Industry Science and Engineering Vol. 2 No. 4, 2025

Evaluation of Combustion Type Riot Ammunition based on AHP Grey Comprehensive Evaluation

Jiayi Sun*
Graduate Brigade of Armed Police Engineering University, Xi'an, Shaanxi, China
**Corresponding Author.*

Abstract: In response to the problems of single and subjective safety evaluation methods for domestic incendiary riot ammunition, a safety evaluation model for a certain incendiary riot ammunition based on the combination of AHP method and grey relational analysis method is proposed. A ammunition safety evaluation index system was constructed using the AHP method, The grey correlation analysis method was used to establish a grey correlation matrix, and the experimental data was dimensionless processed. calculate the correlation coefficients between each index, and achieve the evaluation of the safety level of combustion type riot ammunition.

Keywords: Safety Evaluation of Incendiary Riot Ammunition; Grey Correlation Analysis Method; AHP; Security Level Evaluation

1. Introduction

Riot ammunition serves as a primary equipment for the armed police force in carrying out tasks related to collective incidents, where its "less-lethal" attribute plays an irreplaceable role [1]. Among the commonly used non-lethal ammunitions equipped by the armed police force, the proportion of incendiary riot ammunition is as high as 74%. With such a vast base of ammunition and a high frequency of usage, potential safety hazards easily emerge. In the event of a safety accident, the potential for casualties and significant property losses is unimaginable. Therefore, exceptionally high levels of safety are crucial prerequisites for the application of incendiary riot ammunition.

Both Chinese and foreign scholars have conducted extensive research on the safety assessment of ammunitions. Dong Sanqiang, Feng Shunshan, et al. [2] introduced safety parameters and constructed a safety performance evaluation model for conventional ammunitions. Liu Guoliang and Jiao Gangling [3] summarized and analyzed the research progress on ammunition safety issues in military powers of the West, as well as the types and methods of assessment experiments. The aforementioned studies have predominantly focused on the safety evaluation of conventional ammunitions. In comparison, incendiary riot ammunition might be subject to abnormal environmental loads such as falls, collisions, and fires throughout its entire life cycle post-production, including storage, transportation, usage, and disposal [4]. Therefore, there exists a certain gap in research between the safety testing of incendiary riot ammunition and conventional ammunitions. The establishment and refinement of a standardized system for safety testing and evaluation remain imperative [5].

2. Specific Steps of AHP-based Grey Comprehensive Evaluation

2.1 Establishing a Safety Evaluation Index System

In order to ensure the rationality and scientific nature of the established safety evaluation index system, this study drew inspiration from the Chemical Riot Ammunition Safety Requirements and Technical Requirements for Packaging, Loading/Unloading, Storage, and Transportation of Chemical Riot Ammunition. By referencing relevant literature and consulting non-lethal weapons experts, a relatively sensible safety assessment index system was constructed, as shown in Table 1.

2.2 Establishing Riot Ammunition Safety Evaluation Sets

Some scholars categorize the hazard safety levels of pyrotechnic materials from high to low into five levels [6]. In this paper, the evaluation levels were also divided into five grades, and the evaluation set is:

$$V = \{v_1,\ v_2,\ \cdots,\ v_m\} = \left\{\begin{matrix} High - Security\ Riot\ Ammunition, \\ Relatively\ High - Security\ Riot\ Ammunition, \\ Standard - Security\ Riot\ Ammunition, \\ Moderate - Security\ Riot\ Ammunition, \\ Unsafe\ Riot\ Ammunition \end{matrix}\right\}$$

2.3 Constructing the Secondary Index Evaluation Matrix

Each secondary index was individually evaluated, with m primary index layers and n evaluation indexes per primary index layer. The evaluation matrix for the secondary index layer is denoted as:

$$E_i = (e_{ij1}, e_{ij2}, \dots e_{ijn}) = \begin{pmatrix} e_{i11} & \cdots & e_{i1n} \\ \vdots & \ddots & \vdots \\ e_{im1} & \cdots & e_{imn} \end{pmatrix} \quad (1)$$

