Risk Analysis for the Urban Buried Gas Pipeline With Fuzzy Comprehensive Assessment Method[1]

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Based on the statistical analysis from a great deal of failure cases, generally, the failure causes of buried pipeline can be classified into four factors, namely, third-party damage, erosion–corrosion damage, design and construction error, and incorrect operation. The factors influencing the failure of pipeline are complicated, varied and fuzzy. Especially, the influence factors of third-party damage of buried pipeline are of the character of fuzziness, which are difficult to express with the accurate mathematic models. In this paper, the failure factors of buried gas pipeline are first analyzed by fault tree analysis method. Then, the failure likelihood and failure consequence, two parts of the risk, are evaluated with fuzzy comprehensive assessment method, respectively. Finally, the in-service risk of the buried gas pipeline for a certain city is expressed by the risk matrix, which is established with the failure likelihood as vertical ordinate and the failure consequence as horizontal ordinate. It is concluded that there are two pipeline units belong to high risk category, 24 pipeline units belong to medium-high risk category, 160 pipeline units belong to medium risk category, and 392 pipeline units belong to low risk category. [DOI: 10.1115/1.4004625]

Keywords: risk analysis, buried pipeline, fuzzy theory

1 Introduction

As we know, the buried gas pipeline undertakes the task of transportation of hazardous products. Once the pipeline was damaged, potentially, the hazardous product can cause serious consequence, such as fire and explosion, losses of resident life and properties, and even the social instability. So, transportation of hazardous products by pipeline is a risk [1]. Risk is defined as the product of the probability of failure and the magnitude of the loss, as shown in Eq. (1). Risk is increased when either the probability of the event increases or when the magnitude of the loss increases [1]. In recent years, there are many research works on the risk analysis of oil and gas pipeline. Muhlbauer [1] proposed a semiquantity risk assessment, which was widely used in the oil and gas industry. However, there are some vagueness and fuzziness variables to describe the failure. Tang [2] proposed a reliability assessment method of mechanical components using fuzzy-set theory. Quin and Widera [3] proposed an uncertainty analysis method in quantitative risk assessment. Nessim [4] and Zhou [5] propose a reliability based design and assessment method for natural gas pipelines. Guo and Sun [6] propose the fuzzy assessment method to deal with the earthquake failure of urban buried pipeline. But there is a little work on the risk analysis of the urban buried pipeline with fuzzy-set

$$\text{Risk} = \text{likelihood of failure} * \text{consequence of failure} \quad (1)$$

In this paper, the likelihood and consequence of failure were analyzed for urban buried gas pipeline by multistage fuzzy comprehensive assessment method (MFCA), and the risk of pipeline is also obtained by risk matrix, the risk assessment flow is shown in Fig. 1.

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2 Principle of the Multistage Fuzzy Comprehensive Assessment

Fuzzy comprehensive assessment is based on the theory of fuzzy transform and the principle of maximal degree of membership (MDM), it is going to give the total evaluation for the alternatives or objects, which affected by many kinds of influence factors. According to the complex degree of the evaluative objects, it can be evaluated by the single factor evaluation and multistage comprehensive assessment. In a complicated system, because many factors have to be considered and the influence of each factor is different, it is difficult to compare every factor's contribution by the single factor fuzzy evaluation, thus cannot achieve the valuable evaluated results. Therefore, multistage fuzzy comprehensive assessment usually was adopted. The main procedures are given in points (1)–(7) as follows:

(1) If U is the universe of discourse, $U = \{u_1, u_2, \ldots, u_n\}$, one can express a set of factors for characterizing the major nature of the evaluated issue in which every factor has different fuzziness and every factor includes m grades. Because of the fuzziness of each factor in different conditions, it is hard to define one factor located in a specific grade. The easy way is to regard each factor as a fuzzy subset, which belong to the grading collection. Assuming the fuzzy subset with respect to the ith factor is $\tilde{u}_i = \{u_{i1}, u_{i2}, \ldots, u_{im}\}$, and $\sum_{j=1}^{m} u_{ij} = 1$.

