Research on comprehensive evaluation of six “properties” for equipment products incorporating correlate indexes

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Abstract: The six “properties” for equipment products are critical indexes to improve the quality of equipment development and batch production. In view of current difficulties of auditing six “properties” and putting qualitative or quantitative evaluation into practices, this paper analyses interactive characteristics of six “properties” and organically integrates them based on the VIKOR method. Firstly, the indexes and connotation of six “properties” for equipment products have been elaborated. Secondly, specific relationship among six “properties” is analysed and their interactive coefficients are depicted as two additive fuzzy measures. Thirdly, the effect of interactive coefficient among six “properties” is analysed on group utility and individual regret in the VIKOR method, and specific decision-making steps based on the VIKOR method are also proposed. Finally, two illustrative cases show the differences of multiple indexes decision results under two kinds of conditions and the feasibility and effectiveness of the proposed methods.

1. Introduction
The important design characteristics of equipment products often involve reliability, maintainability, testability, safety, supportability and environmental adaptability, which affect the performance of the equipment products directly. It is well-known that six “properties” are relative with the whole life cycle of equipment product including demonstration, scheme, engineering development, finalization, batch production and in-service. In the stage of equipment demonstration, it is necessary to consider the requirements of six “properties” with the researchers which can be regarded as the input and constraint conditions. In the stage of alternative design, the main tasks are preliminary design, demonstration, and verification of six “properties”. Developing the corresponding organizations and designing six “properties” and proving their effectiveness of research process as the important basis for equipment finalization, will be critical task in the stage of engineering development. The manufacturer will form specific support alternative and develop support system for comprehensive support requirements of the demander in the support stage.

With advanced and complex equipment products and changeable mission profile increasingly, the requirements of six “properties” for equipment products are also increasing. In order to improve the integrity of equipment products and reduce their cost in the whole life cycle, GJB 9001b-2009
strengthens the requirements of six “properties” for equipment products, and ensures steady quality improvement of equipment development and batch production, and urgently needs to evaluate the six aspects objectively in the development process to improve the satisfaction of military equipment and the applicability of operations [1]. Shen Jun analyzed current situation and problems of six “properties” of the land and aviation weapons and equipment to improve the readiness of equipment and success of the mission [2]. According to national military standard, Ge Jinfei put forward working contents of six “properties” and specific measures in the structural design of military electronic equipment [3]. Tian Baojie elaborated some basic tasks such as management and supervision in the development process, which also provide relative standards and specifications for six “properties” management [4]. Huang Shusen analyzed the identification of six outline work items and output of six plan in special audit and put forward three main suggestions [5]. Liu Qiang also analyzed the relationship among general quality characteristics of equipment products and proposed the way of improving the efficiency of six quality supervision [6]. Zhang Jialin focused on the six aspects of management and supervision in the equipment scheme stage [7]. Peng Wenyuan elaborated the strategies of six data information collection and analysis in the stage of equipment development, batch production and use support [8].

The weights of quantitative evaluation indexes of six “properties” for equipment products are AHP and expert weighting basically, and the evaluation value is usually expert scoring method. Zhang Sixiang proposed a weighting method based on expert clustering and deviation entropy to unify experts’ opinions, and used evidence reasoning method to make comprehensive evaluation of new ships [9]. For the perspective of individual attribute: Dmitry Efrosinin uses Laplace transformation to calculate reliability characteristics, reliability function and average number of failures [10]; Wang Yongpan built a Bayesian network-based evaluation model for complex equipment maintenance quality that ignores those factors affecting maintenance process [11]; Jian put forward product maintainability evaluation method based on life cycle theory [12]; Yin Yuanwei proposed a test allocation method based on triangular fuzzy number in view of the fuzziness of expert judgment factors’ importance in the test allocation influenced by multiple factors [13]; Yang put forward a comprehensive evaluation method for aviation maintenance support capability based on principal component analysis [14]; Li also proposed optimal safety evaluation model of complex product system [15]; Jian presented a fuzzy comprehensive evaluation method for ship environmental adaptability [16].

