

# Aftereffect Calculation and Prediction of Methanol Tank Leak's Environmental Risk Accident

Yueting Lang<sup>1</sup>, Lina Zheng<sup>1,2</sup>, Henan Chen<sup>1</sup>, Qiushi Wang<sup>1</sup>, Hui Jiang<sup>1</sup> and Yiwen Pan<sup>1</sup>

<sup>1</sup>College of Marine Technology and Environmental, Dalian Ocean University, Dalian 116023, China

<sup>2</sup>Key Laboratory of Nearshore Marine Environmental Research, Dalian 116023, China

\*Corresponding author e-mail: zln@dlou.edu.cn

**Abstract.** With the increasing frequency of environmental risk accidents, more emphasis was placed on environmental risk assessment. In this article, the aftermath of an Environmental Risk Accident on Methanol Tank Leakage occurred on a cryogenic unit area in a certain oilfield processing plant have been mainly calculated and predicted. Major hazards were identified through the major hazards identification on dangerous chemicals, which could afterwards analyze maximum credible accident and confirm source item and the source intensity. In the end, the consequence of the accident has been calculated so that the impact on surrounding environment can be predicted after the accident.

## 1. Introduction

Several world-shaking environmental pollution incidents have occurred in the history. The world's worst chemical disaster was the isocyanate spilled from a pesticide factory in Bhopal, India in the 1980s (killing about 3500~7500 people at that time, nearly 20,000 people had been killed in until 2002) as well as the accident in Chernobyl nuclear power plant in the former Soviet Union. Major sudden environmental accident problem has been taken seriously by the world. Environmental risk assessment is of great necessity to prevent the environmental pollution accident and provide effective emergency measures.

Environmental risk assessment, a risk assessment about the personal safety and environmental influence which is caused by predictable emergency incident (Generally not including manmade damage and natural disasters) that give rise to the accidental spillage of toxic or harmful substances or form new toxic material during the constructing and running period of construction projects.

With the assessments, we can put forward some reasonable criterion of conduct as well as emergency and mitigation measures in order to reduce the loss and the accident rate of construction projects as well as the impact on the environment to an acceptable degree. The article is aimed at calculating and predicting the after math of environmental risk accidents about a leakage of methanol storage tank in the cryogenic unit area in the oil field gas processing factory.



## 2. Risk identification and major hazard sources identification

### 2.1. The material risks

The commercial natural gas and light hydrocarbon are the main productions in an oilfield gas processing factory. The main technological process is: The oilfield gas collected by gas gathering station has been separated preliminarily by shallow cooling device firstly; the separated dry gas is transported into the cryogenic device for pressurizing, dehydration, refrigeration and separation and is produced into the commercial natural gas; The natural gas from booster stations and the original incoagulable gas are transported into the oilfield gas processing device, the hydrocarbon is recycled through expander and propane as a refrigerant to refrigerate, the light hydrocarbon is transported into cryogenic light hydrocarbon storage tank, some of the cryogenic dry gas is returned to the booster stations, and others is exported. The product of light hydrocarbon is transported to total library for transit through pipelines which are occurred to transport light hydrocarbon after the light hydrocarbon is storage in light hydrocarbon storage tank and buffered. In case of the pipelines maybe are frozen when transporting light hydrocarbon in winter, some methanol is needed to add.

The storage capacity is 600 tons of methanol tanks in the cryogenic equipment area in the oil field gas processing factory. To deal with the material in the cryogenic equipment area in this project, methanol is chosen as the main risk evaluation factor.

### 2.2. Equipment risk

Methanol tank is the main equipment of oil field gas treatment plant cryogenic device area, for example, equipment leakage will cause fire explosion accident.

### 2.3. Significant dangerous source identification

Contrast the major hazard installations for dangerous chemicals identification (GB18218-2009) standard, methanol storage capacity of more than a critical mass, thus constitutes the major hazards. Identification results of major hazard installations for dangerous chemicals are shown in Table 1.

**Table 1.** Identification results

Category	Dangerous chemicals name	Critical mass (t)	Storage capacity (t)
Flammable liquids	Methanol	500	600

## 3. The source term analysis

### 3.1. Most credible accident analysis

According to the analysis, the maximum credible accident identified is methanol tank leakage accident.

### 3.2. Determine the source term and the source

With reference to the simplified method for determining of leaking in "practical techniques and methods of environment risk assessment", determine the project risk accident source term are shown in Table 2.