(2) The magnitude of the impact of factors can be described by the alternative set. Assumed the alternative set with respect to the ith factors is $V = \{v_1, v_2, \ldots, v_p\}$.
The representation of alternatives can be found in many ways, but the verbal model with linguistic variables may be very useful in the area of system safety. The membership functions of the risk factors are proposed as the basis for representing the alternatives. For example, we can define an alternative set as

$$V = \{\text{VeryHigh}, \text{High}, \text{Moderate}, \text{Low}, \text{VeryLow}\}$$

(3) For each factor, a given entry in the rating matrix reflects the magnitude of the impact of the factor upon the corresponding

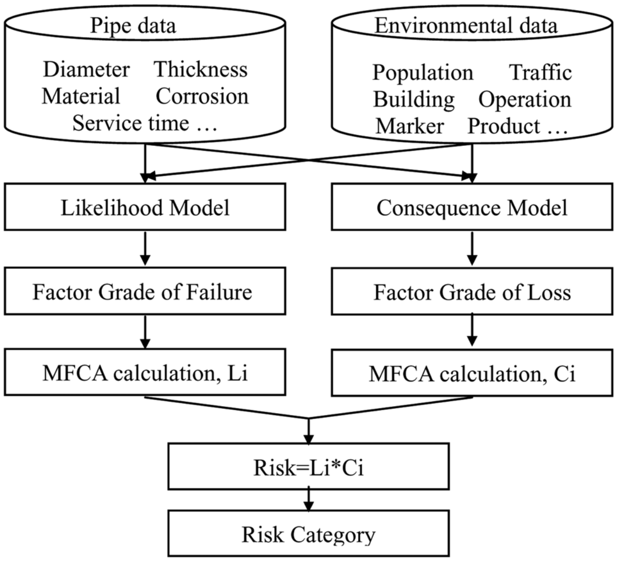

Fig. 1 Risk assessment flow

alternatives. To ascertain a single vector that represents the overall opinion of the criterion, a weight vector should be constructed

$$w = \{w_1, w_2, \ldots, w_i, \ldots, w_n\}, \quad \text{and} \quad \sum_{i=1}^{n} w_i = 1$$

(4) Assumed the grading matrix of the evaluation for the ith factor is $\tilde{R}_i$.

$$\tilde{R}_{i=} \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1n} \\ r_{i21} & r_{i22} & \cdots & r_{i2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{im1} & r_{im2} & \cdots & r_{imn} \end{bmatrix}$$

The physical meaning of $\tilde{R}$ is that when one factor at certain grade, the quantity value of it is $r_{ijk}(k = 1, 2, \ldots, n;$ $j = 1, 2, \ldots, m)$, actually, r_{ijk} is the fuzzy subjection degree for the evaluation grade. Regard the fuzzy membership function of evaluation grade with respect to one factor as the lines to form a matrix, which is the evaluation grade matrix of the factors set. Actually, it is the fuzzy relationship of mapping from U to V. If each factor's grade sequence is arranged according to the consistency of influence tendency for the evaluation object, each factor has the same grading evaluation matrix, i.e., $\tilde{R}_i = \tilde{R}$.

(5) The first-stage of MFCA: it is about the contribution of deciding the value to evaluation objects from the grades of each factor. The grading fuzzy subset with respect to the ith factor is $\tilde{u}_i = \{u_{i1}, u_{i2}, \ldots, u_{im}\}$, which was regarded as factor's weight number. It is combined with the evaluation object, thereby gaining the evaluation from these factors and showing the primary and secondary relationship from these factors. The aggregated vector $\tilde{B}$ can express as follows:

$$\tilde{B}_i = \tilde{u}_i \circ \tilde{R} = (b_{i1}, b_{i2}, \ldots, b_{im}) \quad (2)$$

(6) The secondary stage of MFCA: it is different that the importance level of assigning the value from the evaluation rule for each factor's influence, it has to consider the influences of each factor during the evaluation. When evaluate all factors, the fuzzy general evaluation set can be achieved as follows:

