Evaluation and Improvement of the Intrinsic Safety Level of Employees

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Abstract. Intrinsic safety is the eternal pursuit of power companies. The intrinsic safety level of front-line employees of technical skills posts is the basic guarantee for the security and stability operation of power systems. In order to help power companies scientifically evaluate and effectively improve the intrinsic safety level of employees, a quantifiable evaluation model is created. Combining with the sample to give a verification process, the validity of the model is confirmed. It shows that this model can be adjust to be much greater targeting for different types of jobs of grid companies and the evaluation efficiency is improved while ensuring the accuracy of the evaluation. In practical applications, the evaluation results have many uses such as providing reference for talent-post matching. This paper also designed a training system that matches the evaluation model, which can provide employees with targeted learning basing on their own weak links and quickly improve the intrinsic safety level.

1. Introduction
The term intrinsic safety stems from the explosion-proof design of electrical equipment. Its implication is: without attaching any safety device, only using the design of its own structure to limit the voltage or current of the circuit itself to prevent the occurrence of overheating, arcing or sparking, causing fire or explosion of dangerous gas, the safety and reliability of the equipment are guaranteed fundamentally. Therefore, the concept of intrinsic safety is given[1]. The intrinsic safety mentioned now generally refers to the safe, reliable and harmonious unity of people, things, systems and other elements in the production process of the enterprise, so that all kinds of harmful factors are always under control, and then gradually approach the safety goal of essential and permanent[2].

Relative to the elements of matter, institutions, system, etc., the intrinsic safety of human beings is in a pre-requisite, basic and guiding position. As early as 1996, there were articles pointing out that even if enterprises have invested heavily in technology and economy, they have achieved intrinsic safety in terms of machines, equipment and devices. If there is not a group of high-quality people, it may not be able to make technical equipment and other aspects of the advantages of the formation of real essential security.[3]. So, how to evaluate whether an employee is intrinsically safe? How to continuously improve its intrinsic safety level?

In order to answer these questions, this paper first created an evaluation model to comprehensively assess the intrinsic safety level of employees. Then the evaluation results are fed back to the training unit to provide a reference for safe production. Then a training system matching the evaluation model is designed for employees to learn according to their weaknesses. This process will enable enterprises and employees to better understand and grasp the human factors in safety production.
2. Model Design
There are also many literatures at home and abroad that have studied the employee safety capability models[4-5]. Through the research and analysis of related literature, evaluation index primary selection and expert scoring method selection, according to the specific, measurable, achievable, relevant, time-based five criteria, a model of employees' essential level is determined finally. The model has a tree structure and includes four major items: physical fitness, cognitive ability, safety knowledge, and safe operation. Each major item contains several sub-items, a total of 21 indicators, as shown in Figure 1.

![Student essential safety level assessment model](image)

**Figure 1.** Employee essential safety level assessment model

Each indicator in the model is designed with mature data collection methods and specific acquisition content. Among them, the data collection methods can be divided into six types, namely human resources information system, physical fitness test, psychological assessment, questionnaire survey, theoretical exam and practical exam, as shown in Table 1.

| No. | Model index           | Data source           | Required tools         |
|-----|-----------------------|-----------------------|------------------------|
| 1   | Gender                | HR information system | No                     |
| 2   | Age                   | HR information system | No                     |
| 3   | Visual                | Fitness test          | Visual acuity chart    |
| 4   | Sports ability        | Fitness test          | Mobile application     |
| 5   | Health status         | Questionnaire survey  | Health evaluation form |
| 6   | Observation           | Psychology assessment | Observation ability    |
| 7   | Attention             | Psychology assessment | Schulte grid           |
| 8   | Memory                | Psychology assessment | Wechsler test          |
| 9   | Thinking ability      | Psychology assessment | Wechsler test          |
| 10  | Emotional stability   | Psychology assessment | Emotional stability    |
| 11  | Pressure tolerance    | Psychology assessment | Stress test (PSTR)     |
| 12  | Electric safety working procedure | Theoretical examination | No                     |
| No. | Rules and regulations for production | Theoretical examination | No |
|-----|------------------------------------|-------------------------|----|
| 14  | Standardized work flow            | Theoretical examination | No |
| 15  | Professional emergency plan       | Theoretical examination | No |
| 16  | Knowledge of accident emergency and escape | Theoretical examination | No |
| 17  | Fill in the safety measure card    | Practical operation     | Practical training |
| 18  | Implementation and restoration of safety measures | Practical operation | Practical training |
| 19  | Job specification                 | Practical operation     | Practical training |
| 20  | Use safety tools                  | Practical operation     | Practical training |
| 21  | Emergency rescue skills           | Practical operation     | Practical training |

Among them, the content of psychological assessment adopts mature and professional psychological scale. The content of theory test and practice test is strengthened and improved on the basis of the previous training test content based on the requirements of safety technology and skills of different positions.