Table 1. Safety Evaluation Index System for Incendiary Riot Ammunition

Hierarchy Level	Primary Index	Secondary Index
Safety Evaluation Index System for Incendiary Non-lethal Ammunition	Projectile Safety	Projectile Material, Strength
		High Temperature Safety
		Compatibility between Projectile and Propellant
	Fuze Safety	Fuze Tube Quality
		Delay Time
		Fuze Reliability
	Main Charge Safety	Friction Sensitivity
		Combustion Heat Compatibility
		Electrostatic Sensitivity
		Impact Sensitivity
		Storage Stability
	Packaging Safety	Stacking Conditions
		Fire and High Temperature Resistance
Safety Evaluation Index System for Incendiary Non-lethal Ammunition	Operational and Deployment Integrity	Gunshot Experiments
		Vibration
		Drop Test
		Immersion Test
	Terminal Effect Integrity	Environmental Safety Effectiveness
		Effects of Agents on the Human Body

2.4 Constructing the Grey Correlation Evaluation Matrix

Taking the secondary index layer X_i' as the evaluation index, let $X_0' = \left(X_0'(1), X_0'(2), \dots X_0'(m)\right)^T$ be the relative optimal comparative index for the secondary index layer, where m represents the number of evaluation indexes in the set [7]. Calculate the absolute difference between the comparison sequence and the reference sequence's corresponding elements, based on the formula

$$\xi_i(k) = \frac{min_i\, min_k \quad x_0(k) - x_i(k) \quad + \rho \cdot max_i\, max_k \quad x_0(k) - x_i(k)}{x_0(k) - x_i(k) \quad + \rho \cdot max_i\, max_k \quad x_0(k) - x_i(k)}$$

to obtain the Grey Correlation Coefficient Evaluation Matrix for the indexes of the secondary index layer.

$$R_i = \begin{pmatrix} r_{i11} & \cdots & r_{i1n} \\ \vdots & \ddots & \vdots \\ r_{im1} & \cdots & r_{imn} \end{pmatrix} \quad (2)$$

2.5 Determining the Evaluation Vector for Primary Index Layer

The product of the weight vector of the secondary index layer and the Grey Correlation Coefficient Evaluation Matrix of the indexes in the secondary index layer resulted in the Grey Correlation Coefficient Evaluation Matrix C for the primary index layer.

$$C = W_i \cdot R_i = (w_{i1}, w_{i2}, \dots w_{in}) \begin{pmatrix} r_{i11} & \cdots & r_{i1n} \\ \vdots & \ddots & \vdots \\ r_{im1} & \cdots & r_{imn} \end{pmatrix} = \begin{pmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{i1} & \cdots & c_{in} \end{pmatrix} \quad (3)$$

The evaluation index vector Z for the primary index layer was obtained by multiplying the weight vector of the primary indexes with the Grey Correlation Coefficient Evaluation Matrix of the indexes in the primary index layer.

$$Z = W \quad \cdot C(w_1, w_2, \dots w_n) \begin{pmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{i1} & \cdots & c_{in} \end{pmatrix} = (Z_1, Z_2, \dots Z_n) \quad (4)$$

2.6 Determining the Comprehensive Evaluation Results

For the sake of convenience in evaluation, normalization is applied to Z, with the following formula:

$$Z = \left\{\frac{z_1}{\sum_{i=1}^{n} z_i}, \frac{z_2}{\sum_{i=1}^{n} z_i}, \dots, \frac{z_1}{\sum_{i=1}^{n} z_i}\right\} \quad (5)$$

3. Analysis of Experimental Data

3.1 Projectile Safety

The material of the DSC142 48mm OC tear gas projectile is plastic. After combustion, the projectile undergoes slight deformation, with the highest temperature reaching 250°C.

3.2 Fuze Safety

The timing for the tear gas projectile was set from the moment the flip plate opened upon projection as the starting point to the initiation of action as the endpoint. Ten rounds of ammunition were tested to determine the time taken from the moment of projection to the onset of smoke generation for the hand-thrown tear gas grenade being evaluated. The experimental results are presented in Table 2.