Table 1 Membership function for the linguistic variables

Linguistic variables	Grade of evaluation: 1st	2nd	3rd	4th	5th
	Membership function				
Very high	0	0.125	0.25	0.5	1
High	0.125	0.25	0.5	1	0.5
Moderate	0.25	0.5	1	0.5	0.25
Low	0.5	1	0.5	0.25	0.125
Very low	1	0.5	0.25	0.125	0

$$\tilde{C} = w \circ \tilde{B} = (w_1, w_2, \ldots, w_n) \circ \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1m} \\ b_{21} & b_{22} & \cdots & b_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nm} \end{bmatrix} = (C_1, C_2, \ldots, C_n) \quad (3)$$

where '∘' is the operator sign in matrix composition. In making a comparison with several different operators one can obtain a desirable result by using the following operator:

$$M(\bullet, \oplus) : a \bullet b = ab; \quad a \oplus b = \min(a + b, 1) \quad (4)$$

(7) The preferable resolution is determined by the principle of maximal degree of membership. If the maximum degree of membership from the aggregated vector $\tilde{C}$ is C_k, and the corresponding grade of alternative set is V_k, then the final assessment result V_s can be shown as below

$$V_S = \left\{ V_K | V_K \to \max_{i=1}^{n}(C_i) \right\} \quad (5)$$

The alternative factors set, evaluation set, and the grading set of factors should be built up for the multistage fuzzy synthetic evaluation. In fact, the evaluated factors are described by fuzzy linguistic values, such as "very good, good, normal, bad, very bad" or "very high, high, moderate, low, very low" and so on. If the linguistic variables are quantified by membership function, it will attain good value for the application. However, how to determine the membership function on earth, there is not a completely objective criterion for evaluation for this problem. Zhao [7] brought forward variable membership function of fuzzy language, which was shown in Table 1, and it has won the success in some engineering application.

Thus, the grading matrix of evaluation is

$$\tilde{R} = \begin{bmatrix} 1.0 & 0.5 & 0.25 & 0.125 & 0 \\ 0.5 & 1.0 & 0.5 & 0.25 & 0.125 \\ 0.25 & 0.5 & 1.0 & 0.5 & 0.25 \\ 0.125 & 0.25 & 0.5 & 1.0 & 0.5 \\ 0 & 0.125 & 0.25 & 0.5 & 1.0 \end{bmatrix} \quad (6)$$

When we operate the normalization operation for Eq. (6), the following normalized grading matrix can be obtained:

$$\tilde{R} = \begin{bmatrix} 0.5333 & 0.2667 & 0.1333 & 0.0667 & 0 \\ 0.2105 & 0.4211 & 0.2105 & 0.1053 & 0.0526 \\ 0.1 & 0.2 & 0.4 & 0.2 & 0.1 \\ 0.0526 & 0.1053 & 0.2105 & 0.4211 & 0.2105 \\ 0 & 0.0667 & 0.1333 & 0.2667 & 0.5333 \end{bmatrix} \quad (7)$$

3 Failure Cause Analysis

Generally, the failure causes of pipeline can be grouped someway. Here, in this paper, four groups are proposed, namely third-party damage, corrosion, design error, and incorrect operation, see Fig. 2.