3. Model correction and simplification

3.1. Sample collection

In this paper, the participants of the 2017 intensive training course for new employees of power regulation major were taken as samples to collect relevant data. Among them, questionnaire survey and psychological assessment were carried out uniformly, including rule explanation and assessment, and the time was 30-40 min. The physical fitness test was carried out by the mobile application KEEP, which took 10 minutes per person. Theoretical examination and practical operation examination shall be conducted in accordance with the process and duration of normal training examination, and the assessment of emergency rescue skills shall be added in the practical operation examination. 118 valid samples were collected.

Because of the different ways of data collection and the different dimensions of each index, the data needs to be dimensionless first. Except for gender and age, all indexes were positively correlated functions, which basically accorded with normal distribution. The normalized descriptive statistics are shown in table 2. Assuming that X is the original value, $X'$ is the mean value and S is the standard deviation, then the value of the processed index is $X_c = (X - X')/S$.

| Model index               | Minimum | Maximum | Mean  | Standard deviation |
|---------------------------|---------|---------|-------|--------------------|
| Gender                    | 0.50    | 1.34    | 0.82  | 0.265              |
| Age                       | 59      | 91      | 75.68 | 8.646              |
| Visual                    | 69      | 99      | 87.10 | 9.782              |
| Sports ability            | 70      | 95      | 82.58 | 7.775              |
| Health status             | 62      | 96      | 74.00 | 6.923              |
| Observation               | 60      | 99      | 83.19 | 10.916             |
| Attention                 | 61      | 97      | 75.90 | 11.324             |
| Memory                    | 62      | 89      | 76.81 | 5.764              |

*Table 2. Descriptive statistics of each indicator*
Thinking ability 60 97 78.74 8.226
Emotional stability 75 100 89.81 7.931
Pressure tolerance 70 100 86.13 8.713
Electric safety working procedure 64 91 83.00 7.183
Rules and regulations for production 60 100 82.77 13.251
Standardized work flow 61 100 84.42 10.282
Professional emergency plan 61 90 76.03 9.304
Knowledge of accident emergency and escape 60 84 69.77 6.805
Fill in the safety measure card 63 90 83.65 6.849
Implementation and restoration of safety measures 71 91 80.00 5.538
Job specification 60 92 76.0 9.973
Use safety tools 0.5 0 1.34 0.82 0.265
Emergency rescue skills 59 91 75.68 8.646

3.2. Data analysis

In this paper, SPSS (a series of software products launched by IBM for statistical analysis, data mining, predictive analysis, decision support tasks and related services [13]) is used for data processing and analysis.

When designing the evaluation model, the characteristics of the entire power enterprise technical skill operation are comprehensively considered. When specific to a certain position, there must be some cases where the impact of some indicators is large, and some indicators have less impact. According to the data sample of this paper, the mean difference method and principal component analysis method are adopted to explore several indicators that have the greatest impact on the regulation major. Based on the original evaluation model, an intrinsic safety level assessment model for the regulation major is obtained to improve the efficiency of the assessment.

Firstly, the mean difference method is used to screen the indicators. Take 25% of the highest score and 25% the lowest as the high and low scores, and find out the average difference between the two groups of students in each project, and exclude the projects that do not reach the significant level. Finally, three indicators of vision, sports ability and health status were eliminated.

Then use principal component analysis for exploratory analysis. Principal component analysis is a multivariate statistical method that uses the idea of dimension reduction to convert multiple indicators into several comprehensive indicators under the premise of losing little information. Usually, the comprehensive index generated by transformation is called the principal component, and each principal component is a linear combination of the original variables, and each principal component is unrelated to each other, which makes the principal component have some superiority to the original variable. performance[14]. Before principal component analysis, the KMO and Bartlett spherical test should be passed [15]. In this case the KMO test is 0.69, the reliability is good, and the Bartlett spherical test is significant at 0.001, indicating that it is suitable for principal component analysis.

Correlation analysis of the indicators, the analysis results are shown in Table 3 (the original table is a 16 * 16 matrix, this paper only extracts the part for explanation). The greater the absolute value of the correlation coefficient, the closer the relationship between the two indicators is [4].

| Table 3. Correlation coefficient matrix (partial) |
|-----------------------------------------------|
| Model index       | Attention | Memory | Thinking ability |
| Attention         | 1.000     | 0.186  | 0.091            |
| Memory            | 0.586     | 1.000  | 0.436            |
Thinking ability & 0.791 & 0.436 & 1.000 \\
Emotional stability & -0.165 & 0.198 & 0.058 \\
Electric safety working procedure & 0.631 & 0.703 & 0.454 \\
Rules and regulations for production & 0.397 & 0.704 & 0.325 \\
Standardized work flow & 0.433 & 0.653 & 0.451 \\

The principal component analysis with varimax rotation was used to analyse the factor structure of the intrinsic safety assessment model. According to the lithotriptic diagram, it is reasonable to extract the three factors, and the cumulative variance contribution rate of the three factors is 74.882%. The component load matrix is shown in Table 4. 1, 2, and 3 represent the first, second, and third principal components respectively.