The above literatures carried out in-depth study on management requirements and quantitative comprehensive evaluation of six “properties” for equipment products, which mainly focused on the evaluation problem with single quality characteristics. The implementation of making comprehensive evaluation with the indicators’ relevance of six “properties” need be improved, which limits the application and guidance of comprehensive evaluation models. The paper, therefore, deeply analyzes the characteristics of six “properties” for equipment products, and depicts the correlation between the six related indicators, and analyzes the influence mechanism of correlation on the evaluation results with the VIKOR method, the specific cases are used to illustrate to provide a strong guarantee for the implementation of high-level quality control.
2. Hierarchy model of evaluation indexes of six “properties” for equipment products

2.1 Six evaluation indexes of equipment products

Reliability $c_1$: the ability of completing specified functions under specified conditions and within specified time, including availability $c_{11}$, mean time between failures ($MTBF$) $c_{12}$, reliability $c_{13}$.

Maintainability $c_2$: the ability of carrying out maintenance under specified conditions within specified time in accordance with specified procedures and methods to maintaining or restoring to specified state, which is divided into preventive, corrective, emergency and improved maintenance, including mean time to repair $MTTR$ $c_{21}$, maintenance degree $c_{22}$, maximum time to repair $c_{23}$, repair rate $c_{24}$, etc.

Testability $c_3$: an equipment characteristic which determines its status (workable, inoperable or performance degradation) and isolate its internal faults timely and accurately, which can improve the agility of equipment products and reduce their cost of equipment service cycle, including failure detection rate (FDR) $c_{31}$, failure isolation rate (FIR) $c_{32}$, false alarm rate (far) $c_{33}$, and alarm leakage rate $c_{34}$.

Supportability $c_4$: the ability of equipment design features and planned support resources to meet the use requirements, including mission success rate $c_{41}$, readiness rate $c_{42}$, mean logistics delay time ($MLDT$) $c_{43}$, etc.

Safety $c_5$: the characteristics that will not cause injury or equipment damage, property loss or environmental hazard, including failure rate $c_{51}$, disaster accident possibility $c_{52}$, etc.

Environmental adaptability $c_6$: the ability of equipment product to achieving its predetermined full set of functions under the action of various extreme stresses expected to be encountered in its storage, transportation and use during its life cycle, i.e. the ability which doesn’t produce irreversible damage and work normally, including the satisfaction of climate environment adaptation $c_{61}$, mechanical environment adaptation $c_{62}$ and electromagnetic environment adaptation $c_{63}$.

2.2 The meaning of six evaluation indexes

Availability $c_{11}$: the successful times divide the usage times, that is, the proportion of normal working hours of the system to all working hours.

Mean time between failures ($MTBF$) $c_{12}$: calculate the mean time of two adjacent failures of the product.

Reliability $c_{13}$: the probability of equipment product completing specified function under specified conditions.

Mean time to repair ($MTTR$) $c_{21}$: the average value of actual repair time required for troubleshooting. The observed value is equal to the ratio of the sum of repair time and repair times in a given time.

Maintenance degree $c_{22}$: the probability that repairable product can complete specified maintenance task under specified conditions and within specified time.

Maximum repair time $c_{23}$: maximum repair time (excluding administrative delay or logistics supply delay time) required by equipment product in specified conditions, maintenance level and
maintenance degree, generally 2-3 times of average repair time.

Repair rate $c_{24}$: the repairable probability of equipment product that has not been repaired at a certain time and within the unit time after that time.

Failure detection rate $c_{31}$: the ratio of the number of failures accurately detected by specified method to the total number of actual failures under specified time and conditions.

Fault isolation rate $c_{32}$: the percentage of all faults detected within specified period that can be correctly isolated by specified method to no more than specified ambiguity.

False alarm rate $c_{33}$: the ratio of the number of false alarms in specified time to the total number of fault indications in the same time.

Alarm leakage rate $c_{34}$: the ratio of the number of detection times without fault and the number of normal detection and judgment.

Task success rate $c_{41}$: the ratio of task success times to total tasks.

Readiness rate $c_{42}$: the ratio of the number of tasks performed under specified maintenance support scheme to the total number of tasks.

Average logistics delay time $c_{43}$: the average amount of time that cannot work due to management and logistics reasons, which includes average waiting time for spare parts, average management delay time and average personnel delay time.

Failure rate (instantaneous failure rate) $c_{51}$: the ratio of the number of failures in a unit time after the product reaches the time to the number of products that can still work at the time.

Probability of catastrophic accident $c_{52}$: the probability of disaster caused by the accident.

