LNG Filling Stations Safety Evaluation Technology Research

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Abstract. In this paper, dangerous source of gas stations was identified by LEC method. Through reviewing literature and relevant information, carrying out field research, consulting experts and combining the features of LNG filling stations, a safety evaluation index system was established. Based on the analytic hierarchy process, a fuzzy comprehensive evaluation was made to get its safety level and put forward corresponding security measures.

1 Introduction

Environmental protection is the theme of the contemporary, frequently appeared in a variety of summit themes. The demand for clean energy in each country is imminent. Liquefied natural gas (hereinafter referred to as LNG) as a clean energy, is the use of natural gas, more and more applications in various fields. LNG is inflammable and explosive substance, there is a great potential risk in the process of operation. Once there is an accident, not only endangers the LNG filling stations, but also impact on the property and life safety of people around. Therefore, it is very

2 LEC method

K.J. Graham and Ginny G.F. proposed to take the risk of operating conditions as a dependent variable, the possibility of accident or occurrence of hazardous events, exposure to environmental risk frequency and risk severity as the independent variable. In accordance with the experience to give the independent variable with different corresponding points, using the scoring method, and then calculate the value by the formula, and divide the risk level.

The formula is expressed as D=LEC: L---The possibility of an accident or danger; E---Frequency of the exposure to hazardous environment; C---The consequences of the accident; D---Risk of operating conditions. [1].

3 Safety evaluation of a skid mounted station in Beijing

3.1 Safety evaluation index system of a skid mounted station in Beijing

UUUsing, and combined with an actual skid mounted station in Beijing, then set up suitable safety evaluation index system, see table 1:

Table 1 Safety evaluation index system of a skid mounted station in Beijing

Objective layer	Criterion layer	Index layer
Safety evaluation index system of Changping Dongguan LNG filling station U	Equipment factors U1	LNG storage system U5
		Filling system U6
		Pipe valve system U7
		Low temperature pump and pump pool U8
		Control system U9
	Environmental factors U2	Fire protection distance design U10
		Fire safety in the station U11
		Environmental sanitation in the station U12
	Employee factors U3	LNG quality of import and export U13
		Workers' education level U14
		Certified rate of workers U15
		Management personnel qualifications U16
		Safety awareness and physical quality U17
	Management factors U4	Security rules and regulations U18
		Regular safety education U19
		Regular safety check U20
		Regular equipment management U21

3.2 The fuzzy comprehensive evaluation principle of a skid mounted safety evaluation in Beijing

This paper uses a security evaluation method combining qualitative and quantitative method, analytic hierarchy process and fuzzy comprehensive evaluation method.

3.2.1 Set up factor gather

According to table 1, four main factors of the criterion layer are used as the set of the first level evaluation factors, and seventeen factors of the index layer are used as the set of the two level evaluation factors. [2].

3.2.2 Set up weighting sets

Use analytic hierarchy process to calculate the weight of each index.

(1) Calculation of the weight of the criterion layer

Evaluation index were equipment (U1) factors, environmental factors (U2), employee factors (U3), management factors (U4), by the 1-9 scale method, established judgment matrix, using MATLAB and normalized weight vector w = (0.5954, 0.0536, 0.1130, 0.2379). By formula $\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{w_i}$, calculated the maximum eigenvalue =4.1775, consistency check calculation was CR=0.0665 < 0.1, consistency can be accepted, summarized as shown in Table 2:

Table 2 Factor weight of criterion layer

Judgment matrix U	U1	U2	U3	U4	W	
Equipment factor（U1）	1	7	5	4	0.5954	$\lambda_{\max}$=4.1775
Environmental factors（U2）	1/7	1	1/3	1/5	0.0536	C_R=0.0665＜0.1
Employee factors（U3）	1/5	3	1	1/3	0.1130	Consistency can be accepted
Management factor（U4）	1/4	5	3	1	0.2379	

(2) Calculation of the weight of the index layer

According to the same method, the weight of each factor can be calculated, and all pass the consistency test.

Equipment factor: $W_1 = (0.4407, 0.0950, 0.2340, 0.0523, 0.1780)$

Environmental factors: $W_2 = (0.2005, 0.4279, 0.0872, 0.2844)$

Employee factors: $W_3 = (0.0838, 0.5462, 0.2323, 0.1377)$

Management factor: $W_4 = (0.4673, 0.1601, 0.2772, 0.0954)$

3.2.3 Set up comment set

The risk level of LNG skid mounted station is divided into five levels, respectively, very safe, safe, medium and safe, less safe, very unsafe, that is, V={is very safe, safe, medium, less safe, very

unsafe}[5]. Five experts divided 17 factors and got the expert score table, after statistical processing of the expert score table to get the membership table.