**Table 2.** The accident source term.

Equipment	Leakage aperture (mm)	Leakage time (min)	Harmful medium	The accident types	Release rate (kg/s)	Discharge of highly	Probability
Methanol tank	φ80	30	CH <sub>3</sub> OH	Material leakage	1.07	1.0	1×10 <sup>-5</sup>

When the methanol storage tank leakage, the leakage rate is:

$$Q_L = C_d A \rho \sqrt{\frac{2(P - P_0)}{\rho} + 2gh}$$

In the above formula:

$Q_L$  -- liquid leakage rate, kg/s;

$C_d$  -- liquid leakage coefficient, the common is in the range of 0.6 to 0.64, 0.62 is selected in this paper.

$A$  -- gap area, m<sup>2</sup>;

$P$  -- containers within the medium pressure, Pa;

$P_0$  -- the environmental pressure, Pa;

$g$  -- the acceleration of gravity.

$h$  -- the breach on the height of liquid level, m.

As the method of the storage methanol is atmospheric pressure, leakage rate is calculated as the 1.07kg/s.

After the leakage of methanol, the volatilize-quantity calculation:

Methanol storage tank is stored at room temperature and atmospheric. When it leaks, because the materials have the same temperature environment, the boiling point of methanol is 64.8 °C, so it usually don't occur flash and evaporation heat. There are liquid pool formation in the surrounding after the leakage, and the main reason why volatilize is that liquid pool surface airflow movement causes the liquid evaporation. Due to the leakage liquid after living on a concrete floor surface expands unceasingly, at the same time constantly volatile and spread into the atmosphere, causing air pollution. Quality of evaporation speed press type calculation:

$$Q_3 = \alpha \times p \times M / (R \times T_0) \times u^{(2-n)/(2+n)} \times r^{(4+n)/(2+n)}$$

In the above formula:

$Q_3$  -- the quality of the evaporation rate, kg/s;

$\alpha, n$  -- atmospheric stability coefficient;

$P$  -- the surface of the liquid vapor pressure, Pa;

$R$  -- the gas constant; J/mol k;

$T_0$  -- the environmental temperature, k;

$u$  -- wind, m/s;

$r$  -- liquid pool radius, m.

**Table 3.** Parameter of pool evaporation model.

Stability conditions	n	$\alpha$
Unstable (A, B)	0.2	$3.846 \times 10^{-3}$
Neutral (D)	0.25	$4.685 \times 10^{-3}$
Stable (E, F)	0.3	$5.285 \times 10^{-3}$

The longest diameter of Liquid pool depends on the regional configurations near the point of leakage, the continuity of leakage or instantaneity. When have a cofferdam, the cofferdam radius of maximum equivalent radius of liquid pool; without cofferdam, set liquid instantaneous spread to minimum thickness, calculate the equivalent radius of liquid pool. Using the calculation formula, the result of the speed of evaporation ( $Q_3$ ) is 0.07 kg/s.

#### 4. The accident consequences calculation and prediction

##### 4.1. A model for calculating the risk of accident consequences:

$$C(x, y, o) = \frac{2Q}{(2\pi)^{3/2} \sigma_x \sigma_y \sigma_z} \exp\left[-\frac{(x-x_0)^2}{2\sigma_x^2}\right] \exp\left[-\frac{(y-y_0)^2}{2\sigma_y^2}\right] \exp\left[-\frac{z_0^2}{2\sigma_z^2}\right]$$

In the above formula:

$C(x, y, 0)$  -- The concentration of pollutants in the airing round under the direction of the wind ( $x, y$ ),  $\text{mg}/\text{m}^3$ ;

$X_0, Y_0, Z_0$  -- Coordinate puff center;

$Q$  -- Emissions of smoke during the accident;

$\Sigma x, \sigma_y, \sigma_z$  -- As  $X, Y, Z$  direction of the diffusion parameters, m. Often  $\sigma_x = \sigma_y$ .

##### 4.2. The standard of evaluation

In risk accident cases, there are emissions of pollutants, but it is only caused by a high concentration of pollutants in atmospheric environment in a short duration. The characteristic that people exposure to toxic substances is emergency contact, so limit of contacting poison material in short time is used as evaluation standard when the accident happened. The standards of evaluation are shown in Table 4.

**Table 4.** The standards of evaluation.

The evaluation factors	The body reaction	The concentration of the corresponding ( $\text{mg}/\text{m}^3$ )	Note
Methanol	Life-threatening	86000	
	Severe poisoning	5000	
	General poisoning	500	
	Allow contact concentration	50	

Note: Data in the table from the "degree and hazardous chemicals Handbook in common" (China Light Industry Press) and "chemical toxicity, regulations, environmental data handbook" (Environmental Science Publishing).

