Study on the Construction of Safety Management System of Chinese Electric Power Enterprises Based on Systematic Thinking

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Abstract. In order to clarify the construction process and content of Safety Management System (SMS) and deepen the systematic construction of safety management of power enterprises in China, the paper analyses the current problems of SMS construction of domestic electric power enterprises. A construction method of SMS for China’s electric enterprises is proposed based on systematic thinking and system modelling method. Taking State Grid Corporation of China (SGCC) as an example, the construction model of SMS is designed based on the Hall three dimensions structure model. According to China's national regulations and power industry safety management requirements, as well as practical experience of SGCC, ten core elements of the system were screened. The SMS operation cycle of Leadership-Responsibility-Plan-Do-Check-Act (LRPDCA) was designed based on the concept of Plan-Do-Check-Act (PDCA) and the characteristics of China's power safety management. The results have some guidance significance to continually promote safety management capacity of electric power enterprise in the new era.

1. Introduction

With the continuous enrichment and development of safety management theory, enterprises safety management methods have gone through three development stages [1-2]: experience management based on post-accident control, institutionalized management based on passive compliance, and systematic management based on risk management. Since China implemented the reform and opening-up policy, profound changes of safety management have taken place in the various industries, including power industry. The leap from experience management to institutionalized management has been achieved, and it is currently in the practical stage of the transition from institutionalized management to systematic management. The construction of safety management system (SMS) is a key method to realize corporation systematic management, and it plays an important role in improving corporate safety performance [3].

The power industry is a basic industry of the national economy, and power safety is related to the overall development of the country and the daily life of the people. Therefore, the construction of SMS for power corporations is of great significance for meeting the safety requirements of the national security strategies, adapting to the trend of internationalization and globalization, and enhancing the competitiveness and viability of power corporations. However, the emergence and development of the SMS is rooted in the proactive safety management model of foreign factories and companies [3].
According to practical experience, the international occupational health and safety system standards do not fit in well with the actual situation of safety management in Chinese corporations, which can easily lead to the separation of system construction and actual operation [4-5]. In addition, the rapid development of China's power industry has put forward new management challenges and safety requirements for power corporations. How to combine the advanced safety management concepts of international standards with the safety management experience of China’s power industry to build a suitable SMS for the power corporations in China is an important problem that needs to be studied and resolved at present.

In this paper, we introduced the development in the research of SMS of Chinese corporations mainly including two fields: the development of China’s national standards and specific practice of power corporations. On the basis of analysing the existing problems in the construction of the SMS of Chinese power corporations, this article explores the construction path of the safety management system, and takes the State Grid Corporation of China as an example to clarify the key content of the construction of the SMS in domestic power corporations based on system thinking, and provide reference for the construction of SMSs in other domestic power companies.

2. Current status of SMS construction in Chinese power corporations

2.1. The development history of SMS standards in China

The research on SMS of China began in 1996[3]. In order to enter the international market, the oil and gas industry took the lead in the preparation of SMS standards in 1997, which laid an important foundation for the compilation of SMS standards in other domestic industries, including power industry. In 2001, China issued GB/T 28000 series of standards (OHSAS18000, IDT) and was updated in 2011. Since SMS and SMS standards are derived from the safety management practices of foreign companies, the promotion and implementation effects in most Chinese enterprises are not ideal. Therefore, China began to take safety standardization as the transition of SMSs construction. The safety industry standard that named Basic norms for work safety standardization of enterprises (AQ/T 9006-2010) was officially released in 2010[6]. Since then, China has begun to promote the construction of safety standardization, and has issued corresponding standards in the power industry, such as Basic norms for work safety standardization and Rating standard of power-generated enterprises in 2014[8], etc. On the basis of summarizing practical experience in various industries, China has issued the recommended national standard that named Basic norms for China occupational safety and health management system (GB/T33000-2016) and implemented on April 1, 2017[9]. In 2020, China has issued GB/T45001-2020 (ISO45001:2018, IDT) which has replaced GB/T28000 and became the latest national standard of the SMSs[10].

2.2. Practice of safety management system construction in Chinese power corporations

Since China issued the GB/T28000 series of standards in 2001, some Chinese enterprises has begun to explore the construction of a SMS suitable for their own safety management reality. As a result, some Chinese electric power companies have joined with university research teams or third-party consulting companies to carry out research on the construction of power safety management systems. These studies mainly draw on foreign advanced safety management concepts and methods, such as occupational health and safety management systems (OHSAS) [11], safety, health and environment management systems of National Occupational Safety Association (NOSA) [12], safety management systems based on intrinsic safety theory [13] or risk management theory [14]. Take three large Chinese power corporations as examples:

2.2.1. China Southern Power Grid. In 2003, China Southern Power Grid has started the research on the construction of a SMS based on the CAP diamond management system framework of Enrico International Risk Management Co., Ltd. in South Africa, and combined the traditional methods of
safety management in Chinese power industry in 2017, on the basis of summarizing many years of practical experience of the system operation and absorbing advanced safety management concepts at home and abroad, China Southern Power Grid re-issued “safety production risk management system” which is in need of solving new problems in power safety management [15-16].

