The Methodology System of the Emergency Response Capability Evaluation Based on AHP-Fuzzy Evaluation and the Practical Application for the Refining and Chemical Enterprises

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ABSTRACT

In order to reasonably and efficiently evaluate the emergency response capability of the refining and chemical enterprises, the methodology system of the emergency response capability evaluation based on AHP-Fuzzy for the refining and chemical enterprises was proposed. All factors involved in emergency response capability were divided into six sub capabilities according to the fishbone diagram, and the evaluation index system was established based on the Analytic Hierarchy Process (AHP) theory. Through the numerical solution, the weight distribution of indexes for all hierarchies was determined. After determining the weight distribution of indexes, based on the fuzzy theory, the fuzzy comprehensive evaluation method of emergency response capability was proposed, the fuzzy evaluation language was quantified into the expert evaluation results, and realized the transformation from qualitative evaluation to the quantitative analysis. Furthermore, the 4-day working scheme matching the evaluation model was proposed. On this basis, the A, B and C refining and chemical companies were selected as the pilot enterprises, the emergency capabilities of the three enterprises were systematically evaluated. Moreover, the deficiencies of the established emergency response capability evaluation methodology system were systematically summarized, which formed a closed-loop system of positive and negative dynamic feedback and updates, so as to ensure the dynamic adaptability of the emergency response capability evaluation methodology system. The evaluation methodology system established in this paper could provide the theoretical support for improving the emergency management system and enhancing the emergency capability.

Keywords: *Emergency response capability evaluation; Analytic hierarchy process; Fuzzy comprehensive evaluation; 4-day working scheme; Pilot application*

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1. INTRODUCTION

Oil refining and chemical industry is the strategic pillar industry of the national economy, which has the characteristics of high temperature, high pressure, flammable, explosive, toxic and harmful, the inherent risk of production and operation process is high, and the major accidents happen frequently [1] [2] [3]. Through analyzing the emergency rescue process of various typical accidents in refining and chemical enterprises, it was found that there existed some problems of improper disposal and insufficient emergency response capability in the links of emergency preparation, emergency response and emergency recovery, etc. It is imperative to improve the emergency management level and strengthen the emergency response capability of production safety accidents [4] [5] [6]. Therefore, it is necessary to periodically carry out the emergency response capability evaluation of refining and chemical enterprises, and find out the weaknesses and weak links of emergency management, and then improve the emergency management system and enhance the emergency response capability contrapuntally.

Aiming at the key scientific problem of emergency response capability evaluation of oil refining and chemical enterprises, researchers had carried out a lot of work on this subject. Abbassinia et al. adopted the fuzzy hierarchical analysis and the fuzzy TOPSIS technique to prioritize the criteria of emergency scenarios for corrective actions, and the emergency situations of the petrochemical industry were prioritized due to the weight of these criteria [7] [8]. Han et al. selected the vapor pressure, median lethal concentration, combustibility and explosibility, popularity and detection frequency as the risk assessment index for the chemicals in Shenyang Chemical Industrial Park, the weight from each assessment indicator on the surveillance levels for those chemicals was identified, and the Fuzzy Comprehensive Evaluation was adopted to work out the surveillance assessment level for each chemical in SCIP [9]. Chen et al. aimed at the six emergency management goals, the challenge caused by risk potential and the contribution caused by emergency competence formed by emergency system were calculated separately, and the emergency response capability evaluation was carried out, which could reflect the general condition and the shortcomings of the emergency system [10]. Liu et al. put forward the fire risk evolution and prediction method and the strategy of fire hazard protection layer for petrochemical plant process and apparatus, and used the advanced information technologies, integrating the different functions of risk assessment, monitoring and supervising, forecast and early warning, dynamic decision-making, comprehensive coordination, emergency response, optimize decision-making and so on, which could enhance E-fire safety management of the petrochemical companies and fire prevention technology [11].