3. The relative description and analysis of six “properties” for equipment products

Suppose that there are $n$ kinds of equipment products, which is $P = \{P_1, P_2, ..., P_n\}$. The attributes are $c = \{c_1, c_2, ..., c_m\}$ which is depicted as six “properties”. The evaluated matrixes are $T = [t_{ij}]_{n \times m}$ in which $t_{ij}$ is the evaluation value of $P_i$ under the index $c_j$.

Let $P(c)$ is the power set of $c$, and set function $\mu: P(c) \rightarrow [0, 1]$ satisfy the following two conditions:

$\mu_\varnothing = 0, \mu_\varnothing = 1$; $A \in P(c), B \in P(c), A \subseteq B$, then $\mu_i \leq \mu_y$. $\mu$ will be a fuzzy measure about $P(c)$. It is essentially a set function in which each subset has a corresponding real number and satisfies monotonicity.

3.1 Analysis on the interaction among six “properties”

In order to depict the interaction among six “properties” in detail (i.e. complementary effect and redundancy effect), we use interaction coefficient proposed by grabisch and roubens and two additive fuzzy measures to describe these interactions. Suppose the fuzzy measures of single six indexes and two six indexes be $\mu_i$ and $\mu_y$ respectively. For any arbitrary index, the interaction effect between two
indexes $i$ and $j$ could be described as the following three conditions.

If $\mu_i > \mu_i + \mu_j$, there is complementary effect between index $i$ and $j$. It means that increasing both indicators will improve comprehensive evaluation value, and decreasing both indicators will reduce comprehensive evaluation value.

If $\mu_i < \mu_i + \mu_j$, there is a substitution effect between two indicators. Increasing or decreasing two indicator values at the same time will not increase or decrease comprehensive evaluation value at the same time, and there is a certain benefit reduction effect.

If $\mu_i = \mu_i + \mu_j$, it means that there is zero effect between indicators, and there is no interaction between indicators.

It is not sufficient to use the difference between $\mu_i$ and $\mu_i + \mu_j$ as the interaction coefficient $I_{ij}$ between index $i$ and $j$ when there are interaction effect between $i$, $j$,$\{i, j\}$ and other subsets. For any $\forall T \subseteq X \setminus \{i, j\}$, add $i, j, \{i, j\}$ into a subset $T$, then it is necessary to analyze changeable value of fuzzy measures in the new set.

### 3.2 Index interactions analysis of six “properties”

Definition 1: the interaction coefficient of six “properties” $\{i, j\}$ is defined as

$$I_{ij} = \sum_{t=0}^{n-2} \frac{(n-t-2)!t!}{(n-1)!} \sum_{T \subseteq X \setminus \{i,j\}} (\mu_{iT} - \mu_{IT} - \mu_{JT} + \mu_{JT})$$

where $\mu_{iT} - \mu_{IT} - (\mu_{JT} - \mu_{IT})$ could be divided into $\mu_{iT} - \mu_{IT}$ and $\mu_{JT} - \mu_{IT}$. $\mu_{IT} - \mu_{IT}$ shows the differences of fuzzy measures between set $\{T \cup i\}$ and $\{T \cup i\}$, and it is marginal contribution of adding index $j$ into $\{T \cup i\}$. $\mu_{IT} - \mu_{IT}$ shows the differences of fuzzy measures between set $\{T \cup j\}$ and $\{T \cup j\}$, and it is marginal contribution of adding index $i$ into $T$, which also depicts marginal interaction effect for index $i$ and $j$ in the set $T$. The positive value shows the above action will improve marginal contribution, and negative value will reduce their marginal contribution.

When the indicators of six “properties” are replaced by others, there is $-1 \leq I_{ij} < 0$; when the indicators are independent, there is $I_{ij}=0$; when the indicators are complementary, then $0 < I_{ij} \leq 1$. If some indicators of six “properties” are removed due to their interaction, there have information losses. If part of repeated information is removed, the final comprehensive performance of the equipment product will be improved.

### 3.3 The correlative analysis of six “properties” for equipment products

The definition of six “properties” for equipment products indicates that reliability is the basis of maintainability which is also restricted and influenced by reliability and could be thought as a part of reliability. Maintainability also depends on testability, in which equipment products are easy to be maintained. Product reliability, maintainability and testability need to be supported by supportability. Maintainability and reliability are important conditions for supportability. Safety is a kind of special
reliability, where equipment product is not safe due to failure. Environmental adaptability is often based on whether the product fails, which is the premise and basis of reliability. Therefore, interactive relationship between the above six factors can be described as: environmental adaptability affects reliability, reliability affects maintainability, testability affects maintainability, maintainability and reliability affect supportability, and reliability affects safety.