Table 2. Delay Time Test Results Record for 48mm OC Tear Gas Grenade

S/N	Time (s)	S/N	Time (s)
1	1.10	6	1.18
2	1.20	7	0.94
3	1.28	8	1.22
4	1.15	9	1.13
5	1.17	10	1.19

The maximum value obtained is 1.28s, the minimum value is 0.94s, and the average value is 1.18s.

3.3 Main Charge Safety

Friction sensitivity, impact sensitivity, electrostatic spark sensitivity, and compatibility tests were conducted on the main charge [8]. The experimental results are referenced in Table 3 and Table 4. According to Cui Xiaoping [9], after 5 years of storage, SEM images of a certain tear gas projectile's main charge showed no significant change, indicating that the main charge exhibits exceptionally high safety and stability.

3.4 Packaging Safety

The packaging box filled with weighted projectiles was placed into a test chamber, and the temperature inside the chamber was gradually raised to 70°C, maintaining this temperature for no less than 48 hours. Afterward, the test chamber was returned to normal atmospheric conditions until the packaging temperature stabilized. The appearance of the packaging box and any changes were then examined, as shown in Figure 1.

Table 3. Data from OC Tear Gas Agent Safety Tests

Serial No.	Test Item	Sample Specification	Test Method	Test Conditions	Test Results
1	Friction Sensitivity	Powder	GJB5383.3 GJB5383.4	Swing Angle: 80°; Pressure: 3.5 MPa; Environment: Temperature 20°C, Humidity 52%	Average Ignition Rate: 87.5%
2	Impact Sensitivity	Powder	GJB5383.2	Hammer Weight: 10 kg; Environment: Temperature 20°C, Humidity 52%	Average Ignition Rate: 66%
3	Electrostatic Spark Sensitivity	Powder	GJB5383.8	Capacitance 0.22 μF, Electrode Gap 0.5 mm, Series Resistance 170 kΩ, Charged to 3.0 kV	No Ignition Observed

Table 4. Data from OC Tear Gas Agent Compatibility Tests

Serial No.	Test Item	Test Method	Test Results	Test Conclusion
1	Compatibility of OC Tear Gas Agent with PC Modified Material	According to GJB5383.11-2005; Test Condition: 27°C	Stability: Peak Temperature Change $\triangle Tp$/°C: 1.86; Activation Energy Change Rate $\triangle Ea$/%: 2.56	Grade I (Suitable for Military Use)
2	Compatibility of OC Tear Gas Agent with PE Modified Material	According to GJB5383.11-2005; Test Conditions: 27°C	Stability: Peak Temperature Change $\triangle Tp$/°C: 0.68; Activation Energy Change Rate $\triangle Ea$/%: 5.17	Grade I (Suitable for Military Use)

Test Results: No deformation, failure due to high-temperature expansion, permanent hardening, surface cracking or fracturing, or fading of markings were observed on the test packaging box.

Experimental Method: Ten sets of fully equipped ammunition packages (entire boxes) were selected. The packaging boxes filled with ammunition (weighted projectiles) were stacked vertically in a stack yard to a height not less than 3 meters for stability, with timing commencing after 30 minutes of stabilization. This stacking configuration was maintained for at least 48 hours. Upon reaching the specified duration of the test, the stacks were dismantled, and the appearance of each packaging box was inspected, as illustrated in Figure 2.

Figure 1. High-Temperature Safety Test for 48mm OC Tear Gas Grenade Packaging

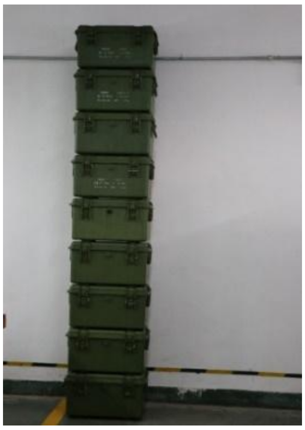

Figure 2. Stacking Safety Test for 48mm OC Tear Gas Grenade Packaging

Test Results: Nine packaging boxes filled with ammunition (weighted projectiles) were vertically stacked in the stack yard to a height of 3.033 meters, lasting for 60 hours without any instances of toppling observed.