To sum up, based on the theories of Analytic Hierarchy Process (AHP), matter-element extensibility and fuzzy comprehensive evaluation, researchers had established the evaluation index system of emergency response capability for refining and chemical enterprises, the corresponding evaluation model was constructed, some research results had certain theoretical significance for improving the emergency response capability of refining and chemical enterprises. However, most of the relevant studies were limited to the mathematical modeling and the theoretical analysis, with too many evaluation indexes and complex processes of model construction and application, which was not conducive to the actual field implementation. In addition, some studies only focused on the determination of the theoretical score of indexes, and involved less in the key links of expert selection and responsibilities division, evaluation schemes and methods, pilot application and evaluation method improvement, etc., a complete closed-loop evaluation system of emergency response capability had not been formed. In view of the above problems, this paper established a closed-loop system of positive and negative dynamic feedback and updates for the emergency response capability evaluation and the pilot application (shown as in Fig. 1), and formed the methodology of emergency response capability evaluation and practical application. The research of this paper could provide the theoretical and practical basis for improving and perfecting the level of emergency management.

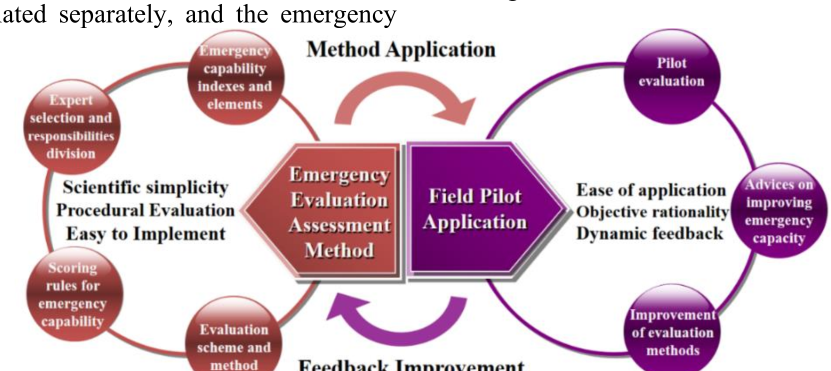

Fig. 1 Closed-loop system of positive and negative dynamic feedback and updates

2. STUDY ON THE INDEXES AND ELEMENTS OF EMERGENCY RESPONSE CAPABILITY FOR OIL REFINING AND CHEMICAL ENTERPRISES

For the refining and chemical enterprise, there existed many kinds and levels of emergencies, resulting in the complex emergency management system and the wide range of emergency rescue, which led to the large number of emergency response capability evaluation indicators, the cumbersome of evaluation process, the large amount of workload and other problems. In this paper, all factors involved in the emergency response capability evaluation were condensed and divided into six sub capabilities (shown in Fig. 2) based on the principle of fishbone analysis, and the emergency response capability of refining and chemical enterprises was evaluated from these six aspects [12] [13] [14] [15].

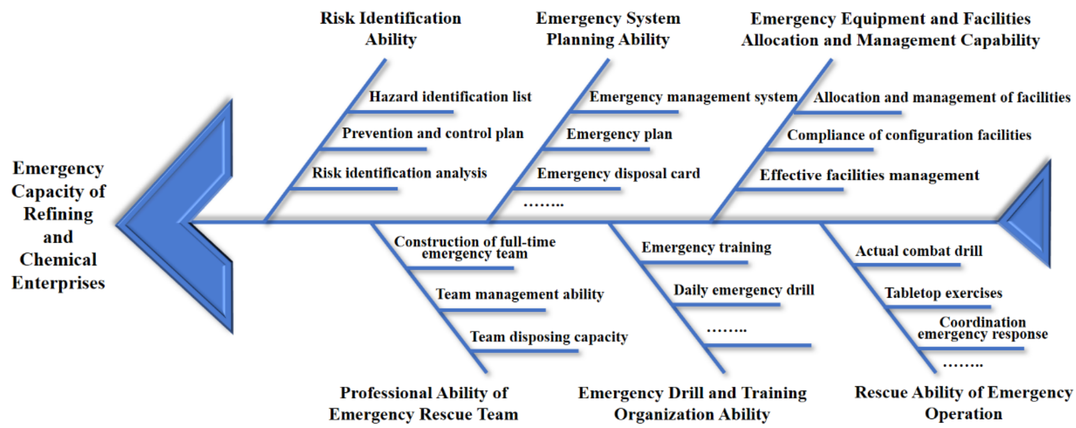

Fig. 2 Fishbone analysis chart of six capabilities for emergency response capability evaluation of oil refining and chemical enterprises

Based on the fishbone analysis method, the elements of six sub item capability indicators were sorted out, and the evaluation points of various capability indicators were summarized as follow.

