Research Journal of Applied Sciences, Engineering and Technology 16(2): 73-76, 2019
DOI:10.19026/rjaset.16.6002
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: November 08, 2018 Accepted: February 12, 2019 Published: March 15, 2019

Research Article

Identification, Assessment and Control of Major Hazard Sources in the Construction of Liquefied Natural Gas Storage Tank by Air Lift

Guanjun Xiao
Jianshe Road, Renqiu City, Hebei Province, 062552, P.R. China

Abstract: The aim of study is taking the advantages of the risk assessment of operating conditions (LEC), this study has carried out the risk assessment of the air lift process in the construction of full containment LNG storage tank with volume of 30000 m^3 in one LNG projects. This performance enables the contractor to identify the major hazard sources in the construction and take safety control measures on site and facilitates to greatly reduce the safety risk in construction and effectively guarantee the smooth air lift operation.

Keywords: Air lift process, Liquefied Natural Gas (LNG), major hazard sources, risk assessment, risk assessment of operating condition (LEC), storage tank construction

INTRODUCTION

LNG storage tank, the main storage facility in the LNG industry chain, is usually constructed by the process of air lift. The air lift process is preferred for its faster speed of construction and lower cost. While, it has also brought challenges including higher construction difficulty, more safety risks and others. In the cases of inadequate preparation in advance or incomplete check in process, the dome may fall after rise due to power failure, lack of air volume or imbalance rise of dome. The safety risk will be increased for the long time of duration in the air lift process. Graham and Kinney (1980) first proposed Risk Assessment of Operating Condition (LEC), Wu *et al*. (2001), Fan *et al*. (2010), Wang *et al*. (2012) and Ji *et al*. (2017) have applied LEC to various engineering fields. Therefore, it is necessary to carry out the risk assessment for the air lift process in the LNG storage tank construction, to control the hazard sources in construction, reduce the construction risks, prevent the accidents and guarantee the safe operation.

MATERIALS AND METHODS

Xiting *et al*. (2017) have studied that the process of air lift for LNG storage tank dome roof is in the principle of buoyancy lift by air with micro pressure. The relatively confined space is formed between the dome roof and the concrete tank wall, into which the fans will constantly pump air with low pressure. The steel structure of tank roof will stably rise to the designed height in the predetermined route after getting rid of its gravity and the force of fraction with the tank wall. The process will be finally completed after the connection of the dome roof and the pressure-bearing ring at tank top.

Wei *et al*. (2018) identified, assessed and controlled major hazard sources in the construction engineering, the construction procedure of LNG storage tanks is divided into four step preparation for air lift, commencement of air lift, dome roof in place and close out.

The risk assessment of operating conditions (LEC) is applied by Luo *et al*. (2004) and Zhang *et al*. (2007) to evaluate the danger and hazard to operators working in the environment with potential risks:

Danger mark D = L*E*C

where,

D (Danger) = The combination of occurrence likelihood of risk factors and the class of the caused consequence
L (Likelihood) = The likelihood of accident occurrence
E (Exposure) = The frequency of operator's exposure into the dangerous environment
C (Consequence) = The consequence that may be caused in case of the accident.

The larger the D value is, the higher the risk is. When D value exceed the unacceptable or unallowed risk limit, it will be identified as major hazard source. The values of L, E, C, D and the value range of D for

Table 1: Likelihood of accident occurrence (L)

Value	Likelihood of accident occurrence
10	Certain
6	Likely
3	Possible, but infrequent
1	Perhaps, out of expectation
0.5	Unlikely
0.2	Rare
0.1	Impossible

Table 2: Frequency of exposure into the dangerous environment

Value	Frequency of exposure
10	Continuous
6	Daily work time
3	Once a week
2	Once a month
1	Once a year
0.5	Rare

Table 3: Consequence caused by the accident occurred

Value	Frequency of exposure
100	Catastrophe, large number of deaths
40	Disaster, several deaths
15	Severe, one death
7	Serious injury or serious hazard
3	Slight injury or hazardous
1	Minor harm or against the basic safety and sanitation requirements

different classes refer to the study of Lingcai *et al*. (2011) are shown in the following Table 1 to 4.

A LNG Liquefaction Plant Project completed in Shanxi Province, China in 2017 year, the air lift process in the construction of full containment 30000 m^3 LNG storage tank in one LNG projects is shown in Fig. 1. Its hazard has been identified and its risk assessment has been carried out by Job Safety Analysis (JSA) to determine the major hazard sources.

Table 4: Classification of hazard level

D value	Hazard level	Class
>320	Extremely hazardous, operation to be stopped	
160~320	Highly hazardous, immediate correction required	
70~160	Significantly hazardous, critical control	
20~70	Hazardous, necessary control	
<20	Slightly hazardous, acceptable	

RESULTS AND DISCUSSION

Control principle of the major hazard source in LNG storage tank construction air lift as follow:

- Elimination and reduction of risk by applying advanced techniques, adopting safe alternative measures and taking personal protection into account.
- Pre-arranged planning and emergency measure linkage mechanism.
- Determination of response strategies by technical management with process control and real-time tracking.