From micro perspective, the failure rate determines the probability of the accident, and reducing the failure rate is conducive to reducing the probability of the accident, which shows a certain positive correlation. If the failure rate is a fixed value, the mean time between failures is its reciprocal, the higher the failure efficiency is, the lower the reliability is, but the greater the alarm leakage rate is.

There exists positive correlation relationship between reliability and $\text{MTBF}$, the higher the reliability is, the longer $\text{MTBF}$ is. Availability, repair rate, $FDR$, $FIR$, $FAR$ and $\text{MTTR}$ are negatively correlated. The smaller the availability $\text{MTTR}$ is, the greater the availability is, which is negatively correlated, and there is positively correlated between $\text{MTBF}$ and the availability. The higher the alarm leakage rate is, the less time the system can work normally, which directly affects the availability and indirectly affects the reliability and maintainability.

There is a positive correlation between repair rate and maintenance degree, that is, the greater the repair rate is, the greater the maintenance degree is. There is positive correlation among $FDR$, $FIR$ and failure rate, and between $FAR$ and failure rate, increasing false alarm rate will increase the complexity of test circuit and reduce reliability.

The readiness rate has positive correlation with mission success rate and reliability, which reflects combat effectiveness, and determines the degree or ability to perform the mission in good condition to some extent. Correlation analysis of readiness rate and average logistics delay time: the average time what equipment cannot work is the sum of average maintenance time and average support delay time and average management delay time. Reducing delay time can improve equipment readiness in the actual environment.

4. VIKOR analysis of six “properties” for equipment products based on relevance

4.1 Analysis of VIKOR group utility value considering interaction coefficient

If $I_{ij}$ is positive, the indicators $c_i, c_j$ are complementary. Let $|t^j \rho - t^i \rho|$ shows the differences between the index $c_i, c_j$, the smaller the difference is, the greater the contribution of the index to the comprehensive evaluation value of decision alternative is. $0.5I_{ij} |t^j \rho - t^i \rho|$ is a penalty term, which means the penalty of the bad index to the good index in the complementary index. When there is a strong complementary relationship between the indexes, $|t^j \rho - t^i \rho|$ may reduce the group utility value of the decision alternatives.

If $I_{ij}$ is negative, the indicators $c_i, c_j$ may replace each other. The greater the difference between the alternative index values is, the greater the contribution of the indexes to comprehensive evaluation value of the decision alternatives is. If $|t^j \rho - t^i \rho|$ is larger, the values of $I_f^j$ or $I_f^i$ will become smaller. The compensation item $0.5I_{ij} |t^j \rho - t^i \rho|$ is positive and shows that the good index in the alternative indexes compensates the poor index, which is often used to compensate small part of group benefit value caused by small index value. When there is a strong substitution relationship between the indicators, $|t^j \rho - t^i \rho|$ will improve group utility value of the decision alternatives.

If $I_{ij}$ is zero, it means that the index $c_i, c_j$ are independent, which can be calculated directly by using
the classical weighted average operator.

4.2 Analysis of individual regret of VIKOR considering interaction coefficient

Different from group utility, individual regret is maximum value of normalized index value and weight of each decision alternative. If there are few indicators, it will be simple. With the increase of the number of the evaluated indicators, individual regret needs to compare positive and negative values of interaction coefficient between six indicators and the difference degree between interaction index values, which greatly increases calculation difficulties. In this paper, penalty value or compensation value is applied to average weighted values considering difference and interaction.

4.3 Design steps of VIKOR evaluation considering interaction coefficient

According to comprehensive evaluation of six “properties” for equipment products considering the interaction effect among the indicators, the interaction coefficient is integrated into group utility and individual regret to describe practical problems in detail and accurately. The improved VIKOR decision model is as follows:

Step 1: normalize \( T' = [t_{ij}]_{mn} \), and compute \( T'' = [t''_{ij}]_{mn} = \frac{\max_{i} t''_v - t''_v}{\max_{i} t''_v - \min_{i} t''_v} \).

Step 2: compute \( I'' \) based on definition 1.

Step 3: Compute group utility \( S_p = \sum_{q=1}^{n} w_q t'_{pq} - 0.5 \sum_{\{i,j\}} I_{ij} |t''_p - t''_q| \).

Step 4: Compute individual regret \( R = \max \left\{ \sum_{\{i,j\}} I_{ij} |t''_p - t''_q| \right\} \).