(1) Risk identification capability: evaluate the risk identification analysis in the enterprise hazard identification list, the risk prevention and control plan and the emergency plan. And inspect whether there are significant risks that are not identified or lack the of capability risk control.

(2) Emergency system planning capability: evaluate the compilation of the enterprise emergency management system, emergency plan and emergency disposal card, as well as the planning and construction of the emergency organization system, emergency plan system, emergency procedures and measures, emergency resources and collaborative emergency rescue mechanism.

(3) Emergency equipment and facilities allocation and management capability: evaluate the allocation and management of emergency equipment and facilities, as well as the compliance configuration and effective management of enterprise emergency equipment and facilities.

(4) Professional capability of emergency rescue team: evaluate the construction of the full-time fire emergency rescue team, team management capability and professional disposal capability, as well as the team construction or linkage professional emergency response capability of other emergency rescue forces (such as pipeline repair).

(5) Emergency drill and training organization capability: evaluate the organization, implementation and implementation effect of emergency training and daily emergency drill.

(6) Rescue capability of emergency operation: evaluate the emergency operation capability of enterprise employees, the practical operation capability of professional emergency team, and the enterprise coordination and linkage emergency disposal capability, etc. through spot check, double-blind actual combat drill and desktop drill.

3. EVALUATION MODEL OF EMERGENCY RESPONSE CAPABILITY BASED ON AHP-FUZZY EVALUATION

3.1 Calculation Model of Index Weight for Emergency Response Capability Evaluation Based on AHP

Due to the proposed six sub item capability indicators and their matching evaluation points had different degrees of impact on the overall emergency response capability of refining and chemical enterprises, in this paper, the AHP theory was adopted to determine the index weight of each sub item capability and the corresponding secondary evaluation elements to realize the scientific and reasonable evaluation. The numerical computation steps were as follows:

(1) Establishment of emergency response capability evaluation index system

The overall emergency response capability of oil refining and chemical enterprises was taken as the target layer T, and the proposed six sub item capacities were taken as the level I index layer Ui. Furthermore, the evaluation elements involved in the six sub item capability indicators were sorted out, the evaluation points of each sub item capability indicator were clarified, which were taken as the level II indicator layer Uij. On this basis, the evaluation index system of emergency response capability of refining and chemical enterprises was established, which was shown in Fig. 3.

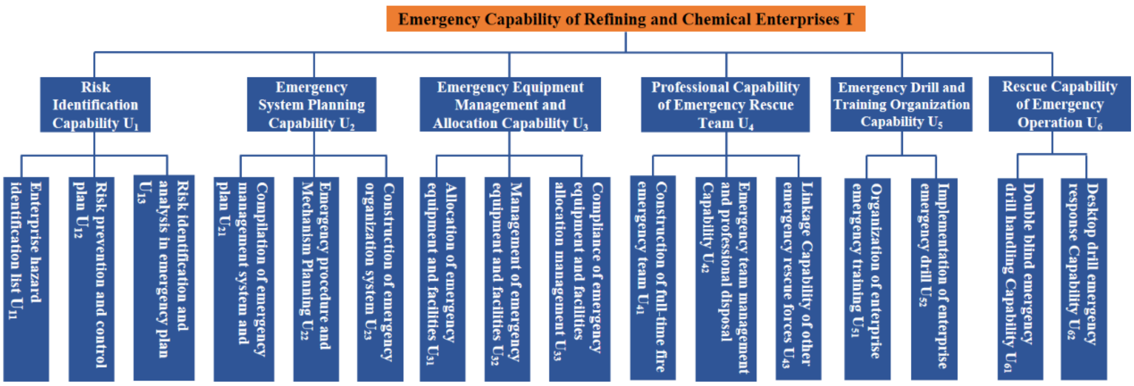

Fig. 3 Evaluation index system of emergency response capability of refining and chemical enterprises

(2) Construction of Judgment Matrix

According to the emergency rescue procedure of refining and chemical enterprises, the relative importance of pairwise of six capability indexes for level I index layer compared to the target layer T was determined by means of expert group discussion, and the judgment matrix T-U was constructed based on the 1 ~ 9 scale method.