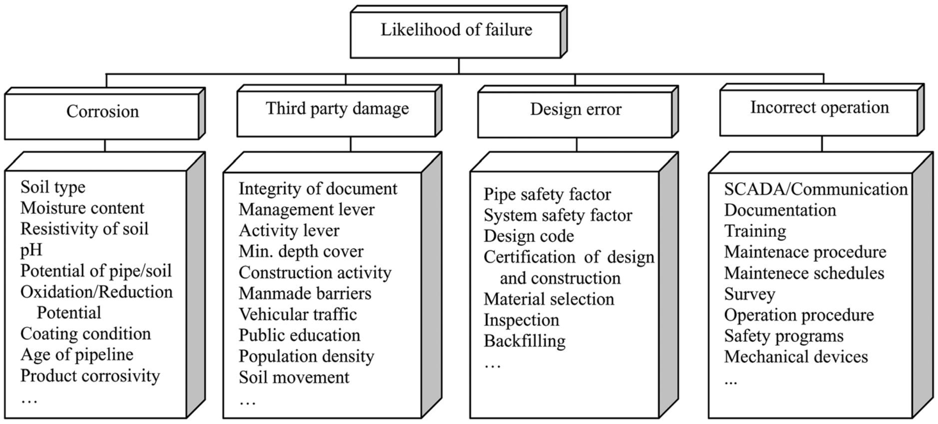

Fig. 2 Failure causes of buried pipeline

"Third-party damage" as it is used here, refers to any accidental damages done to the pipe by activities of nonpipeline personnel [1]. The probability of third-party damage is dependent upon the nature of possible intrusions, the ease with which the buried pipe can be reached by the intruding party, and the activity level. The possible intruders include excavating equipment, vehicular traffic, trains, farming equipment, and dredges [1]. The factors that affect the susceptibility of the buried pipe include depth of cover, nature of cover (earth, rock, concrete, or paving), manmade barriers (fences, barricades, levees, and ditches), natural barriers (trees, rivers, ditches, and rocks), presence of pipeline markers, frequency and thoroughness of survey, and inspection.

Corrosion consists of three categories: atmospheric corrosion, internal corrosion, and buried metal corrosion. Corrosion is of concern because any loss of pipe wall thickness invariably means a reduction of structural integrity and hence an increase in risk of failure [8]. The two factors that must be assessed are the material type and both the internal and external environments.

3.1 Third-Party Damage Analysis. Fault tree analysis (FTA) was used to evaluate reliability and safety of complex systems. FTA is a valuable tool for general use in multidisciplined risk assessments, single and multiple failure analyses, pointing out the aspects of the system that are important to failure, identifying potential accidents in a system, and developing qualitative and quantitative system reliability analyses [9]. Here, FTA method was used to explore the causes of third-party damage based on the logic relationship between the top event and the basic event, which was illustrated in Fig. 3. Fussel–Vesely algorithm was employed to get the minimal cut set

$$\begin{aligned} T = {} & AB + AC + AD + AH + AI + FG + FI \\ & + EFC + EFH + BJ + HJ + IJ \end{aligned}$$

Table 2 lists the basic events and its structural importance. Table 2 indicated that the main factors of third-party damage are depth cover, management level, and soil movement. The weight function of the basic events can obtain from the structural importance, which was also listed in Table 2.

In order to explain the fuzzy assessment procedure of third-party damage, the pipeline of a certain city is taken as an example. The urban buried pipeline network service over 20 yr was divided into 578 assessing units. For a certain unit, assumed that the grade of depth cover u_1 and vehicular traffic u_2 belongs to 'II' category, the grade of manmade barriers u_9 belongs to 'I' category, and the grade of others factors $u_3, u_4, u_5, u_6, u_7, u_8$, and u_{10} belongs to 'III' category. Then, the first-stage of MFCA can be expressed as

$$\tilde{B}_i = \tilde{A}_i \circ \tilde{R}_i = (\, b_{i1}, \quad b_{i2}, \quad \ldots, \quad b_{i5} \,)$$

where

$$b_{ij} = \sum_{k=1}^{5} a_{ik} r_{ikj} \quad (i = 1, 2, \ldots, 10; j = 1, 2, \ldots, 5)$$

So, for the factor of u_1, because its grade is the second category, then,

$$\tilde{A}_1 = \{\, 0.2105, \quad 0.4211, \quad 0.2105, \quad 0.1053, \quad 0.0526 \,\}$$