Step 5: Compute \( Q = \frac{S_p - \min S_p}{\max S_p - \min S_p} + (1 - \nu) \frac{R - \min R}{\max R - \min R} \), where \( \nu \in [0,1] \).

Step 6: Rank the decision alternatives based on \( Q \). The smaller \( Q \) is, the better the corresponding decision alternative is. Propose as a compromise solution the alternative \( a_{(1)} \) which is the best ranked by the measure \( Q \) (minimum). \( a_{(2)} \) is the alternative with the second place in the ranking list by \( Q \), \( m \) is the number of the alternatives. If the following two conditions are satisfied.

Condition 1: Acceptable advantage: \( Q_{(2)} - Q_{(1)} \geq 1/(n - 1) \)

Condition 2: \( S_{(1)} \) and \( R_{(1)} \) are minimal values between \( S \) and \( R \).

The alternative \( a_{(1)} \) should also be the best alternative used by \( S \) and \( R \). A set of compromise solutions is proposed as follows, if one of the conditions is not satisfied.

(1) Alternative \( a_{(1)} \) and \( a_{(2)} \) if only the condition 2 is not satisfied

(2) Alternative \( a_{(1)}, \ldots, a_{(M)} \), if the condition 1 is not satisfied; \( A_{(M)} \) is determined by the relation
\(Q(A_m) - Q(A_{n1}) < 1/(m-1)\) for maximum \(M\).

5. Case study
Suppose there are four types of equipment products with 19 six indexes, mainly including Reliability \(c_1\) (availability \(c_{11}\), mean time between failures \(c_{12}\), reliability \(c_{13}\)), Maintainability \(c_2\) (mean time to repair \(c_{21}\), maintenance \(c_{22}\), maximum time to repair \(c_{23}\), repair rate \(c_{24}\)), Testability \(c_3\) (failure detection rate \(c_{31}\), failure isolation rate \(c_{32}\), false alarm rate \(c_{33}\), alarm leakage rate \(c_{34}\)), Supportability \(c_4\) (mission success rate \(c_{41}\), operational readiness rate \(c_{42}\), average logistics delay time \(c_{43}\)), Safety \(c_5\) (loss of efficiency \(c_{51}\), possibility of disaster and accident \(c_{52}\)), Environmental Adaptability \(c_6\) (satisfaction degree of climate environment adaptation \(c_{61}\), satisfaction degree of mechanical environment adaptation \(c_{62}\), satisfaction degree of electromagnetic environment adaptation \(c_{63}\)). The final index values of six “properties” for equipment are shown as follows:

Table 1. Values of six “properties” for 4 types of equipment.

| Index | T1   | T2   | T3   | T4   |
|-------|------|------|------|------|
| \(c_{11}\) | 0.98 | 0.95 | 0.97 | 0.94 |
| \(c_{12}\) | 66   | 48   | 67   | 47   |
| \(c_{13}\) | 0.93 | 0.90 | 0.94 | 0.88 |
| \(c_{21}\) | 8    | 14   | 11   | 16   |
| \(c_{22}\) | 0.99 | 0.98 | 0.95 | 0.94 |
| \(c_{23}\) | 18   | 22   | 21   | 26   |
| \(c_{24}\) | 0.95 | 0.94 | 0.90 | 0.88 |
| \(c_{31}\) | 0.05 | 0.09 | 0.04 | 0.11 |
| \(c_{32}\) | 0.02 | 0.03 | 0.01 | 0.05 |
| \(c_{33}\) | 0.05 | 0.07 | 0.04 | 0.09 |
| \(c_{34}\) | 0.15 | 0.14 | 0.18 | 0.12 |
| \(c_{41}\) | 0.99 | 0.95 | 0.98 | 0.93 |
| \(c_{42}\) | 0.9958 | 0.9869 | 0.9951 | 0.9801 |
| \(c_{43}\) | 8    | 6    | 5    | 4    |
| \(c_{51}\) | 0.0152 | 0.0208 | 0.0149 | 0.0213 |
| \(c_{52}\) | 0.04 | 0.06 | 0.03 | 0.07 |
| \(c_{61}\) | 0.98 | 0.94 | 0.96 | 0.92 |
| \(c_{62}\) | 0.9952 | 0.9941 | 0.9943 | 0.9932 |
| \(c_{63}\) | 0.9986 | 0.9923 | 0.9983 | 0.9955 |

Firstly, normalize the decision matrix, and the normalized results are seen as Table 2.