3.5 Operational Safety

At a distance of 20 meters from the firing point, the DSC142 model 48mm OC tear gas Grenade ammunition was tested using a 95-type 5.8mm rifle, with ordinary ammunition aimed at the central part of the main charge of the projectile body and the ignition section of the hand-thrown anti-riot ammunition.

Test Results: A total of 10 rounds of the DSC142 model 48mm OC tear gas ammunition were tested, and none of the rounds exhibited any signs of combustion or explosion.

Twenty rounds of ammunition were placed in a vibration chamber, with the center amplitude set to 150mm and frequency to 1Hz, vibrating for a duration of 2 hours. Following the vibration, the ammunition (with individual packaging) was placed in a temperature-controlled chamber, where the temperature was adjusted to be 27°C above water temperature, maintaining the chamber at this temperature for 4 hours. Subsequently, the ammunition was immersed in 1-meter-deep water for 24 hours, as shown in Figure 3. After the immersion and vibration, the tested ammunition was dropped from a height of 1.5 meters onto a cement floor, with each round being dropped once in each of 20 different orientations. After the drops, the appearance of the ammunition was inspected for any changes, as shown in Figure 4.

Test Results: None of the ammunition exhibited safety concerns such as ignition caused by vibration, and the packaging remained intact after vibration. After immersion, no water had entered the ammunition packaging. During the drop tests, the ammunition did not exhibit any safety issues, such as ignition or cracking, that would affect its operational safety.

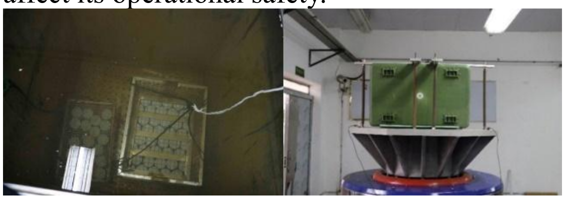

Figure 3. Immersion and Vibration Safety Test for 48mm OC Tear Gas Grenade

Figure 4. Horizontal Drop Test for 48mm OC Tear Gas Grenade

3.6 Terminal Effects Safety

During the course of action, incendiary tear gas grenades exhibit a prolonged burning duration of approximately 25 seconds [10]. Furthermore, the temperature of the projectile is typically around 250°C. These factors collectively pose potential safety risks when such ammunition is used in flammable or explosive environments. For instance, during the Venezuela nightclub incident on June 16, 2018, 17 individuals tragically died due to suffocation and fires caused by tear gas grenaders.

4. Evaluation of Safety for DSC142 Model 48mm OC Tear Gas Grenades

4.1 Establishing the Decision Matrix and Weight Calculation

Feedback was gathered from 10 experts specializing in non-lethal weapons to assess the importance of six primary indexes. Combining the 1-9 scale, the most rational decision matrix for the primary indexes U was derived.

$$U=\begin{pmatrix}1 & 3/4 & 3/5 & 3/2 & 3/7 & 1/2\\ 4/3 & 1 & 4/5 & 2 & 4/7 & 2/3\\ 5/3 & 5/4 & 1 & 5/2 & 5/7 & 5/6\\ 2/3 & 1/2 & 2/5 & 1 & 2/7 & 1/3\\ 7/3 & 7/4 & 7/5 & 7/2 & 1 & 7/6\\ 2 & 3/2 & 6/5 & 3 & 6/7 & 1\end{pmatrix}$$

Similarly, a decision matrix for the secondary indexes $U_1 \sim U_6$ was constructed.

