Investigation on Multi-level Extensive Evaluation of the Safety Risk of Tank Guns’ Live Shooting

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Abstract. Adopting a systematic perspective to create the safety management evaluation of the index system of tank guns’ live shooting, which formed from three elements, for example, people, tools, and management. Next, an extensive evaluation approach used to install an evaluation model for safety management and more impartial entropy utilized. Later, the value method used to estimate the weight of every layer of indicators, and then the evaluation model is employed to a standard case investigation. Hence, the application outcomes prove the practicability of the evaluation model.

Keywords: Tank Gun, Live Shooting, Safety Management, Extensive Evaluation

1. Introduction
There are numerous accidents and hidden risks of the tank gun’s live shooting, so it is essential to increase safety management in training. To guarantee that the practice of tank guns’ live shooting can accomplish effectively and orderly. Also, hidden severe safety hazards excluded in the procedure of implementation. Therefore, it is at a condition of agreeable degree [1], which is the target of fire training safety management.

2. Construction of an evaluation index system for the safety management of tank guns’ live shooting
Tank guns’ live shooting is a scheme consisting of people, tools, and management. They have a correlative and jointly restrictive connection[2]. Consequently, a general examination of multiple risk elements in the shooting process accomplished by adopting a systematic theory. Thus, the index system eventually built is presented in Figure 1.
Figure 1. Index system for security evaluation

### 3. Model construction of safety management evaluation of tank guns’ live shooting according to the extensive evaluation model

Define the risk degree domain for the safety management of tank guns’ live shooting: 

\[ U = \{ U_1, U_2, U_3 \} \]

where \( U \) stands for the risk degree domain, \( U_1, U_2, U_3 \) stand for the risk degrees of “Dangerous”, “Safe”, and “Very safe” respectively.

The evaluation determinant set \( C \) for arranging every hazard index is 

\[ C = \{ C_1, C_2, C_3 \} \]

and each element in \( C \) is composed of sub-indicators, for example, \( C_1 = \{ C_{11}, C_{12}, ..., C_{1m_1} \} \), \( C_2 = \{ C_{21}, C_{22}, ..., C_{2m_2} \} \), \( C_3 = \{ C_{31}, C_{32}, ..., C_{3m_3} \} \), where \( m_1, m_2, m_3 \) are the number of sub-indicators involved in \( C_1, C_2, C_3 \) respectively.

#### 3.1. Ascertain the standard and knot domains

Let \( R_{oj} = (N_{oj}, C, V_{oj}) \) where \( N_{oj} \) describes the j-th level in the rating evaluation standard formed by the evaluation target, \( C_i \) (\( i = 1, 2, m \)) depicts the characteristics of the evaluation object \( N_{oj} \), and \( V_{oj} \) is the level of \( N_{oj} \). The scale of magnitude defined by all features \( C_i \), that is, the scope of data adopted by every degree concerning the identical feature-the traditional domain[3].

Let \( R_{yi} = (U, C, V_u) \), where \( C \) describes the sum of the isolated degrees, and \( V_u \) is the magnitude scale defined by \( U \) for the feature \( C_i \), that is, the node domain of \( C_i \).

#### 3.2. Ascertain the matter to estimate

The matter component comprised of the information of the target to estimate \( C_i \) named the matter component to measure[4], and the associated data or analysis outcomes of the target to evaluate shown in the construction of the next matter components:

\[
R = \begin{bmatrix}
C_1 & C & C_m \\
C_2 & C_m \\
\vdots & \vdots & \ddots \\
C_m & V_m
\end{bmatrix}
\]  

(1)
Where $Ci$ depicts the goal to measure; $i = 1, 2, \ldots$; $n$ outlines the number of the purpose to estimate; $Vimk$ is the value of $Ci$ on $Cil$, which is the particular data measured by multiple indicators of the target to assess.