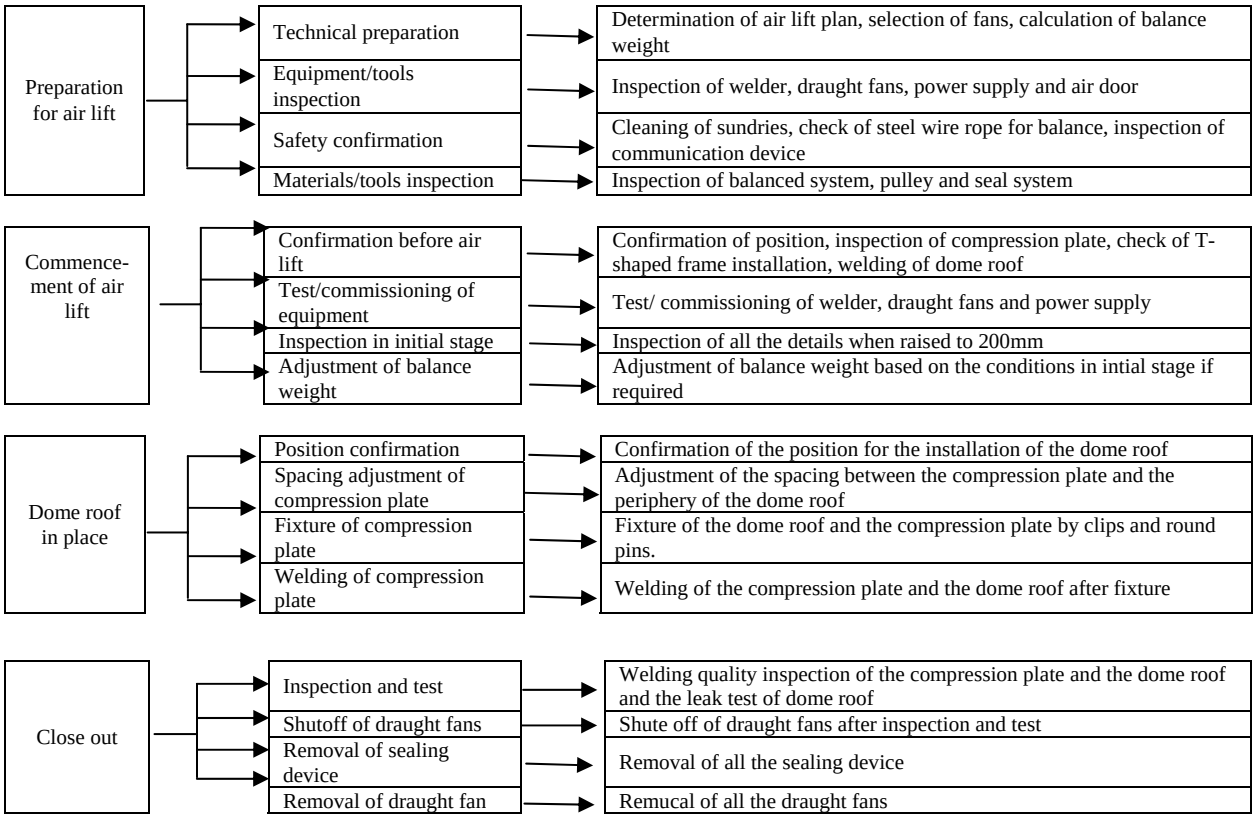

Fig. 1: Process flow diagram of air lift

After research the response measures for the major hazard source as follow:

- **Unprepared heavy work:** The selected slings for lifting loads should meet the lifting capacity. All the slings should be checked carefully before lifting and the slings shall be changed if any defect is found. The warning shall be set in lifting area and personal custody shall be arranged.
- **Operator's incorrect wearing of safety belt:** Climbing operator must wear qualified safety belt. The operator in high places should tie up safety belt tightly. The climbing operators should be controlled strictly and high platform should be checked frequently.
- **Insecure tools and materials:** The tools should be placed in their cabinet and should not be placed in operation platform at will. Materials in high places should be fixed tightly and high platform should not be pile up with too many materials.
- FAQ (Frequently Asked Questions) and their solutions in LNG Storage Tank Construction by Air Lift

FAQ and their solutions in LNG Storage Tank Construction by Air Lift as follow:

Seal plate being blown over: If the case occurs before the commencement of air lift, the pressure increasing shall be immediately stopped, the volume damper shall be slowly turn off. When the tank roof slowly declines to the edge support, the air blowers shall be turn off. If one seal plate is found blown over during the process of air lift, the volume damper shall be adjusted to keep the pressure balance in the tank and the seal device shall be checked after the tank top is stable.

