Study on Protective Effect of Different Kinds of Labor Protection Products in Power Supply Enterprises

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Abstract. Scientific and reasonable use of labor protection equipment can not only eliminate the economic loss of accidents, but also improve the efficiency of workers, and even improve the economic benefits of power supply enterprises. The evaluation of the protective effect of labor protective articles can provide reference for the equipment of labor protective articles. In this paper, starting from personal protection, a whole set of protective effect evaluation system is established from the aspects of protective ability, abrasion resistance and tear resistance, comfort and others according to the requirements of power supply protection, and then conduct empirical analysis to discuss the different protective effects of different types of protective articles. The results showed that protective clothing C and E with the best protective effect not only had higher anti-seepage and anti-penetration ability, but also had anti-static and anti-radiation ability, the protective effect of which is 36.9% than that of the worst one. Anti-seepage and anti-penetration ability can be used as the primary selection standard of protective clothing. When selecting protective products, if the economic conditions permit, choose a higher-priced protective product, and the protection effect is better. If there are special protection needs, such as protection shoes against cold or high temperature, you can choose protective products with special protective properties according to your needs. The results obtained can be used as a reference for different post protection products.

1. Introduction
With the rapid development of China's economy, people's demand and dependence on electricity have increased accordingly. Electric power industry is not only the basic industry related to the national economy and people's livelihood, but also the most important basic energy industry in the development of China's national economy. According to the statistics from the national energy administration, China's total electricity consumption was 6.8449 trillion kWh in 2018, up 8.5% year on year and up 1.9% from the same period last year. While contributing to economic growth, the safety and health problems of power generation enterprises or power supply enterprises have also received extensive attention. Power generation enterprises have attracted more attention due to their more serious occupational hazards.
However, employees in power supply enterprises may be exposed to a variety of occupational hazards, such as noise, extreme temperature, dust, ultraviolet radiation, etc., which constantly threaten the health of employees. In the process of production activities of power supply enterprises, the use of labor protection equipment plays a very important role in ensuring the health and safety of relevant employees. Scientific and reasonable use of labor protection equipment, not only can prevent the economic loss of accidents, but also can improve the work efficiency of workers, and improve the economic benefits of power supply enterprises. The protective effect of labor protection articles is the key premise to provide security. The evaluation of the protective effect of labor protection articles can provide reference for the provision of labor protection articles. The standards for the administration of labor protection articles of the employing units issued in 2015 stipulates that the employing units shall provide laborers with labor protection articles that meet the national standards, and the protective performance of imported labor protection articles shall not be lower than the relevant standards of China [1].In the regulations on the allocation of labor protection articles issued and implemented in 2017, labor protection articles are divided into nine categories according to the protective parts, and the configuration standard of labor protection articles for power supply enterprises is explained in detail in appendix B [2]. With the enhancement of the protection consciousness and the improvement of the protection standard, more and more attention has been paid to the protection effect of labor protection articles in the process of practical activities.

2. Construction of a protective effect evaluation system for labor protection products

2.1. Evaluation index system of protection effect

Considering the types of outdoor work and protection needs of operators in power supply enterprises, from the perspective of human protection, labor protection products mainly include protective clothing, protective masks, protective gloves and protective shoes. Therefore, this paper establishes an evaluation system for the protective effect of a complete set of human protection equipment. For the protection requirements of labor protection products of power supply enterprises, referring to Protective clothing—Performance requirements of chemical protective clothing (GB124539-2009) [3], Test methods for mechanical properties of protective clothing, puncture resistance and dynamic tearing of materials [4], Protective gloves for working in the hot environment (FZ / T 73040-2010) [5] and other standards, this paper establishes an evaluation system for the protection effect of protective equipment from the aspects of protection ability, wear resistance, tear resistance, comfort, etc., and builds an index system for the protection effect of different types of labor protection products for power supply enterprises. As shown in Figure 1.