##### 4.3. The calculation and prediction of the consequences of the accident leakage of methanol tank

Using the calculation model is specified in Section 3.1 to predict the influence that methanol emission of methanol tank leakage to the environment. In the calculation of little wind (wind speed 0.75m/s), wind (wind speed 2.3m/s), under different atmospheric stability of B, D, F, influence scope of leakage accident of methanol is shown in Table 5.

**Table5.**Effect on range of all kinds of meteorological conditions of methanol spill (m).

The wind speed	Concentration of the standard	life-threatening			Severe poisoning			General poisoning			Allow contact concentration			
		B	D	F	B	D	F	B	D	F	B	D	F	
		86000mg/m <sup>3</sup>			5000 mg/m <sup>3</sup>			500mg/m <sup>3</sup>			50 mg/m <sup>3</sup>			
0.75 m/s	S c o p e	5min	——	——	——	5	5	5	10	10	30	35	70	120
		10min	——	——	——	5	5	5	10	10	30	35	75	120
		15min	——	——	——	5	5	5	10	10	30	35	75	120
		20min	——	——	——	5	5	5	10	10	30	35	75	120
		25min	——	——	——	5	5	5	10	10	30	35	75	120
		30min	——	——	——	5	5	5	10	10	30	35	75	120
2.3 m/s	S c o p e	5min	——	——	——	15	25	45	120	200	380	460	480	450
		10min	——	——	——	15	25	45	120	200	530	500	790	860
		15min	——	——	——	15	25	45	120	200	530	500	860	1260
		20min	——	——	——	15	25	45	120	200	530	500	860	1640
		25min	——	——	——	15	25	45	120	200	530	500	860	2010
		30min	——	——	——	15	25	45	120	200	530	500	860	2350

According to the analysis of the calculation result, when methanol leakage occurred, the range of leading to life-threatening effects may is only in the range of factory district; the range of leading to severe poisoning is 5 to 45meters; the range of leading to poisoning generally is 10 to 530meters; the range of exceeding maximum allowable concentration of short-term is 35 to 2350meters.

From the table, except in the windy conditions, after the methanol leakage accident occurred in 25minutes, there are more than "STEL" around 2000 meters. Within 30minutes when the methanol storage tank leak, there is almost no influence on the environment of this project in the range of 2000 meters.

## 5. Conclusion

According to the analysis by means of engineering material and equipment, the accident is determined to methanol tank leakage accident in this paper. In spite of the accident has little effect on the surrounding environment, the project is still should adopt feasible measures to prevent the risk of accidents, and make 'Risk of accident anticipated plan' for immediately starting when the accident happens. After the strict implementation of risk management and emergency measures, we can make the probability of risk occurrence and the consequences to a minimum.

## Acknowledgements

This work was financially supported by Dalian Ocean University Students' innovation and entrepreneurship program plan project and Liaoning Province Finance Research Foundation.

## References

- [1] Fang Wang, Yue Gao, Wenxu Dong, Zhiwei Li, Xiaoping Jia, Raymond R. Tan. Segmented pinch analysis for environmental risk management [J]. Resources, Conservation & Recycling, 2017, 122:353-361.
- [2] Yongsheng-Geng, Introduction to the environmental risk assessment [J]. Environmental science Tribune, 2010, 29 (5):86-91.
- [3] Zhong-ye, Zhongtao-Chen. Environmental risk assessment and the suggestion [J]. Petrochemical industry safety environmental protection technology, 2010, 26 (5):14-16.
- [4] Lu Han, Yonghui Song, Liang Duan, Peng Yuan. Risk assessment methodology for Shenyang Chemical Industrial Park based on fuzzy comprehensive evaluation [J]. Environmental Earth Sciences, 2015, 73 (9):5185-5192.
- [5] I. M. H. R. Antunes, M. T. D. Albuquerque, F. A. N. Sanches. Spatial risk assessment related to

- abandoned mining activities: an environmental management tool [J]. *Environmental Earth Sciences*, 2014, 72 (7):2631 - 2641.
- [6] Technical Guidelines for Environmental Risk Assessment on Projects, Environmental protection industry standard of the People's Republic of China (HJ/T 169—2004), the state environmental protection administration 2004.12.
- [7] Gary S. Silverman, Meghan K. Wally. Preparation of environmental studies and sciences students to participate in the environmental risk dialogue [J]. *Journal of Environmental Studies and Sciences*, 2016, 6:580-588.