One air blower stalling: If the case occurs during the process of air lift, the air suction control valve shall be immediately throttled down to reduce air loss and the spare air blower shall start at the same time. If the case occurs in welding, the control valve shall be shut down and the spare air blower shall start. "U" type pressure gage at tank top should be monitored to prevent the over pressure or low pressure. The volume damper shall be controlled.

One generator failing to work: The backup power shall start to work and the air blower shall be restarted. The emergency shutoff valve of the air blower shall be throttled down.

Tank roof falling caused by the failure of all the draught fans: All the opening shall be closed to reduce tank roof falling speed to the lowest. If the air pressure in the tank still can't support tank roof to raise, the spare draught fan shall start while keeping all draught fans working simultaneously. If both two draught fans fails to work, the grinding machine shall start to cut off the emergent chain block which controls the air channel flashboard, in order to put down the flashboard. All the measures shall be taken to slow down the tank pressure drop. After the tank roof slowly declines to the edge support, the draught fans shall be changed or the electrical circuit shall be inspected and the remedial measure shall be taken.

CONCLUSION

Based on the practical conditions at site, the hazard level has been finally classified after the consultation with specialists, design engineers and construction engineers, assessment of likelihood of accident occurrence and the consequence caused. The details are shown in Table 5.

Table 5: Identification list of hazard factors in air lift operation

				Risk assessment				
No.	Operation	Hazard factors	Consequence	L	E	C	D	Hazard level
1	Installation of T-shaped frame	Operator's incorrect wearing of safety belt	Falling from high place	1	6	7	42	General
2		Damaged power line	Electric shock	3	3	7	63	General
3	Test and commissioning of draught fan system	Unprepared lifting operation	Lifting injury	3	6	7	126	Major
4		Defective power system	Electric shock	3	6	3	54	General
5	Installation of steel balance rope at dome roof	Operator's incorrect wearing of safety belt	Falling from high place	3	6	7	126	Major
6		Insecure tools or materials	Mauling by objects	3	6	7	126	Major
7	Balance weight in position	Operator's incorrect wearing of safety belt	Falling from high place	3	6	7	126	Major
9		Insecure tools or materials	Mauling by objects	3	6	3	54	General
10		Defective lifting equipment	Lifting injury	3	3	7	63	General
11	Process inspection	Operator's incorrect wearing of safety belt	Falling from high place	1	6	15	90	Major
12		Lack of safeguard procedures for equipment	Mechanical injury	3	3	7	63	General
13	Air lift	Defective power system	Electric shock	3	6	3	54	General
14		Lack of safeguard procedures for equipment	Mechanical injury	3	3	7	63	General
15		Operator's incorrect wearing of safety belt	Falling from high place	3	6	7	126	Major
		Insecure tools or materials	Mauling by objects	3	6	3	54	General

The hazard source shall be identified as major when D value is over 70. Table 5 NO. 3, 5, 6, 7, 10 and 14 are major hazard sources in air lift operation. These major hazard sources should be improved and controlled in the construction to prevent the accidents.

Similar to LNG storage tank construction by air lift, large projects with more factors in process, higher construction difficulty and more safety risks, can adopt the risk assessment of operating conditions (LEC) and control the major hazard sources in construction, in order to eliminate and reduce hazard, reduce cost and enhance efficiency. Combined with similar overseas projects, the typical problems in air lift have been analyzed and concluded and the response strategies can be determined by real-time dynamic tracking and critical control.

REFERENCES

Fan, B. *et al*., 2010. Reverse installation technique with pneumatic lifting for steel inner cylinder of 240 m stack in Chaozhou power plant. Eng. J. Wuhan Univ., 43(8): 336-339.

Graham, K.J. and G.F. Kinney, 1980. A practical safety analysis system for hazards control. J. Safety Res., 12(1): 13-20.

Ji, L. *et al*., 2017. Risk analysis and safety management for confined space operations. Shenhua Technol., 15(09): 3-6.

Lingcai, C. *et al*., 2011. Identification, assessment and control of major hazard sources in the construction engineering. Eng. Construct., 25(2): 267-269.

Luo, Y., Y. Fan and X. Ma, 2004. Risk Analysis and Safety Evaluation. Chemical Industry Press, Beijing.

Wang, J. *et al*., 2012. Application of LEC-M method in safety evaluation in ship lift construction. J. Safety Sci. Technol., 8(10): 179-184.

Wei, C. *et al*., 2018. Control of air lift process in large LNG storage tank. China Petrol. Chem. Stand. Qual., 38(14): 171-172.

Wu, Z.Z. *et al*., 2001. Method of Risk Evaluation and its Applications. Press of Metallurg, Beijing.

Xiting, D. *et al*., 2017. Study on the safety protection of LNG tank. Construct. Design Proj., 07: 73-74+77.

Zhang, J. *et al*., 2007. Research on Safety Assessment and Management Methods of Construction Hazard. School of Civil and Hydraulic Engineering, Dalian University of Technology, Dalian.