$$U_1=\begin{pmatrix}1 & 3 & 4\\ 1/3 & 1 & 2\\ 1/4 & 1/2 & 1\end{pmatrix}$$

$$U_2=\begin{pmatrix}1 & 3 & 1/3\\ 1/3 & 1 & 1/7\\ 3 & 7 & 1\end{pmatrix}$$

$$U_3=\begin{pmatrix}1 & 3 & 5 & 7 & 7\\ 1/3 & 1 & 3 & 5 & 5\\ 1/5 & 1/3 & 1 & 3 & 3\\ 1/7 & 1/5 & 1/3 & 1 & 1\\ 1/7 & 1/5 & 1/3 & 1 & 1\end{pmatrix}$$

$$U_4=\begin{pmatrix}1 & 1/5\\ 5 & 1\end{pmatrix}$$

$$U_5=\begin{pmatrix}1 & 2 & 3 & 5\\ 1/2 & 1 & 2 & 3\\ 1/3 & 1/2 & 1 & 2\\ 1/5 & 1/3 & 1/2 & 1\end{pmatrix}$$

$$U_6=\begin{pmatrix}1 & 1/3\\ 3 & 1\end{pmatrix}$$

The CR value of the decision matrix U is 0, with CRvalues of U_1~ U_6 being 0.017, 0.006, 0.027, 0, 0.0055, and 0, all below 0.1, meeting the consistency test.

The calculation of eigenvectors and the largest eigenvalue are omitted in this text, and the computed results are directly presented. See Table 5 below for the weights of indexes in the safety evaluation system for a specific incendiary tear gas grenade.

Hence, the weight vectors for each level of indexes are obtained as follows:

$$W=\{w_1,w_2,w_3,w_4,w_5,w_6\}=\{0.111,0.148,0.185,0.075,0.259,0.222\}$$

$$W_1=\{w_{11},w_{12},w_{13},\}=\{0.625,0.2385,0.1365\}$$

$$W_2=\{w_{21},w_{22},w_{23},\}=\{0.2426,0.088,0.6694\}$$

$$W_3=\{w_{31},w_{32},w_{33},w_{34},w_{35}\}=\{0.514,0.258,0.1223,0.0529,0.0529\}$$

$$W_4=\{w_{41},w_{42}\}=\{0.1667,0.8333\}$$

$$W_5=\{w_{51},w_{52},w_{53},w_{54}\}=\{0.4829,0.272,0.157,0.0882\}$$

$$W_6=\{w_{61},w_{62}\}=\{0.1255,0.8745\}$$

Table 5. Weights of Indexes in Safety Evaluation System for a Specific Incendiary Tear Gas Grenade

Primary Index	Primary Index Weight (%)	Secondary Index	Weight of Secondary Indexes within Primary Index Layer (%)	Secondary Index Weight (%)
U_1	11.1%	U_{11}	62.50	6.94
		U_{12}	23.85	2.65
		U_{13}	13.65	1.52
U_2	14.8%	U_{21}	24.26	3.59
		U_{22}	8.8	1.3
		U_{23}	66.94	9.91
U_3	18.5%	U_{31}	51.4	9.51
		U_{32}	25.8	4.77
		U_{33}	12.23	2.26
		U_{34}	5.29	0.98
		U_{35}	5.29	0.98
U_4	7.5%	U_{41}	16.67	1.25
		U_{42}	83.33	6.25
U_5	25.9%	U_{51}	48.29	12.51
		U_{52}	27.2	7.04
		U_{53}	15.7	4.07
		U_{54}	8.82	2.28
U_6	22.2%	U_{61}	12.55	2.79
		U_{62}	87.45	19.41

4.2 Determining the Evaluation Levels

A grading system was employed to represent the relationship between the evaluation factor set and safety levels. The specific levels are shown in Table 6 below:

Table 6. Evaluation Index Levels

Evaluation Level	High-Security Riot Ammunition	Relatively High-Security Riot Ammunition	Standard-Security Riot Ammunition	Moderate-Security Riot Ammunition	Unsafe Riot Ammunition
Score	[0.8, 1]	[0.6,0.8]	[0.4,0.6]	[0.2,0.4]	[0, 0.2]