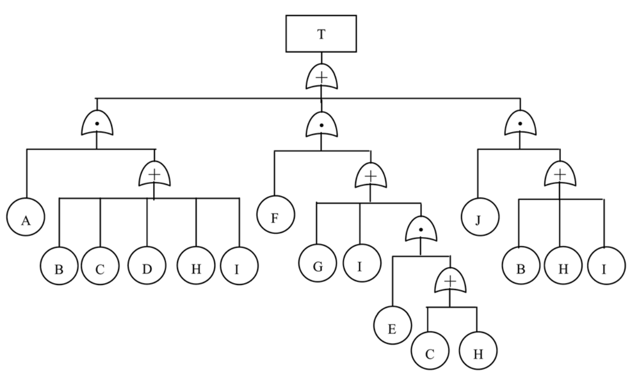

Fig. 3 FTA of third-party damage

Table 2 Basic events and its structural importance

Basic event	Factor	Meaning of basic event	Structural importance	Weight factor
A	u_1	Depth cover	0.3085	0.2608
B	u_2	Vehicular traffic	0.0664	0.0561
C	u_3	Underground condition	0.0351	0.0297
D	u_4	Aboveground condition	0.0234	0.0198
E	u_5	Integrity of management	0.0273	0.0231
F	u_6	Management level	0.2382	0.2014
G	u_7	Activity level	0.0585	0.0495
H	u_8	Construction activity	0.0742	0.0627
I	u_9	Manmade barriers	0.1054	0.0891
J	u_{10}	Soil movement	0.2460	0.2079

The aggregated vector $\tilde{B}_1$ can be expressed as follows:

$$\tilde{B}_1 = \tilde{A}_1 \circ \tilde{R}$$

$$= (0.2105, 0.4211, 0.2105, 0.1053, 0.0526) \circ \begin{bmatrix} 0.5333 & 0.2667 & 0.1333 & 0.0667 & 0 \\ 0.2105 & 0.4211 & 0.2105 & 0.1053 & 0.0526 \\ 0.1 & 0.2 & 0.4 & 0.2 & 0.1 \\ 0.0526 & 0.1053 & 0.2105 & 0.4211 & 0.2105 \\ 0 & 0.0667 & 0.1333 & 0.2667 & 0.5333 \end{bmatrix}$$

$$= (0.2275, \quad 0.2901, \quad 0.2301, \quad 0.1588, \quad 0.0934)$$

As the same way, the aggregated vectors of other factors are

$$\tilde{B}_1 = \tilde{B}_2 = (0.2275, \quad 0.2901, \quad 0.2301, \quad 0.1588, \quad 0.0934)$$

$$\tilde{B}_3 = \tilde{B}_4 = \tilde{B}_5 = \tilde{B}_6 = \tilde{B}_7 = \tilde{B}_8 = \tilde{B}_{10} = (0.1460,\ 0.2186,\ 0.2709,\ 0.2186,\ 0.1460)$$

$$\tilde{B}_9 = (0.3574, \quad 0.2882, \quad 0.1946, \quad 0.1184, \quad 0.0414)$$

The fuzzy general evaluation set $\tilde{C}$ can be achieved as follows:

$$\tilde{C} = w \circ \tilde{B} = (0.2608, 0.0561, 0.0297, 0.0198, 0.0231, 0.2014, 0.0495, 0.0627, 0.0891, 0.2079) \circ \begin{bmatrix} 0.2275 & 0.2901 & 0.2301 & 0.1588 & 0.0934 \\ 0.2275 & 0.2901 & 0.2301 & 0.1588 & 0.0934 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.1460 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.1460 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.1460 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.1460 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.1460 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.4160 \\ 0.3574 & 0.2882 & 0.1946 & 0.1184 & 0.0414 \\ 0.1460 & 0.2186 & 0.2709 & 0.2186 & 0.4160 \end{bmatrix}$$

$$= (0.1907, \quad 0.2475, \quad 0.2512, \quad 0.1907, \quad 0.1201)$$

Based on the principle of MDM, in this example, the grade of third-party damage is III category for the certain pipe. If calculate for all pipes, we can get the grade of third-party damage for all pipes. The grade of third-party damage results for all pipe units is presented in Table 3.