(3) Calculation of Index Weight Coefficient

① Normalized the judgment matrix T-U according to column

$$\overline{z_{ij}} = \frac{z_{ij}}{\sum_{k=1}^{m} z_{kj}}, (i, j = 1, 2, \cdots m) \tag{1}$$

② Added the normalized judgment matrix by rows

$$\overline{W_i} = \sum_{j=1}^{m} \overline{z_{ij}}, (i, j = 1, 2, \cdots m) \tag{2}$$

③ Normalized the vectors $\overline{W} = \left(\overline{W_1}, \overline{W_2}, \cdots \overline{W_m}\right)^T$ added by rows

$$W_i = \frac{\overline{W_j}}{\sum_{j=1}^{m} \overline{W_j}}, (i = 1, 2, L, m) \tag{3}$$

The calculated feature vector $W = \left(w_1, w_2, \cdots w_m\right)^T$ was the weight vector.

④ According to the equation T-U $W = \lambda_{\max} W$, calculated the maximum eigenvalue $\lambda_{\max}$ of matrix T-U

$$\lambda_{\max} = \sum_{i=1}^{m} \frac{(ZW)_i}{m w_i} = \frac{1}{m} \sum_{i=1}^{m} \frac{(ZW)_i}{w_i} \tag{4}$$

(4) Consistency Test

① Judge the consistency index of matrix deviation $C.I.$

$$C.I. = \frac{\lambda_{\max} - n}{n - 1} \tag{5}$$

② Random consistency ratio $C.R.$

$$C.R. = \frac{C.I.}{R.I.} \tag{6}$$

Where, $R.I.$ was the average random consistency ratio, which could be determined by querying the random consistency index value table.

(5) Total Hierarchical Sorting

Calculated the weight coefficients and consistency test results of six capability indexes of level I index layer, which was shown in Table 1.

Table 1 Hierarchy model of emergency response capability evaluation for refining and chemical enterprises

T	U_1	U_2	U_3	U_4	U_5	U_6	w_i
U_1	1	1/4	1/2	2	3	1/3	0.1060
U_2	4	1	3	4	5	2	0.3716
U_3	2	1/3	1	3	3	1/2	0.1594
U_4	1/2	1/4	1/3	1	2	1/3	0.0732
U_5	1/3	1/5	1/3	1/2	1	1/4	0.0501
U_6	3	1/2	2	3	4	1	0.2398
C.R.	0.0286 < 0.1 (The consistency of judgment matrix is acceptable)						

Using the same method, the judgment matrix of each level II index compared to the level I index layer was constructed, the corresponding weight coefficient and the total weight were calculated. Through calculating, the weight calculation all passed the consistency test.

3.2 Quantitative Analysis Model of Emergency Response Capability Evaluation Based on Fuzzy Comprehensive Evaluation

The expert group mainly adopted the subjective fuzzy concept to qualitatively describe the evaluation results of various index factors, which would result in great subjectivity, unclear boundary and difficult-to-quantify [9] [16] [17] [18] [19]. In this paper, based on the fuzzy comprehensive evaluation theory, the fuzzy comprehensive evaluation model of emergency response capability of refining and chemical enterprises was constructed, the fuzzy degree language concept in expert evaluation results was quantified, which would transform the qualitative judgment into quantitative analysis, and realize the effective evaluation of multi-factor and multi-level complex problems. The specific steps of modeling were as follows:

(1) The establishment of factor array U of emergency response capability evaluation. According to the AHP model of emergency response capability evaluation of refining and chemical enterprises, six emergency response capability evaluation indexes in level I index layer were recorded as U={Ui}={U1, U2,⋯Ul}. And the level II index array was set as Uik ={Ui1, Ui2,⋯Uik}.