Table 3 Index factors membership of LNG skid mounted station

Number	Index factors	comment set				
		Very safe	Safe	Medium and safe	Less safe	Very unsafe
U5	LNG storage system	0.2	0.6	0.2	0	0
U6	Filling system	0	0.2	0.2	0.6	0
U7	Pipe valve system	0	0.2	0.6	0.2	0
U8	Low temperature pump and pump pool	0.6	0.4	0	0	0
U9	Control system	0.2	0.6	0.2	0	0
U10	Fire protection distance design	0	0.2	0.2	0.6	0
U11	Fire safety in the station	0	0	0.6	0.4	0
U12	Environmental sanitation in the station	0.4	0.6	0	0	0
U13	LNG quality of import and export	0	0.6	0.4	0	0
U14	Workers' education level	0	0	0.6	0.4	0
U15	Certified rate of workers	0.6	0.4	0	0	0
U16	Management personnel qualifications	0	0.2	0.6	0.2	0
U17	Safety awareness and physical quality	0	0.2	0.6	0.2	0
U18	Security rules and regulations	0	0.2	0.4	0.4	0
U19	Regular safety education	0	0	0	0.4	0.6
U20	Regular safety check	0	0.2	0.2	0.6	0
U21	Regular equipment management	0	0.4	0.4	0.2	0

3.2.4 Fuzzy comprehensive evaluation of factors in criteria layer

(1) Equipment factors

The fuzzy evaluation matrix is determined from table 3:

$$R_1 = \begin{bmatrix} 0.2 & 0.6 & 0.2 & 0 & 0 \\ 0 & 0.2 & 0.2 & 0.6 & 0 \\ 0 & 0.2 & 0.6 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \\ 0.2 & 0.6 & 0.2 & 0 & 0 \end{bmatrix}$$

$$W_1 = (0.4407, 0.0950, 0.2340, 0.0523, 0.1780)$$

Fuzzy comprehensive evaluation of equipment factors:

$$B_1 = W_1 * R_1 = (0.1551，\ 0.4579，\ 0.2831，\ 0.1038，\ 0)$$

(2) Environmental factors

$$B_2 = W_2 * R_2 = (0.0349，\ 0.2631，\ 0.4106，\ 0.2915，\ 0)$$

(3) Employee factors

$$B_3 = W_3 * R_3 = (0.3277，\ 0.2925，\ 0.2723，\ 0.1075，\ 0)$$

(4) Management factors

$$B_4 = W_4 * R_4 = (0，\ 0.1871，\ 0.2805，\ 0.4364，\ 0.0961)$$

3.2.5 Fuzzy comprehensive evaluation of LNG skid mounted station

The fuzzy comprehensive evaluation matrix of LNG is obtained by the combination of the evaluation results of each single factor in the criterion layer:

$$R = \begin{bmatrix} 0.1551 & 0.4579 & 0.2831 & 0.1038 & 0 \\ 0.0349 & 0.2631 & 0.4106 & 0.2915 & 0 \\ 0.3277 & 0.2925 & 0.2723 & 0.1075 & 0 \\ 0 & 0.1871 & 0.2805 & 0.4364 & 0.0961 \end{bmatrix}$$

Table 3 shows the weight of the criterion layer:

$$\mathrm{W} = (0.5954, 0.0536, 0.1130, 0.2379)$$

The fuzzy comprehensive evaluation for the LNG skid mounted station:B=W*R=(0.1312，0.3643，0.2881，0.1934，0.0229)v

$$\mathrm{B} = \mathrm{W} * \mathrm{R} = (0.1312，\ 0.3643，\ 0.2881，\ 0.1934，\ 0.0229)$$

The grades of the safety evaluation of gas station is relatively safe.

4 Conclusions

Using AHP method to get the evaluation index weights of the skid mounted station, the equipment factors are the most important in the criterion layer, occupy 0.5954, and management factors occupy 0.2379, employee factors occupy 0.1130, Environmental factors occupy 0.0536 respectively. According to the fuzzy comprehensive evaluation, that the safety level of the skid mounted station is safe, correspond to the actual situation. Equipment factors of the skid mounted station accounted for a relatively large weight, and the safety of the equipment is good, the probability of occurrence of accidents is low. The problem which more prominent is management factors, evaluation result is less safe, safety training and education, safety check is not enough, need to further improve.

References

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