Table 3 Results of third-party damage

Factors	I	II	III	IV	V
Depth cover	51	98	146	199	84
Vehicular traffic	423	54	47	27	27
Underground condition	351	152	47	28	0
Aboveground condition	16	63	181	311	7
Integrity of management	0	0	578	0	0
Management level	0	0	578	0	0
Activity level	473	78	19	5	3
Construction activity	560	16	0	1	1
Manmade barriers	490	47	19	10	12
Soil movement	550	0	0	16	12
Sum	0	463	74	35	6

3.2 Corrosion Analysis. The loss of pipe wall due to corrosion can be relatively uniform or localized [8]. The corrosion rate is dependent upon the moisture content of soil, *p*H of soil, resistivity of soil, potential of pipe/soil, potential of oxidation/reduction, coating condition, age of pipeline, product corrosivity, and material of pipe. So, in the corrosion analysis model, four factors were considered, including soil performance, coating performance, pipe performance, and service time. For the factor of soil, there are five subfactors, including the soil type, moisture content of soil, *p*H of soil, resistivity of soil, and potential of pipe/soil. For the factor of coating performance, there are five subfactors, including the coating type, appearance of coating, coating thickness, coating resistivity, and puncture potential of electrospark. According to the on-site inspection of the pipeline, the checklist of corrosion was designed, and the results were summarized in Table 4. Figures 4–6 show the corrosion failure photograph of iron casing pipe and steel pipe.

4 Risk Analysis

4.1 Likelihood Analysis. As mentioned above, the failure causes of pipeline can be divided into four groups. So, the likelihood category can be assessed by the corrosion category, the third-party damage category, the design error category, and the incorrect operation category. For the factor of design error and incorrect operation, the categories of them can be gotten similar to the factor of corrosion. Here, the multistage fuzzy comprehensive assessment method was also employed. In order to perform the fuzzy analysis, first, we have to determine the grade of factors. So, the detailed classification was carried out for every input factors based on the investigation data. In order to explain the calculation procedure, here, for example, there is a certain pipe, its category of corrosion u_1, the category of third-party damage u_2, and the incorrect operation u_4 belongs to III category, and the design error u_3 belongs to II category.

The weight of evaluation factors is calculated by analytic hierarchy process (AHP). Compared to the factor of corrosion and third-party damage, corrosion is more important than third-party damage, design error, and incorrect operation. Third-party damage is more important than design error, and design error is more important than incorrect operation. Therefore, the judgment matrix is

Table 4 Summary of corrosion damage

	Grade				
Subfactor	I	II	III	IV	V
Soil performance	11	26	18	0	0
Coating performance	47	5	3	0	0
Pipe performance	31	2	3	14	5
Service time, years	0	0	0	25	0
Evaluated category	8	17	13	17	0

Fig. 4 Corrosion dent of iron casing pipe

$$A=(a_{ij})_{4\times4}=\begin{bmatrix}1 & 1.2 & 2 & 2.5\\ 0.833 & 1 & 1.5 & 2\\ 1/2 & 0.667 & 1 & 1.2\\ 0.4 & 0.5 & 0.833 & 1\end{bmatrix}$$

So, using AHP method, the weight factor can be derived from the comparison matrix.

$$w=(\,0.3677,\quad 0.2954,\quad 0.1868,\quad 0.1501\,)$$

So, based on the first-stage MFCA, the aggregated vector $\tilde{B}$ can express as follows:

Fig. 5 Corrosion of steel elbow

Fig. 6 Corrosion of steel pipe

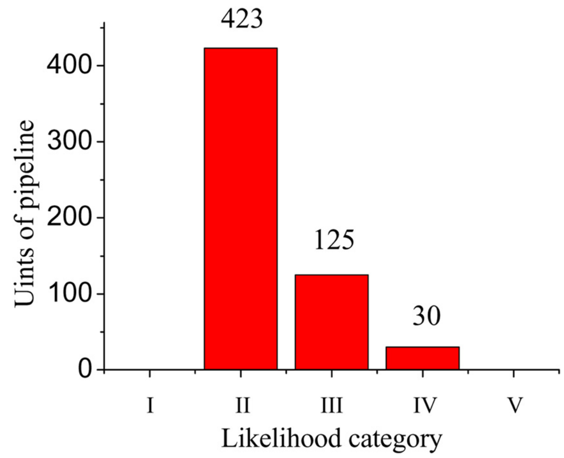

Fig. 7 Likelihood of pipeline

$$\tilde{B}_1=\tilde{A}_1\circ\tilde{R}=\{0.146,0.2186,0.2709,0.2186,0.146\}$$
$$\tilde{B}_4=\tilde{B}_2=\tilde{B}_1$$
$$\tilde{B}_3=\{0.2275,0.2901,0.2301,0.1588,0.0934\}$$