(2) The establishment of comment array V. According to the scoring rules of emergency response capability, in the fuzzy comprehensive evaluation model, the five degree-language were adopted as the comment array V={good, relatively good, general, relatively poor, poor}.

(3) The establishment of fuzzy relation matrix R. According to the established comment array, combined the scoring results of experts for each level II index factor, the membership of each index factor Uik relative to the comment array was calculated one by one. Suppose n experts evaluated the index Uik, and q experts selected certain one comment level in the comment array, and the membership degree of the index to this comment was q/n, on this basis, the fuzzy relationship matrix R=(rij)l×k was generated. Where, rij represented the membership of the number i indicator to the selected comment.

(4) Generation of fuzzy comprehensive evaluation vector. According to the weight vector W of each index determined by the AHP model, synthesized the W and the fuzzy relationship matrix R by the fuzzy operator, the fuzzy comprehensive evaluation vector Y covering each evaluation index was obtained, in which the fuzzy operator adopted the weighted average operator $M(\bullet,\oplus)$.

(5) Quantitative handling and analysis of emergency response capability evaluation results. In order to intuitively and quantitatively reflect the evaluation results, the five degree-languages in comment array were assigned the fuzzy values, which was shown in Table 2.

Table 2 Evaluation standard for emergency response capability of refining and chemical enterprises

Score	$100 > V \geq 80$	$80 > V \geq 60$	$60 > V \geq 40$	$40 > V \geq 20$	$V < 20$
Evaluation level	good	relatively good	general	relatively poor	poor

Next, the weighted average method was adopted to determine the final quantitative evaluation results. Taking the middle value of the assignment interval of the five emergency response capability evaluation: “good” = 90, “relatively good” = 70, “general” = 50, “relatively poor” = 30, “poor” = 10, and the value assignment matrix was formed as P= [90, 70, 50, 30, 10]. On this basis, the determined fuzzy comprehensive evaluation vector was multiplied by the assignment matrix, and the quantitative value of the evaluation result was determined. Finally, the evaluation grade was determined according to the score value interval.

4. METHODOLOGY SYSTEM OF EMERGENCY RESPONSE CAPABILITY EVALUATION OF OIL REFINING AND CHEMICAL ENTERPRISES

4.1 Expert Selection and Responsibilities Division

Selected the experts with high theoretical level and rich practical experience in the field of oil refining and chemical emergencies as members of the emergency response capability evaluation expert group. The selected experts should have been engaged in relevant professional work in this field for more than 10 years, and the number of experts was not less than 10. The expert group set one group leader, who was mainly responsible for the overall planning of the evaluation, dividing and coordinating of labor, organizing discussion, summarizing the evaluation problems and determining the evaluation conclusions. Two deputy team leaders were set up to be responsible for the management and coordination of experts of the emergency management evaluation group and the on-site evaluation group. Among them, the evaluation group of emergency management was responsible for the task of organizing responsibility evaluation, risk identification evaluation, regulations and emergency plan evaluation, desktop emergency drill, employee interview, emergency management communication and other tasks.

The on-site evaluation team was responsible for fire team management evaluation, on-the-spot emergency facilities and equipment inspection, workshop team disposal plan and emergency disposal card evaluation, grass-roots double-blind emergency drill, grass-roots emergency management forum and other tasks.

4.2 Emergency Response Capability Evaluation Scheme and Method

The emergency response capability evaluation of oil refining and chemical enterprises mainly adopted the evaluation methods of questionnaire, data access, staff interview, on-site inspection and organization drill. After expert group finished the intraday evaluation task, the expert group leader should organize the seminar to sort out and summarize various problems found in the evaluation work and complete the list of emergency response capability evaluation.