In the evaluation index system (a) of the protective effect of protective clothing, in reference to the standards such as Protective clothing—Performance requirements of chemical protective clothing (GB124539-2009) [3], Static protective clothing (GB12014-2009) [6] and other standards, permeability (a11), pressure resistance penetration (a12), liquid repellency (a13), hydrostatic pressure resistance (a14), splash liquid tightness (a15), spray liquid tightness (a16) and solid particle penetration resistance (a17) are selected as the indexes of permeability and penetration resistance (a1). Abrasion resistance (a21), flexural damage resistance (a22), puncture resistance (a23), tear strength (a24) and breaking strength (a25) are selected as the indexes of wear resistance and tear resistance (a2). Dustproof efficiency (a31), dust amount (a32), shielding efficiency (a33) and charged charge amount (a34) are selected as the indicators of anti-static capability (a3). The anti-microwave radiation (a41) is selected as the anti-radiation capability index (a4). High temperature resistance (a51), low temperature resistance (a52) and material (a53) are selected as the comfort level indicators (a5).
2.2. Method for evaluating protective effect of labor protection products

In the index system for the evaluation of the protective effect of labor protection products, the data corresponding to each index is multiplied by its weight. The evaluation effect of the obtained labor protection articles is in formula (1). We use the score as the basis for judgment, and make a comparative analysis from the perspective of different criteria layers. This article discusses the different protective effects of different types of protective equipment, and then determines the overall and protective effects classified by protection category. The results obtained from this can be used as a reference basis for protective equipment in different positions.

\[ S_j = \sum_{i=1}^{n} a_{ij} \times W_i \]  

Among them, \( S_j \) represent the score of the \( j \)th labor protection article (\( j = A, B, C \)). The higher the score, the better the protection effect. \( a_{ij} \) represent the value corresponding to each index. \( W_i \) represent the weight of the \( i \) index calculated by the analytic hierarchy process.

3. Case study

Take 6 common protective suits on the market as examples, represented by A, B, C, D, E, F. We score the parameters of different types of protective clothing according to the above method, and then calculate the comprehensive score of various protective clothing, as shown in Table 1. According to the evaluation results, among the 6 types of protective clothing, the comprehensive protective effect of category C and E protective clothing is the best, the comprehensive protective effect of category A and F protective clothing is second, and the comprehensive protective effect of category B and D protective clothing is relatively worst. Among them, the difference between the best comprehensive protection effect and the worst is 36.9%. In the criterion layer, the scores of the corresponding indicators included in the impermeability and penetration resistance and wear and tear resistance are quite different. All indicators in the comfort level are qualitative indicators, and there is no difference in the scores of the indicators. Since the indicators in the anti-static capability cannot obtain specific data, they can only determine whether each protective clothing has anti-static capability. In the actual evaluation process, each quantitative index is classified as a qualitative index.
Table 1. Evaluation of protective effect of different types of protective clothing.