The fuzzy general evaluation set $\tilde{C}$ can be achieved as follows:

$$\begin{aligned}\tilde{C}&=w\circ\tilde{B}\\&=(0.3677,0.2954,0.1868,0.1501)\circ\\&\begin{bmatrix}0.146 & 0.2186 & 0.2709 & 0.2186 & 0.146\\ 0.146 & 0.2186 & 0.2709 & 0.2186 & 0.146\\ 0.2275 & 0.2901 & 0.2301 & 0.1588 & 0.0934\\ 0.146 & 0.2186 & 0.2709 & 0.2186 & 0.146\end{bmatrix}\\&=(\,0.1612,\quad 0.2320,\quad 0.2633,\quad 0.2074,\quad 0.1362\,)\end{aligned}$$

Based on the principle of maximal degree of membership, the grade of likelihood is III category.

Certainly, for the different pipes, the category of corrosion, category of third-party damage, category of incorrect operation, and category of design error are also different. If calculate for all pipes, we can get the grade of likelihood for all pipes. The grade of likelihood results for all pipe units evaluated is presented in Fig. 7. From Fig. 7, there is no 'V' and 'I' category of likelihood, and 30 units belong to 'IV' category.

4.2 Consequence Analysis. Once the buried gas pipeline fails, it could result the serious consequences including casualties, impact on environment, property loss, the supply influence of gas,

