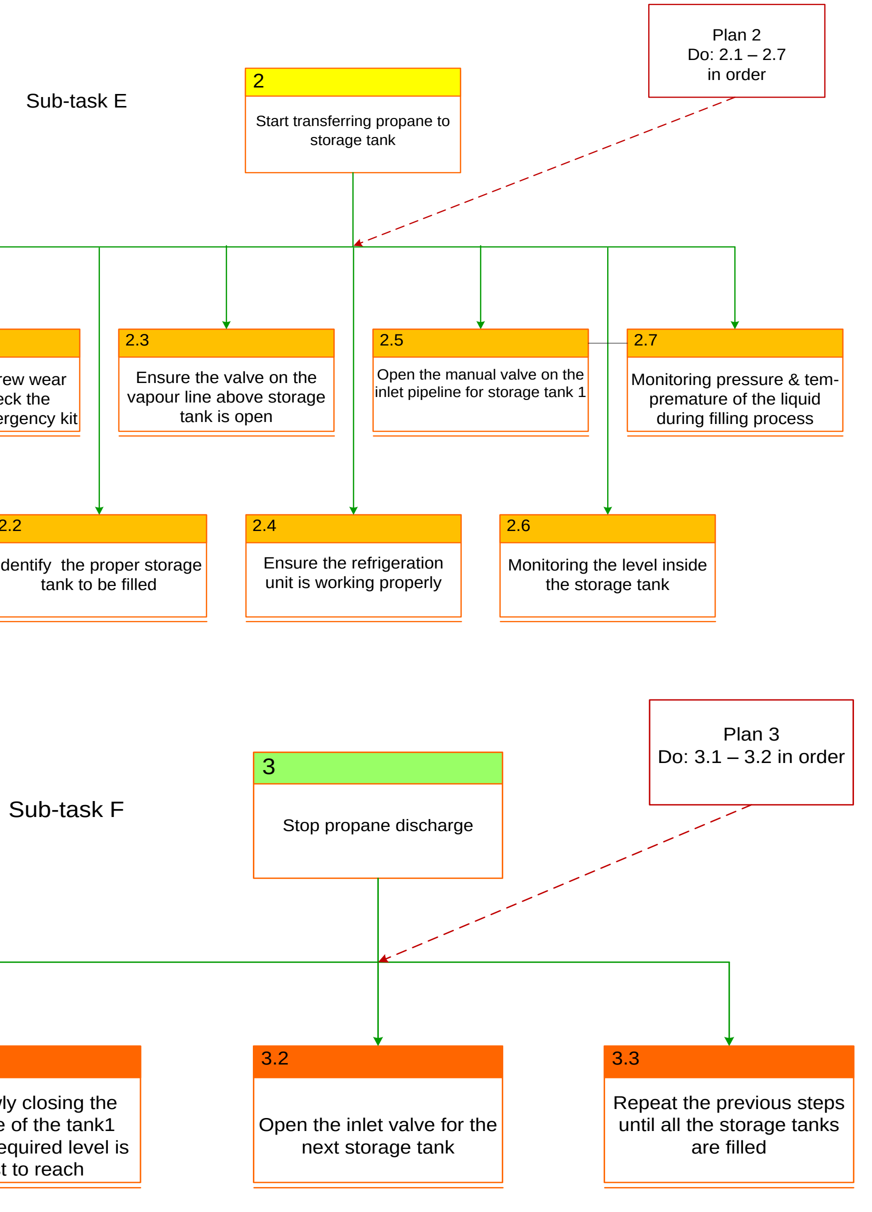


Fig. 6. Tasks involved in filling the propane storage tank.

8. CONCLUSION

This paper has provided some standards to analyze the risk assessment of a propane storage tank. The analysis has covered a selection of hazard identification and risk assessment techniques that are thought to be suitable and reliable for studying this part of the plant. As it has been explained from the qualitative risk assessment, it results that the risk of a major accidents (1,3,4,7,9,16,18,20,21,24,25,26,29,37,39 and 40) are acceptable , being necessary a periodical monitoring and a strict operational system. The biggest risk of a major accident belongs to incidents (2,5,6,8,10,12,17,19,22,23,27,31 and 38).Incidents (15,28 and 36) has a reduced risk because of the probability of occurrence, but the consequences can be significant and these scenarios can not be ignored. Incidents (11, 13 and 32) also include medium risks, but the consequences of such accidents can be severe if they are not managed immediately by the operating personnel.

Both of working equipments and operators should work in combination to ensure smooth working processes and hence to avoid any undesired problem or incident. Over all, great concerns should be given to the critical hazardous events associated with propane storage tanks, and their possibility to cause fatalities.

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