Table 4. Component load matrix

| Model index | 1      | 2     | 3      |
|-------------|--------|-------|--------|
| Observation | 0.815  | -0.387 | -0.308 |
| Attention   | 0.421  | -0.283 | 0.123  |
| Memory      | 0.683  | 0.383  | 0.078  |
| Thinking ability | 0.642  | 0.353  | 0.190  |
| Emotional stability | 0.783  | 0.465  | 0.266  |
| Pressure tolerance | 0.818  | 0.141  | 0.609  |
| Electric safety working procedure | -0.279  | 0.094  | -0.087 |
| Rules and regulations for production | -0.075  | 0.926  | 0.416  |
| Standardized work flow | 0.714  | 0.824  | 0.303  |
| Professional emergency plan | 0.005  | -0.671 | 0.297  |
| Knowledge of accident emergency and escape | 0.082  | 0.849  | 0.534  |
| Fill in the safety measure card | 0.227  | -0.170 | 0.839  |
| Implementation and restoration of safety measures | -0.394  | 0.111  | 0.799  |
| Job specification | 0.391  | -0.364 | 0.979  |
| Use safety tools | 0.094  | 0.452  | 0.835  |
| Emergency rescue skills | -0.312  | 0.544  | 0.659  |

3.3. Model calibration
According to the results of principal component analysis, the first common factor has a large load value on the three variables of observation, emotional stability and pressure tolerance, which belongs to the cognitive ability. The second common factor has a large load on the three variables of rules and regulations for production, standardized work flow and knowledge of accident emergency and escape, which belongs to the safety knowledge. The third common factor has a large load value in the four variables of filling in the safety measure card, implementation and restoration of safety measures, job specification and using safety tools, which belongs to the large item of safe operation.

After calculating each factor score of the total sample and the composite principal component scores, the results of the simple correlation analysis of the variables showed that there is a moderate correlation between the three large items, and the correlation is significant. It indicates that the three major items have good internal consistency, which are mutually connected and differentiated. It reflects the intrinsic safety level of employees from different aspects, and the model has good structural validity.

Finally, a targeted intrinsic safety level assessment model for the regulation major is obtained, as shown in Figure 2. Compared with the original model, the model is more simplified and more targeted, which improves the feasibility and convenience of evaluation implementation.
It is worth noting that the employees in this sample are all aged between 22 and 28, and males account for 72%, and their physical quality is above good level. The regulation major is for indoor light physical work, and the requirements for sports ability are relatively low. Therefore, in the data results, the physical fitness index is not reflected. However, for other majors, especially those related to ascending operations, outdoor line inspections, equipment maintenance and other types of work, the importance of physical fitness will be greatly enhanced. Therefore, it is necessary for us to collect enough samples according to the job responsibilities requirements of different majors for different age groups. To correct the indicators and weights of the original model, so that each type of work has its own personalized intrinsic safety assessment model.

4. model application

4.1. Data value
Once the assessment is carried out and a certain number of samples are accumulated, the data will become an important resource for training and production, creating multiple values.

Firstly, the intrinsic safety level data of employees can be researched and analyzed through clustering, decision tree and other algorithms to mine data values and guide the improvement of training content.

Second, after the end of each training period, the intrinsic safety assessment results of the employees will be fed back to the training unit in time, which can be used as the basis for work safety management, selection and evaluation.

Third, it can be summarized and ranked according to the intrinsic safety indicators of employees according to their own units, and fed back to the higher-level units and local city companies, so that the units can make up for the gaps and learn from each other.

4.2. Course System
According to the evaluation model designed in this paper, a comprehensive series of courses can be developed to form a menu-style training system, as shown in Figure 3. Employees do not need to attend all courses. They can learn selectively according to their own assessment results and strengthen their weaknesses, so as to rapidly improve their intrinsic safety level in a short period of time.

Figure 2. Intrinsic safety level assessment model for regulation major

![Student essential safety level assessment simplified model for regulation major](image)
Course Structure

- Physical improvement course
  - Physical education course
    - Healthy living guidance
    - Observation training
    - Attention training
    - Memory method training
    - Thinking training
    - Imagination training
    - Emotion management course
    - Stress management course
    - Electric safety working procedure
    - Rules and regulations for production
    - Standardized job flow
    - Professional emergency plan
    - Accident emergency and escape
    - Fill in the safety measure card
    - Standardized workflow training
    - Safety tools using
    - First aid and self-rescue
    - Special emergency drill
- Cognitive improvement course
- Emotion management course
- Safety production knowledge course
- Safe operation skills course

Figure 3. Employee Intrinsic Safety Level Enhancement Course System

As a training center, it should assume the functions of a data center. Record the evaluation results and learning experiences of each employee, and present them in the form of curves or reports, so as to clearly show the growth track of the intrinsic safety level for each employee. Finally forms a benign closed-loop of ‘evaluation-feedback-promotion-re-evaluation’ of the intrinsic safety level of employees.

5. conclusion

Based on safety, starting from the point of view of people and using data as a tool, this paper scientifically quantifies the safety production capacity of employees, and achieves timely feedback and effective improvement.

The development of artificial intelligence calls for more return to humanity and attention to human nature. In the entire safety work, the intrinsic safety of people will become more and more important. Therefore, the research of this paper has a very broad prospect.

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