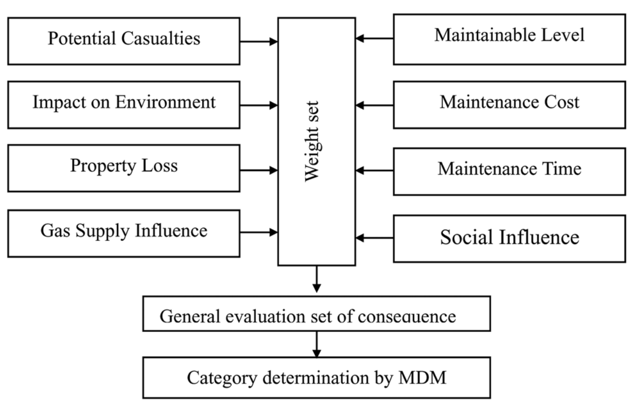

Fig. 8 Consequence model

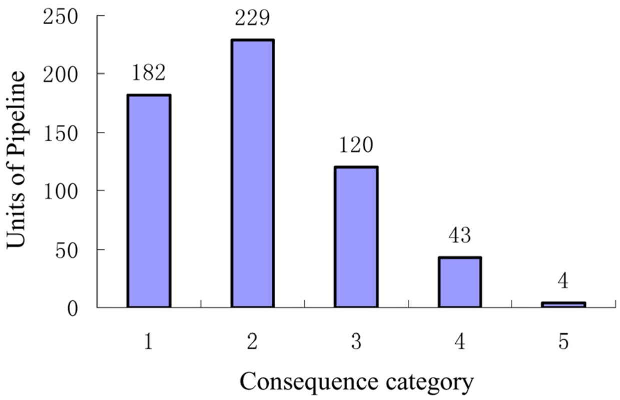

Fig. 9 Consequence category

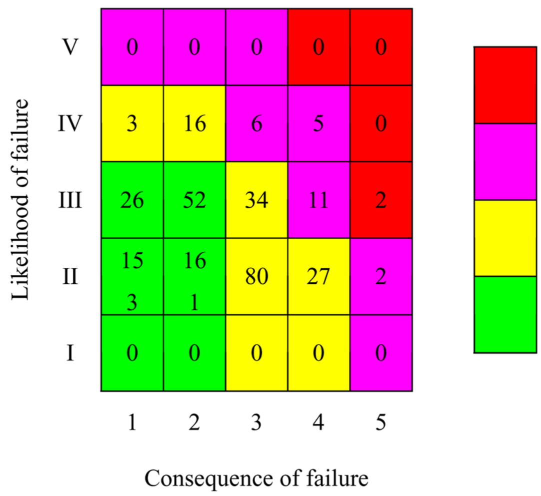

Fig. 10 Risk matrix

social influence, and maintenance. The consequence fuzzy assessment model is presented in Fig. 8. For the consequence analysis model, there are eight factors, including potential casualties, impact on environment, property loss, gas supply influence, maintainable level, maintenance cost, maintenance time, and social influence. Potential casualties and impact on environment can be calculated by the fire model, the main influence subfactors including operation pressure, gas type, diameter of pipe, leakage size, etc. Property loss and gas supply influence were mainly influenced by the complex of network and population density. The other three factors were related on the maintenance situation.

The weight of consequence factors was also derived by AHP method, and the judgment matrix was as follows:

$$A = (a_{ij})_{8\times 8} = \begin{bmatrix} 1 & 1 & 3 & 4 & 3.5 & 2.5 & 1.5 & 2 \\ 1 & 1 & 2 & 3 & 2.5 & 1.5 & 1 & 1.2 \\ 1/3 & 0.5 & 1 & 1.5 & 1 & 1 & 0.5 & 2/3 \\ 0.25 & 1/3 & 2/3 & 1 & 1 & 0.5 & 1/3 & 0.4 \\ 0.286 & 0.4 & 1 & 1 & 1 & 2/3 & 0.4 & 0.5 \\ 0.4 & 2/3 & 1 & 2 & 1.5 & 1 & 2/3 & 1 \\ 2/3 & 1 & 2 & 3 & 2.5 & 1.5 & 1 & 1 \\ 0.5 & 0.833 & 1.5 & 2.5 & 2 & 1 & 1 & 1 \end{bmatrix}$$

So, the weight of consequence factors can be calculated with AHP method.

$$\tilde{A} = (0.2315,\ 0.1703,\ 0.0827,\ 0.0560,\ 0.0699,\ 0.1043,\ 0.1582,\ 0.1301)$$

The results of the consequence analysis are presented in Fig. 9. There are four units of pipeline belong to '5' category consequence, which means the consequence is very huge, 43 units of pipeline belong to '4' category consequence, and the others are equal to or less than '3' category.

4.3 Risk Results. Based on API 581 [8], the category of risk can be characterized by 'so called' risk matrix. API 581 provides a matrix as shown in Fig. 10 with frequency on the vertical axis (listed in categories I–V with V having the highest frequency event and I having the lowest frequency event) and consequences on the horizontal axis (listed as 1-5 with 5 having the highest consequence and 1 having the lowest consequence). Parts of risk matrix indicate a high, medium-high, medium, and low risk. Figure 10 also shows the risk for all evaluating pipeline, where the numbers in Fig. 10 is the units of pipeline. It is indicated that there are two pipeline units belong to high risk category, 24 pipeline units belong to medium-high risk category, 160 pipeline units belong to medium risk category, and 392 pipeline units belong to low risk category.

5 Conclusions

In this paper, multistage MFCA method was presented to assess the risk of buried gas pipeline of a certain city of China by accurately calculating the likelihood and consequence of failure. The failure causes of pipeline can be divided into four groups, such as third-party damage, corrosion, design and construction error, and incorrect operation. The likelihood is determined by the corrosion damage, the third-party damage, design error, and incorrect operation by MFCA method, using the data for the pipes and the environment. The results show that corrosion damage and third-party damage contribute greatest to the likelihood of failure. The consequence is also determined by MFCA method, and the factor of interest include the potential loss of life and property, stability of gas supply and social, and the maintenance activity. As a result, the risk of each pipeline can be evaluated by MFCA method, and characterized by risk matrix. There are two pipeline units belong to high risk category, measurements should be taken to reduce the risk as low as reasonable practicable.

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