4.3 Establishing the Secondary Index Evaluation Matrix

Based on the analysis of the test results of the DSC142 model 48mm OC tear gas grenade, the secondary index evaluation grades were determined, and the secondary index evaluation matrix is established as follows:

$$E_1 = \begin{pmatrix} 0 & 0.65 & 0 & 0 & 0 \\ 0 & 0 & 0.55 & 0 & 0 \\ 0.85 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$E_2 = \begin{pmatrix} 0.8 & 0 & 0 & 0 & 0 \\ 0.85 & 0 & 0 & 0 & 0 \\ 0.97 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$E_3 = \begin{pmatrix} 0.87 & 0 & 0 & 0 & 0 \\ 0.85 & 0 & 0 & 0 & 0 \\ 0.89 & 0 & 0 & 0 & 0 \\ 0 & 0.66 & 0 & 0 & 0 \\ 0.8 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$E_4 = \begin{pmatrix} 0.9 & 0 & 0 & 0 & 0 \\ 0.95 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$E_5 = \begin{pmatrix} 0.9 & 0 & 0 & 0 & 0 \\ 0.9 & 0 & 0 & 0 & 0 \\ 0.95 & 0 & 0 & 0 & 0 \\ 0.9 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$E_6 = \begin{pmatrix} 0 & 0.7 & 0 & 0 & 0 \\ 0 & 0.7 & 0 & 0 & 0 \end{pmatrix}$$

4.4 Establishing the Grey Correlation Evaluation Matrix

Based on the vector evaluation grades, it is observed that the closer an evaluation index is to 1, the better the evaluation result. Therefore, let the optimal index be $x_0 = (x_0, x_{02}, \ldots, x_{0n}) = (1,1,\ldots 1)$. Thus, the grey correlation calculation formula for the sub-index layer's indexes can be transformed into:

$$r(x_{ij}, x_{0j}) = \frac{\min_i \min_j |x_{ij}-1| + 0.5 \cdot \max_i \max_j |x_{ij}-1|}{|x_{ij}-1| + 0.5 \cdot \max_i \max_j |x_{ij}-1|} \quad (6)$$

By Formula (6), the grey evaluation matrix for each sub-index can be computed:

$$R_1 = \begin{pmatrix} 0 & 0.39 & 0 & 0 & 0 \\ 0 & 0 & 0.33 & 0 & 0 \\ 0.6 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$R_2 = \begin{pmatrix} 0.33 & 0 & 0 & 0 & 0 \\ 0.4 & 0 & 0 & 0 & 0 \\ 0.77 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$R_3 = \begin{pmatrix} 0.57 & 0 & 0 & 0 & 0 \\ 0.53 & 0 & 0 & 0 & 0 \\ 0.61 & 0 & 0 & 0 & 0 \\ 0 & 0.333 & 0 & 0 & 0 \\ 0.46 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$R_4 = \begin{pmatrix} 0.33 & 0 & 0 & 0 & 0 \\ 0.5 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$R_5 = \begin{pmatrix} 0.333 & 0 & 0 & 0 & 0 \\ 0.333 & 0 & 0 & 0 & 0 \\ 0.50 & 0 & 0 & 0 & 0 \\ 0.333 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$R_6 = \begin{pmatrix} 0 & 0.333 & 0 & 0 & 0 \\ 0 & 0.333 & 0 & 0 & 0 \end{pmatrix}$$

4.5 Determining the Evaluation Vector for the Primary Indexes

According to Formula (4), the grey correlation coefficient evaluation matrix for the primary index layer C can be calculated as:

$$C = W_i \cdot R_i = \begin{pmatrix} 0.116 & 0.4062 & 0.1312 & 0 & 0 \\ 0.9182 & 0 & 0 & 0 & 0 \\ 0.8176 & 0.0349 & 0 & 0 & 0 \\ 0.9417 & 0 & 0 & 0 & 0 \\ 0.3593 & 0 & 0 & 0 & 0 \\ 0 & 0.333 & 0 & 0 & 0 \end{pmatrix}$$

Based on Formula (5), the evaluation vector for the primary index layer is given by:

$$\overline{Z} = (0.4637, 0.1255, 0.0146, 0, 0)$$

4.6 Determining the Safety Evaluation Results

The vector $\overline{Z}$ was normalized, resulting in:

$$Z = (0.768, 0.208, 0.024, 0, 0)$$

The safety evaluation results for the DSC142 Type 48mm OC tear gas grenade are shown in Table 7.