Table 2. Normalized values of six “properties” for 4 types of equipment.

| Index | T1   | T2   | T3   | T4   |
|-------|------|------|------|------|
| \(c_{11}\) | 0.0000 | 0.7500 | 0.2500 | 1.0000 |
| \(c_{12}\) | 0.9500 | 0.0500 | 1.0000 | 0.0000 |
| \(c_{13}\) | 0.1667 | 0.6667 | 0.0000 | 1.0000 |
| \(c_{21}\) | 1.0000 | 0.2500 | 0.6250 | 0.0000 |
| \(c_{22}\) | 0.0000 | 0.2000 | 0.8000 | 1.0000 |
| \(c_{23}\) | 0.0000 | 0.5000 | 0.3750 | 1.0000 |
| \(c_{24}\) | 0.0000 | 0.1429 | 0.7143 | 1.0000 |
| \(c_{31}\) | 0.8571 | 0.2857 | 1.0000 | 0.0000 |
| \(c_{32}\) | 0.7500 | 0.5000 | 1.0000 | 0.0000 |
| \(c_{33}\) | 0.2000 | 0.6000 | 0.0000 | 1.0000 |
| \(c_{34}\) | 0.5000 | 0.3333 | 1.0000 | 0.0000 |
Secondly, we compute interaction coefficient based on definition 1, then:

Table 3. The table of interaction coefficient.

| Interaction | $I_{12,13}$ | $I_{11,21}$ | $I_{24,21}$ | $I_{31,21}$ | $I_{32,21}$ | $I_{33,21}$ | $I_{34,11}$ |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Values      | 0.0213      | -0.1011     | -0.0934     | -0.1123     | -0.1021     | -0.1238     | -0.1208     |

Thirdly, compute group utility and individual regret and $Q$ based on the procedure of VIKOR. The weights of the indexes could be obtained by entropy method, which are 0.0499, 0.0720, 0.0495, 0.0452, 0.0537, 0.0407, 0.0526, 0.0543, 0.0499, 0.0459, 0.0630, 0.0495, 0.0561, 0.0420, 0.0708, 0.0630, 0.0454, 0.0423, 0.0541 based on Step 3 to Step 5, which can be described as Table four.

Table 4. The table of VIKOR parameter value considering index relevance.

| Product | Group utility | Individual regret | Q       |
|---------|---------------|--------------------|---------|
| T1      | 0.4409        | 0.1128             | 0.4019  |
| T2      | 0.5172        | 0.0646             | 0.1042  |
| T3      | 0.4897        | 0.0907             | 0.2839  |
| T4      | 0.8075        | 0.1246             | 1.0000  |

If we don’t consider the relevance among six indexes, the parameter value can be seen as:

Table 5. The table of VIKOR parameter value without considering index relevance.

| Product | Group utility | Individual regret | Q       |
|---------|---------------|--------------------|---------|
| T1      | 0.3076        | 0.0684             | 0.2353  |
| T2      | 0.5190        | 0.0652             | 0.3123  |
| T3      | 0.4337        | 0.0720             | 0.6863  |
| T4      | 0.6461        | 0.0708             | 0.9118  |

The results calculated in Table 4 and table 5 show that final evaluation results have changed under the environment of considering index correlation and without considering correlation for the same type of equipment products. In the case of index correlation, the value of T2 is the lowest, and the orders are expressed as T2, T3 and T1. Without considering the correlation of indicators, the order is T1, T2 and T3. The results of compromise solutions are consistent under two conditions.

Based on the illustrative results, the correlation of index will affect the decision results, the correlative degree among decision index will lead to different compromise solutions. The above case study shows the order of alternatives had been changed with correlative indexes, thus, we should consider and analyze the effect of relativeness of indexes on the results, where it is very difficult to clarify the effectual mechanic with different interaction coefficient.

6. Conclusion
The comprehensive evaluation of six “properties” is an important critical issue in the field of equipment quality evaluation, and also related to how to implement effective methods of quality control for improving the level of six “properties”. In this paper, we fully consider the correlation among six “properties”, and analyze their impact on the comprehensive evaluation results, and then
give the steps of index correlation evaluation based on VIKOR method. According to the evaluation results, we can reasonably reflect their impact on the final decision alternatives, which provides a solid theoretical guidance for improving the level of six “properties”.

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