3.3. Discover the connection of every degree of the target to evaluate

The association function can adopt as a device to quantitatively define the quantitative and qualitative variations of things. The similar calculation formula is:

$$K(v_i) = \begin{pmatrix} R(v_i, V_{0j}) - R(v_i, V_{0i}) & R(v_i, V_{0j}) - R(v_i, V_{0i}) & \cdots & R(v_i, V_{0j}) - R(v_i, V_{0i}) \\ -R(v_i, V_{0j}) - R(v_i, V_{0i}) & R(v_i, V_{0j}) - R(v_i, V_{0i}) & \cdots & R(v_i, V_{0j}) - R(v_i, V_{0i}) \\ \cdots & \cdots & \cdots & \cdots \\ R(v_i, V_{n0}) - R(v_i, V_{ni}) & R(v_i, V_{n0}) - R(v_i, V_{ni}) & \cdots & R(v_i, V_{n0}) - R(v_i, V_{ni}) \end{pmatrix}$$

(2)

In the similarity function, $Kj(vil) > 0$ depicts the level to which $vil$ refers to $V0jl$. $Kj(vil) < 0$ indicates the level to which $vil$ does not belong to $V0jl$, and $Kj(vil) = 0$ determines the level to which $vil$ regards to both $V0jl$ and $V0jl$.

Obtain the transformation matrix $Ki$ of first-level evaluation:

$$K = \begin{pmatrix} K(c_1) & K(c_2) & \cdots & K(c_m) \\ K(c_1) & K(c_2) & \cdots & K(c_m) \\ \cdots & \cdots & \cdots & \cdots \\ K(c_1) & K(c_2) & \cdots & K(c_m) \end{pmatrix}$$

(3)

3.4. Ascertain the weight coefficient

The standardization matrix measured, and all index values managed confidently[5]. Besides, the proportion of the index value $Pij$ of the $ith$ target to be estimated under the $j$ index is determined, and the standardization matrix got.

$$Pj = \frac{X_j}{\sum_{i=1}^{m} X_j} (i = 1, 2, \cdots, mj = 1, 2, \cdots, n)$$

(4)

Estimate the entropy value of every index: $\Theta_j = -\frac{1}{n} \sum_{i=1}^{m} Pj1nPj$

Determine the coefficient of the diversity of every indicator: $g = 1 - \Theta$

Measure the weight of every indicator:

$$W = \frac{g}{\sum_{i=1}^{m} g} (i = 1, 2, \cdots, mj = 1, 2, \cdots, n)$$

(5)

The evaluation index weight vector $W = (W1, W2, W3, \ldots, Wn)$ according to the entropy weight received[6].

3.5. Rating level

Make the first-level evaluation $Bi = AiKi$, and measure the first-level evaluation vectors of other indicators in the criterion layer in turn. The second-level evaluation alteration matrix $K = B1 \; , B2 \; , B3 \; , \ldots \; , Bn \; \top$ got, and the second-level evaluation $B = AK$.

If it satisfies: $K(C) = j_0 \in \{1, 2, \cdots, m\}^B$ , then the target $C$ to estimate, which belongs to level $j0$. 

3
4. Application and Analysis
Determine the risk degree $U = \{U_1, U_2, U_3\}$, where $U_1 = <0,60>$ reveals in a dangerous circumstance; $U_2 = <60,80>$ presents in a safe status; $U_3 = <80,100>$ shows in a very safe condition [7].

To limit the uncertainty of tank guns’ live shooting, the group invited eight specialists to develop an assessment team to estimate three units. All indexes calculated on a percentage foundation and the standard of the master ratings utilized to reach the security of the three units of tank guns. Thus, the management score revealed in Table 1.