| Objective | Criterion | Index                      | Weight | A | B | C | D | E | F |
|-----------|-----------|----------------------------|--------|---|---|---|---|---|---|
|           |           | permeability and penetration resistance $a_1$ |        |   |   |   |   |   |
|           |           | permeability $a_{11}$ | 0.109  | 6 | 2 | 6 | 3 | 6 | 3 |
|           |           | pressure resistance penetration $a_{12}$ | 0.014  | 6 | 3 | 6 | 4 | 6 | 4 |
|           |           | liquid repellency $a_{13}$ | 0.049  | 3 | 3 | 3 | 3 | 3 | 3 |
|           |           | hydrostatic pressure resistance $a_{14}$ | 0.010  | 2 | 2 | 3 | 2 | 3 | 3 |
|           |           | splash liquid tightness $a_{15}$ | 0.032  | 1 | 1 | 1 | 1 | 1 | 1 |
|           |           | spray liquid tightness $a_{16}$ | 0.021  | 1 | 1 | 1 | 1 | 1 | 1 |
|           |           | Solid particle penetration resistance $a_{17}$ | 0.075  | 1 | 1 | 1 | 1 | 1 | 1 |
|           |           | wear resistance and tear resistance $a_2$ |        |   |   |   |   |   |
|           |           | abrasion resistance $a_{21}$ | 0.022  | 3 | 3 | 6 | 6 | 2 | 3 |
|           |           | flexural damage resistance $a_{22}$ | 0.036  | 6 | 4 | 4 | 2 | 4 | 4 |
|           |           | puncture resistance $a_{23}$ | 0.074  | 2 | 2 | 1 | 2 | 1 | 2 |
|           |           | tear strength $a_{24}$ | 0.085  | 4 | 3 | 3 | 6 | 4 | 6 |
|           |           | breaking strength $a_{25}$ | 0.074  | 3 | 5 | 3 | 4 | 3 | 6 |
|           |           | anti-static capability $a_3$ |        |   |   |   |   |   |
|           |           | dustproof efficiency $a_{31}$ | 0.064  | 0 | 0 | 1 | 0 | 1 | 0 |
|           |           | dust amount $a_{32}$ | 0.091  | 0 | 0 | 1 | 0 | 1 | 0 |
|           |           | shielding efficiency $a_{33}$ | 0.019  | 0 | 0 | 1 | 0 | 1 | 0 |
|           |           | charged charge amount $a_{34}$ | 0.026  | 0 | 0 | 1 | 0 | 1 | 0 |
|           |           | anti-radiation capability $a_4$ |        |   |   |   |   |   |
|           |           | anti-microwave radiation $a_{41}$ | 0.080  | 0 | 0 | 1 | 0 | 1 | 0 |
|           |           | comfort level $a_5$ |        |   |   |   |   |   |
|           |           | high temperature resistance $a_{51}$ | 0.030  | 1 | 1 | 1 | 1 | 1 | 1 |
|           |           | low temperature resistance $a_{52}$ | 0.030  | 1 | 1 | 1 | 1 | 1 | 1 |
|           |           | material $a_{53}$ | 0.060  | 1 | 1 | 1 | 1 | 1 | 1 |

The evaluation scores of various types of protective clothing in terms of impermeability, penetration resistance, wear resistance, tear resistance, antistatic ability, radiation protection ability and comfort level are shown in Figure 3. Class C and E protective clothing not only has high anti-seepage and anti-penetrating ability, but also has anti-static ability and anti-radiation ability, so its comprehensive evaluation and protection effect is the best. Although Class A protective clothing has high impermeability and penetration resistance, and Class F protective clothing has high wear resistance and tear resistance, but because they do not have anti-static and radiation protection capabilities, the comprehensive evaluation of the protection effect is weaker than Class C and E. The protective clothing of class B and D is strong in wear resistance and tear resistance, but weak in anti-seepage and anti-penetrating, and is not protected against radiation and static electricity, so the comprehensive protection effect is poor. From this, it can be seen that the protective clothing's anti-seepage and anti-penetrating ability has an important influence on its comprehensive protective effect.
4. Conclusion
Based on personal protection, according to the requirements of power supply protection, this paper establishes the protective effect evaluation system for the whole set of labor protection articles in power supply enterprises from the aspects of protection ability, wear resistance and tear resistance, comfort and so on, and makes empirical analysis to discuss the different protection effects of different kinds of protection articles. The empirical analysis shows that the protective clothing with the best comprehensive protective effect not only has strong anti-seepage and anti-penetrating ability and wear resistance, but also has anti-static ability and anti-radiation ability that other types of protective clothing do not have. In the selection of protective articles, when economic conditions permit, choose higher-priced protective articles, and their protective effect is better. If you have special protection needs, such as protective shoes that require cold or high temperature protection, you can choose protective products with special protective properties according to your needs. This result can provide a basis for the selection of labor protection articles for different positions in power supply enterprises. It should be noted that in the process of data collection, it was found that some inspection reports of some commodities are incomplete, and there are no anti-static related parameter tests for power supply companies, which will be discussed in depth in future research.

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[5] FZ/T 73040-2010 High temperature and high heat operation protective gloves.
[6] GB 12014-2009 Anti-static working suit.