Table 7. Safety Evaluation Results for DSC142 Type 48mm OC Tear Gas Grenade

Evaluation Level	High-Security Riot Ammunition	Relatively High-Security Riot Ammunition	Standard-Security Riot Ammunition	Moderate-Security Riot Ammunition	Unsafe Riot Ammunition
Score	[0.8, 1]	[0.6, 0.8]	[0.4, 0.6]	[0.2, 0.4]	[0, 0.2]
Safety of the Ammunition	76.8%	20.8%	2.4%	0	0

According to the principle of maximum membership degree, the score falls within the "High-Security Riot Ammunition" range, making the safety evaluation level for this incendiary tear gas grenade "High-Security Riot Ammunition".

5. Conclusion

This paper combines the AHP (Analytic Hierarchy Process) and Grey Relational Analysis methods, using AHP to evaluate the weights of safety indexes, and applying Grey Relational Analysis to process the ranking matrix. This approach integrates both qualitative and quantitative analysis, fully considering the grey system characteristics of influencing factors while addressing the limitation of Grey Relational Analysis, which does not account for the differing index weight coefficients. This evaluation method eliminates the drawbacks inherent in each of the two methods individually, resulting in more scientifically accurate and reliable outcomes.

Based on the connotations and characteristics of the safety evaluation of incendiary riot ammunition, a safety evaluation index system has been established. A safety evaluation model based on AHP-Grey Comprehensive Evaluation was proposed, and the Grey Relational Analysis method was used to conduct a multi-level evaluation of its safety level. Taking the DSC142 type 48mm OC tear gas grenade as an example, the feasibility and scientific nature of the established evaluation model were verified. This study provides new research ideas and methods for future safety evaluations of incendiary riot control ammunition.

References

[1] Ban Chao. Review of the Development of Non-Lethal Ammunition. Chemical Engineering and Equipment, 2016, (01): 185-187.
[2] Dong Sanqiang, Feng Shunshan, Jin Jun. Researches on Safety Assessment Model of Ammunitions. Acta Armamentarii, 2011, 32(04): 421-425.
[3] Liu Guoliang, Jiao Gangling, Ma Ying, et al. Study on Safety Test Method of Ammunition. Modern Defense Technology, 2023, 51(1): 107-118.
[4] Zhao Yandi. Safety Design Analysis and Verification. Beijing: National Defense Industry Press, 2005.
[5] Li Xinzhang, Ma Yongzhong. Analysis of the Current Status of Safety Issues in Combustion/Explosion-Type Anti-Riot Ammunition. Chemical Engineering and Equipment, 2024, (05): 165-167+32. DOI: 10.19566/j.cnki.cn35-1285/tq.2024.05.002
[6] Zhang Xiaocheng. Hazardousness Assessment and Classification of Fireworks and Pyrotechnics. Fireworks Technology and Market, 2014, (4): 2-13.
[7] Cui Zenglin. Elevator Safety Evaluation Method Based on Grey Correlation Analysis and Analytic Hierarchy Process. China Elevator, 2022, 33(15): 59-63.
[8] Wang Hongying, Mou Yinglin, Su Shichun, et al. Performance Study of a Stimulant-Type Smoke Agent. Explosives, 2013, (01): 36-38.
[9] Cui Xiaoping, Ma Yongzhong, Yang Jian. Study on the Reliability of a Gun Firing Tear Gas Grenade. Explosive Materials, 2018, 47(02): 48-53.
[10]Ling Meng. Domestic Tear Gas Grenade: Flourishing – A Conversation with Associate Professor Liu Lusheng of the Armed Police Engineering Academy. Small Arms, 2001, (10): 2-4.