Table 1. Score table of safety management and correlation level of multiple determinants

| Criteria layer | Index level                  | Unit 1 | Unit 2 | Unit 3 | Correlation |
|----------------|------------------------------|--------|--------|--------|-------------|
| Person factor C1 (0.3750 ) | Shooter level C11 (0.1251) | 72     | 95     | 62     | -0.300 0    |
|                | Capacity of commander C12 (0.1246) | 78     | 92     | 54     | -0.450 0    |
|                | Service personnel quality C13 (0.1253) | 70     | 88     | 61     | -0.250 0    |
| Tools factor C2 (0.2503 ) | Gun status C21 (0.1254) | 83     | 73     | 58     | -0.575 0    |
|                | Ammunition storage C22 (0.1249) | 76     | 75     | 49     | -0.400 0    |
|                | Vehicle level C33 (0.1248) | 83     | 73     | 58     | -0.575 0    |
| Management factor C3 (0.3747 ) | Shooting command process C31 (0.1248) | 78     | 90     | 55     | -0.450 0    |
|                | Shooting preparation guide C32 (0.1257) | 83     | 78     | 64     | -0.575 0    |
|                | Troubleshooting of potential safety hazards C13 (0.1242) | 80     | 92     | 50     | -0.525 0    |

The following uses C3 of unit 1 as a case to show the estimation process, and the calculation of the other two units will immediately provide the calculation consequences[8].

Discover the material components to estimate for C3 as:

$$R_b = \begin{bmatrix} C_1 & C_1 & 78 \\ C_2 & 83 \\ C_3 & 80 \end{bmatrix}$$

(6)

Define the connection of Ci evaluated, and then, the association of other indicators can achieve:
Based on the first-level evaluation transformation matrix $K$ of $C_3$ and the weight coefficient of $C_3$, the first-level evaluation accomplished:

$$B_3 = A_3 \cdot K_3 = \begin{bmatrix} -0.1936, & -0.0126, & 0.0234 \end{bmatrix}$$

From the outcomes of the first-level evaluation to earn the second-level evaluation transformation matrix, and then second-level extensive evaluation is achieved:

$$B = A \cdot K = \begin{bmatrix} -0.1500, & 0.0438, & -0.0150 \end{bmatrix}$$

The second level evaluation’s outcomes of the other two units are measured in turn.

**Table 2.** Consequences of the secondary evaluation of every unit

|            | Dangerous | Safe   | Very safe |
|------------|-----------|--------|-----------|
| Unit 1     | -0.1500   | 0.0438 | -0.0150   |
| Unit 2     | -0.2267   | -0.1098| 1.3397    |
| Unit 3     | 0.0269    | -0.0153| -0.1189   |

Based on the consequences of the secondary evaluation, the indicators of Unit 1 and Unit 2 are higher the safety level. On the one hand, it is vital to strengthen the training of the shooter, the firing commander, form the command method, and the research of hidden safety risks to keep security[9]. On the other hand, we should actively increase our work on firearms and ammunition, assistance facilities, and firing preparation direction, and further enhance the management degree. The management status of Unit 3 is comparatively difficult, and numerous characters are at a hazardous level, which requires to be grown in each aspect to produce a collection of functional safety management measures to stop misfortunes.

5. **Discussion**

Launch a multi-level extensive evaluation approach to conduct an extensive evaluation of the secondary indicators of the safety management in tank gun’s live shooting, and then thoroughly complete the primary assessment. The evaluation outcomes are suitable for completely knowing the state of the goal to be estimated. According to the multi-level extensive evaluation method[10], this analysis produces a safety management evaluation model of tank guns’ live shooting, quantifies the qualitative indicators, and standardizes the evaluation symbols to perform the evaluation indicators that have comparability. The contrastive examination of the data can adequately conclude the safe working tendency of the tank gun’s live shooting. Moreover, the multi-level extensive evaluation approach employs a correspondence capacity for quantitative calculation, which can execute the evaluation manageable and secure and can precisely show the indicators that require to be updated. Consequently, several oriented measures can take, which can dramatically decrease the uncertainty of accidents and stop difficulties before they happen.

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