In order to achieve the scientific scoring of various indicators, the four-day work plan for the emergency response capability evaluation of refining and chemical enterprises was formulated. The evaluation work plan was easy to implement, and required a short time. The details of the four-day work plan were shown in Fig. 4:

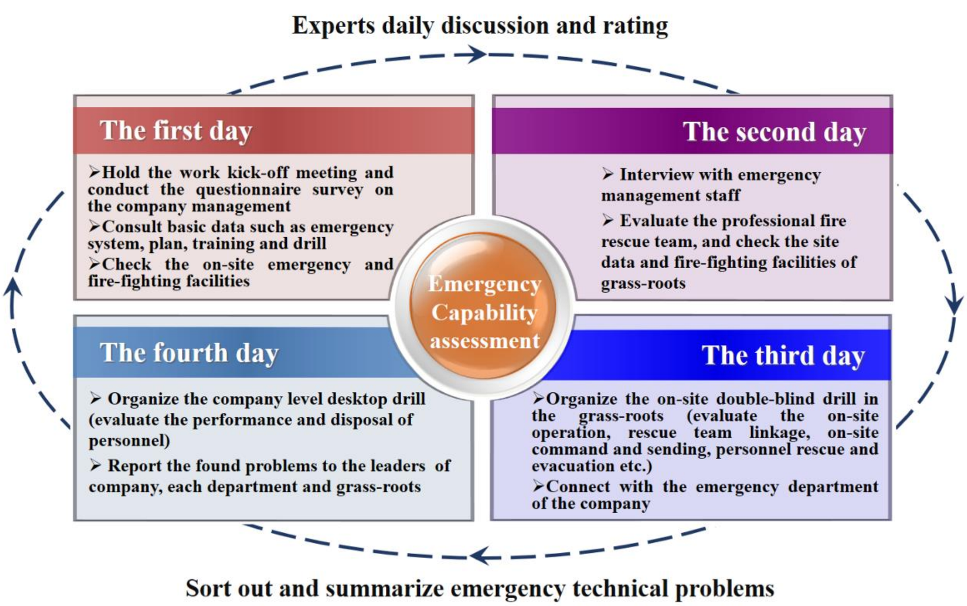

Fig. 4 The four-day work plan of emergency response capability evaluation for oil refining and chemical enterprises

4.3 Emergency Response Capability Evaluation Method and Problem List Sorting

The emergency response capability evaluation of oil refining and chemical enterprises mainly adopted the evaluation methods of questionnaire, data access, staff interview, on-site inspection and organization drill. After expert group finished the intraday evaluation task, the expert group leader should organize the seminar to sort out and summarize various problems found in the

evaluation work and complete the list of emergency response capability evaluation (shown as in Table 3).

Table 3 Sample list of emergency response capability evaluation for refining and chemical enterprises

Problem description		
Corresponding Index	□**Risk Identification**	□**Emergency System Planning**
	□Enterprise hazard identification list	□Compilation of emergency management and plan
	□Risk prevention and control plan	□Emergency procedure and Mechanism Planning
	□Risk identification and analysis in emergency plan	□Construction of emergency organization system
	□**Emergency Equipment Management and Allocation**	□**Emergency Rescue Team**
	□Allocation of emergency equipment and facilities	□Construction of full-time fire emergency team
	□Management of emergency equipment and facilities	□Emergency team management and disposal
	□Compliance of emergency equipment management	□Linkage capability of other rescue forces
	□**Emergency Drill and Training Organization**	□**Emergency Rescue Operation**
	□Organization of enterprise emergency training	□Double blind emergency drill handling
	□Implementation of enterprise emergency drill	□Desktop drill emergency response
Problem category	□Important problems	□General problems
Problem photos		

According to Table 3, the emergency response capability evaluation expert group sorted out and summarized the problems found in the evaluation work, ticked the corresponding index factors, judged the category of the problems, and attached the on-site evaluation photos matching the problems, so that the emergency management staff could recognize the existing problems and facilitated the targeted improvement. In Table 3, the problem categories mainly include important problems and general problems. Important problems referred to the key problems that had an important impact on the sub item emergency response capability, or the problem with major omissions in compliance, which need to formulate specific measures for improvement. General problems referred to the problems that had the limited impact on the sub item emergency response capability, but would weaken the emergency response capability of specific index, which need to immediately correct or continuously improve. After the evaluation work, experts group judged various indicators according to the on-site evaluation, and evaluate them with the degree language “good, relatively good, general, relatively poor and poor” as the evaluation grade, so as to realize the qualitative evaluation of the emergency response capability of refining and chemical enterprises.

