Research on the Evaluation Method of the Health State of Transmission Tower

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Abstract. Due to long-term environmental effects such as wind, rain and sun, the transmission tower components are easy to bend and corrode, which poses hidden dangers to the safe operation of transmission lines. For the problem of complex and poor practicability of evaluation methods of tower state, a practical method for evaluating the health state of transmission towers is proposed to meet the actual needs in this paper.

1. Introduction
Due to long-term environmental effects such as wind, rain and sun, the transmission tower components are easy to bend and corrode, which poses hidden dangers to the safe operation of transmission lines. Therefore, it is necessary to grasp the health status of transmission towers in time, which requires the study on the health status evaluation methods of transmission towers to guide the operation and maintenance of old transmission towers. Hidden dangers will be discovered in time, and effective maintenance measures can be formulated to protect the power grid[1]. By the overall ultimate bearing capacity of the structure, Yao analyzed the reliability of the tower structure[2]. Xia proposed a method of evaluating the safety state of the tower structure based on the analytic hierarchy process[3]. Zou proposed an evaluation method for the operation status of transmission lines based on variable weight comprehensive theory and fuzzy comprehensive evaluation method[4]. In recent years, power system equipment has developed towards intelligence[5], but these evaluation methods are too complicated and not very practical, which are not conducive to the actual operation of grassroots personnel. In response to this problem, a practical method for evaluating the health state of transmission towers is proposed to meet the actual needs in this paper.

2. Design of Evaluation for Tower Health Status

2.1. Definition of state quantity
The state quantity is a general term of various technical indicators, test data and operating conditions that reflect the status of the transmission tower. The following provisions are made as follows.

1. According to the degree of influence of the state quantity on the safety of the tower, there are four levels from light to heavy. The corresponding weights are weight 1, weight 2, weight 3, and weight 4, and the coefficients are 1, 2, 3, and 4 respectively. Weight 1 and weight 2 correspond to general state quantities, and weight 3 and weight 4 correspond to important state quantities.

2. According to the degree of deterioration of the state quantity, it is divided into four levels from light to heavy, namely I, II, III, and IV, and the corresponding basic deduction points are 2, 4, 8, and 10 points.
③ The deduction value of the state quantity is equal to the basic deduction value of the state quantity multiplied by the weight coefficient (see the following table), and no deduction will be made when the state quantity is normal.

| Deterioration | Basic deduction value | weight 1 | weight 2 | weight 3 | weight 4 |
|---------------|-----------------------|----------|----------|----------|----------|
| I             | 2                     | 2        | 4        | 6        | 8        |
| II            | 4                     | 4        | 8        | 12       | 16       |
| III           | 8                     | 8        | 16       | 24       | 32       |
| IV            | 10                    | 10       | 20       | 30       | 40       |

2.2. Deduction standard of State quantity
The deduction standard of state quantity is shown in the table below.

| State quantity                  | Weight coefficient | State degree | Deduction standard                                                                 | Basic deduction | Total deductions |
|---------------------------------|--------------------|--------------|-------------------------------------------------------------------------------------|-----------------|-----------------|
| Tower tilt                      | 4                  | IV           | The inclination of ordinary iron tower is ≥20‰, and the inclination of iron tower  | 10              | 40              |
|                                 |                    | III          | The inclination of ordinary iron tower is 15‰~20‰, and the inclination of iron      | 8               | 32              |
|                                 |                    | II           | The inclination of ordinary iron tower is 10‰~15‰, and the inclination of iron      | 4               | 16              |
| Bending of main material        | 4                  | IV           | The bending of the main material is greater than 7‰.                                | 10              | 40              |
|                                 |                    | III          | The bending of the main material is 5‰~7‰.                                        | 8               | 32              |
|                                 |                    | II           | The bending of the main material is 2‰~5‰.                                        | 4               | 16              |
| Skew situation of cross arm     | 4                  | IV           | Skewness is greater than 10‰.                                                      | 10              | 40              |
|                                 |                    | III          | Skewness is 5‰~10‰.                                                               | 8               | 32              |
|                                 |                    | II           | Skewness is 1‰~5‰.                                                                | 4               | 16              |
| Missing and loose components    | 4                  | IV           | Lack of a large number of small angles and bolts or many gusset plates. Bolts are   | 10              | 40              |
|                                 |                    | III          | Lack of lots of small angles and bolts or few gusset plates. Bolts are loose by     | 8               | 32              |
|                                 |                    | II           | A small amount of small angle steel and bolts are missing, and the bolts are loose  | 4               | 16              |
2.3. Definition of tower operating status and evaluation criteria

The operating status of the tower is divided into four levels: normal condition, normal condition, normal condition and serious condition. The condition definition is shown in Table 3, and the evaluation criteria is shown in Table 4.

### Table 3. Definition of Tower operating status

| Tower status | Definition |
|--------------|------------|
| normal condition | It means that each state quantity of the tower is stable and within the warning value and attention value (hereinafter referred to as the standard limit) stipulated in the regulations, and it can operate normally. |
| normal condition | It means that some state variables of the tower are developing towards the standard limit, but the standard limit is not exceeded. The operation can still be continued, and the monitoring during operation should be strengthened. |
| normal condition | It means that some important state quantities of the iron tower are close to or slightly exceed the standard value, and the operation should be monitored and maintenance should be arranged in a timely manner. |
| serious condition | It means that there are some lines of the tower that have seriously exceeded the standard value, and it is necessary to arrange power outage maintenance as soon as possible. |

### Table 4. The evaluation standard of tower condition

| Tower status | normal condition | normal condition | normal condition | serious condition |
|--------------|------------------|------------------|------------------|------------------|
| Single deduction | ≤10 | 12~14 | 30~32 | ≥40 |

3. Conclusion

Due to long-term environmental effects such as wind, rain and sun, the transmission tower components are easy to bend and corrode, which poses hidden dangers to the safe operation of transmission lines. For the problem of complex and poor practicability of evaluation methods of tower state, a practical method for evaluating the health state of transmission towers is proposed to meet the actual needs in this paper.

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