5. PILOT APPLICATION OF EMERGENCY RESPONSE CAPABILITY EVALUATION AND DYNAMIC IMPROVEMENT OF EVALUATION METHODS

5.1 Pilot Application of Emergency Response Capability Evaluation

Three oil refining and chemical enterprises A, B and C were selected as the pilot enterprises. All three enterprises had the crude oil processing capacity of more than 10 million tons, the production unit conditions and types of processes were complete. 10 experts of the evaluation team adopted the evaluation method to evaluate 6 level I indicators and 16 level II indicators of the selected three enterprises. On this basis, using the established AHP-fuzzy evaluation methodology system, the membership of each index factor of the emergency capacity for the three enterprises was determined.

According to the membership degree of each index factor of the emergency response capability of three refining and chemical enterprises, taking the enterprise A as an example, the corresponding fuzzy comprehensive evaluation matrix was calculated, and the scoring results of the emergency response capability for the enterprises were quantified. The fuzzy relation matrix R1 of level I index of “risk identification capability U1” of enterprise A was as follow.

$$\begin{bmatrix} 0.1 & 0.3 & 0.5 & 0.1 & 0 \\ 0.2 & 0.3 & 0.5 & 0 & 0 \\ 0 & 0.1 & 0.7 & 0.2 & 0 \end{bmatrix} \quad (7)$$

According to the weight vector of each level II index relative to the level I index of "risk identification capability U_1" determined in the section 3.2: W_1= [0.2970 0.5396 0.1634]. Using the fuzzy operator $M(\bullet, \oplus)$, the fuzzy comprehensive evaluation vector of "risk identification capability U_1" was calculated and determined, that was Y_1=W_1*R_1= [0.1376 0.2673 0.5327 0.0624 0]. Using the same method, the rest fuzzy comprehensive evaluation vectors of enterprise A was calculated, including the emergency system planning Capability U_2, emergency equipment management and allocation capability U_3, professional capability of emergency rescue team U_4, emergency drill and training organization capability U_5, rescue capability of emergency operation U_6. On this basis, according to the calculation results of fuzzy comprehensive evaluation vectors of the level I index, the fuzzy relation matrix R_A relative to the target layer T was composed as follow.

$$R_A = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \\ R_5 \\ R_6 \end{bmatrix} = \begin{bmatrix} 0.1376 & 0.2673 & 0.5327 & 0.0624 & 0 \\ 0.1000 & 0.2624 & 0.5376 & 0.1000 & 0 \\ 0.4215 & 0.3238 & 0.2410 & 0.0137 & 0 \\ 0.0857 & 0.2571 & 0.5143 & 0.1286 & 0.0143 \\ 0.0667 & 0.3333 & 0.4667 & 0.1333 & 0 \\ 0.2000 & 0.3333 & 0.3333 & 0.1333 & 0 \end{bmatrix} \quad (8)$$

According to the weight array W_T = [0.1060 0.3716 0.1594 0.0732 0.0501 0.2398] of each level I index relative to the target layer T, the fuzzy comprehensive evaluation vector Y_A = W_T*R_A = [0.1765 0.2929 0.4356 0.0940 0.0010] of enterprise A emergency response capability evaluation was calculated. Moreover, according to the assignment matrix P, it was determined that the emergency response capability evaluation score of enterprise A was 61.00, and the score was in the range of $80 > V \geq 60$. According to the evaluation standard for emergency response capability Table 2, the emergency response capability of the enterprise A was "relatively good".

Using the same method, the fuzzy comprehensive evaluation vectors of enterprise B and C were calculated as Y_B= [0.1348 0.1877 0.5610 0.0942 0.0223], Y_C= [0.1004 0.3857 0.4519 0.0620 0]. Finally, according to the assignment matrix P, the emergency response capability evaluation scores of enterprise B and C are were calculated to be 56.39 and 60.50 respectively, and the emergency response capability of them were "general" and "relatively good" respectively.

5.2 Suggestions on Improving the Emergency Response Capability of Pilot Enterprises

According to the emergency response capability evaluation results of the three pilot enterprises, the emergency response capability evaluation results of enterprises A and C were "relatively good" and enterprise B was "general". The evaluation results showed that the enterprises A and C could effectively carry out emergency rescue in case of emergencies, and reduce the staff and property losses caused by emergencies. The emergency equipment management and allocation capability of enterprises A and the rescue capability of emergency operation of enterprises C were outstanding, which was worthy of learning and popularizing. The emergency response capability of enterprise B was general. Through analyzing the membership degree of each index and the actual evaluation, it was found that the enterprise B existed the insufficient risk prevention and control measures, imperfect public sentiment response measures in risk identification. Besides, in the aspect of emergency equipment management and allocation, there existed many hidden dangers of on-site fire emergency facilities and failure of protective equipment, which resulted in the overall score of enterprise B was low.

Through summarizing the list of emergency response capability problems, index scoring results and actual evaluation of the three pilot enterprises, the outstanding problems existed in the emergency response capability of refining and chemical enterprises were analyzed and summarized, and the matching suggestions for improving the emergency capacity of the three enterprises were put forward.

5.3 Dynamic Improvement and Updates of Emergency Response Capability Evaluation Method

After carrying out the pilot application of emergency response capability evaluation of refining and chemical enterprises, it was necessary to summarize the shortages of the constructed emergency response capability evaluation method, and continuously improved the found problems, and formed the dynamic feedback closed-loop system, so as to ensure the dynamic adaptability of the emergency response capability evaluation methodology system.

In this emergency response capability evaluation of refining and chemical enterprises A, B and C, it was found that the constructed methodology system had the following shortages:

The emergency response capability evaluation was carried out in the way of evaluation, discussion and improvement. The problems found in evaluation process need to be sorted and collected manually, which reduced the work efficiency. Therefore, in the next stage of work, we could develop emergency response capability evaluation software that could assist the evaluation work and collect assessment problems, so as to improve the level and efficiency of emergency response capability evaluation.

6. CONCLUSION

(1) Based on the principle of fishbone analysis, all factors involved in emergency response capability evaluation were condensed and divided into six sub capabilities, the evaluation elements of various capability indicators were combed and summarized, the evaluation index system of emergency response capability of refining and chemical enterprises was constructed, and the weight distribution of indicators at all levels was determined based on AHP theory. On this basis, using the fuzzy comprehensive evaluation theory, the fuzzy comprehensive evaluation model was established. Combined with the constructed emergency response capability evaluation index system and each index weight, the fuzzy degree language concept in the expert evaluation results was quantified, which could realize transformation of the qualitative judgment into the quantitative analysis, so as to effectively evaluated the multi-0factor and multi-level complex emergency response capability evaluation problems.

(2) The 4-day working scheme matching with the emergency response capability evaluation model was proposed. The 4-day working scheme was the process working plan and method mainly included the expert selection and responsibilities division, the determination of index weight, the scoring rules of emergency response capability, the emergency response capability evaluation measures, the listing of capability evaluation problems, and personnel interview of enterprise emergency department, etc.

(3) Taking three refining and chemical enterprises A, B and C as the pilot, based on the established AHP-Fuzzy evaluation methodology system of refining and chemical enterprises, the evaluation scores of emergency response capability were determined to be 61.00, 56.39 and 60.50 respectively. On this basis, the emergency response capability of the three enterprises were systematically evaluated and compared, the corresponding suggestions for improving the emergency response capability were put forward. Furthermore, through summarizing the shortages of the emergency response capability evaluation methodology system, the corresponding improvement and updates scheme was put forward, which also formed the dynamic positive and negative feedback closed-loop system for the established emergency response capability evaluation methodology system, so as to ensure the timeliness and dynamic adaptability of the emergency response capability evaluation methodology system.

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