2.2.2. China Huaneng Group CO., Ltd. In 2006, China Huaneng Group Co., Ltd. (Huaneng) began to research on the construction of its own SMS. On the one hand, Huaneng absorbed the advanced concepts and methods of SMSs, and learned from the successful practices of SMSs in power industry. On the other hand, China’s national laws and policies is considered in the period of designing for the SMS. In 2009, Huaneng published “Requirements of safety production management system in Huaneng power plant” (Q/HB-G-08.L01-2009) which focus on the safety, health and environment, production processes and emergency management[17]. Since then, continuous improvement in pilot applications of the safety production management system is still one of the key work tasks of Huaneng. In July 2019, Huaneng completed the renewal of its own SMS through the safety production management system research and practice project.

2.2.3. China Datang corporation Ltd. Driven by its own development strategy in 2011, China Datang corporation Ltd. (Datang) released "Specification of the intrinsically safety management system in power generation corporation" (Q/CDT 101 0002-2011) and other series of standards and management methods [18], which is based on Datang’s production safety management concepts and methods at the time, and combined with domestic safety production standardization documents and occupational safety and health management system standards. The relevant standards and methods were revised and improved twice in 2014 and 2016 to further highlight the concept of risk management and control enhances the practicality of element management processes and methods.

2.3. Problems in the construction of safety management system for Chinese power corporations

Through analysis of the practical experience of domestic power companies, it is found that the problems existing in the construction of the SMS in Chinese power companies are mainly reflected in the following aspects:

One is the lack of safety culture and leadership. Chinese power enterprises used to rely on government supervision and comply with national laws. The main driving force for the construction of the SMS mostly comes from meeting the requirements national or industry regulators, as well the enterprise strategy to avoid being at a competitive disadvantage. Companies rely heavily on government and industry supervision, and meet relevant policy requirements as the primary safety management goals. Work safety tends to be passive compliance rather than active control, and a safety atmosphere of full participation and independent management has not been formed.

Another one is the lack of practical foundation. The insufficient system awareness of company employees will result in insufficient execution of the SMS construction. Considering that the construction of SMSs in Chinese corporation started with compliance certification, most national standards of SMSs are equivalent to translating international standards directly. It is difficult to integrate system standard models with actual work content. Especially at the beginning of the SMS construction, some leaders and employees have insufficient knowledge of the “system”, their mindset of system management is solidified - it is believed that SMS is a simply pieced together from a number of management modules - they unilaterally equated the SMS with the sum of a series of safety management documents, resulting in a disconnect between SMS construction and work operations, and failed to achieve systematic management and dynamic improvement.

Therefore, the primary task of the research in Chinese power enterprises’ SMSs is to extract a scientific construction path. On the basis of modern safety management theories, the purpose and significance of establishing the SMS for power enterprises should be clarified.
3. The path and method of the safety management system construction in Chinese power corporations

By analysing the construction process of the SMS in three Chinese power corporations (China Southern Power Grid, China Huaneng Group CO., Ltd., and China Datang corporation Ltd.) [15-18], the general construction path of the SMS in Chinese power companies is summarized.

3.1. The First Step: Theoretical and practical research

The construction of the SMSs for Chinese power enterprises should be based on the correct epistemology and modern safety management theories. Risk management should be regarded as the core of safety management, and the ability of leadership and the importance of safety culture should be emphasized. The construction of the SMSs also needs to demonstrate the requirements SMS standards at home and abroad. On the one hand, it draws on the practice of some advanced enterprises, and on the other hand, it retains the effective safety management methods that have been proven through years of practice, such as the power safety assurance system and supervision system, power anti-accident measures, etc. This phase helps to clarify the cognition of SMSs and framework content of the SMSs.

3.2. The Second Step: System analysis and modeling

The safety management of power enterprises is a complex system, so the construction of SMSs as a system engineering needs to be based on system thinking [19] to comprehensively analyse the enterprise’ safety management situation, and clarify the design ideas of the SMS. According to system modelling methods [19-20], such as the Hall three-dimensional structure model, all aspects involved in the work safety management of power enterprises are analysed from multiple dimensions, and the construction model of SMS for power enterprises is designed.

3.3. The Third Step: System elements determining

On the basis of system analysis and modelling, and the elements setting in national standards and power industry requirements, and the safety management objects and methods of the power corporation, the key elements of the SMS and the relationships between these elements are clarified through screening, comparison, and classification.

3.4. The Last Step: System operating model determining

Considering the key tasks of work safety management in Chinese power enterprises, such as safety leadership and safety culture construction, the system operation model is optimized based on the traditional Deming management model (Plan-Do-Check-Act, PDCA), which pays more attention to the driving force of leadership and responsibility.

4. An example of safety management system construction in a Chinese power corporation

Based on the above SMS construction path, taking the State Grid Corporation of China as an example, the key content of the construction of a safety management system for power enterprises based on system thinking is explained.

4.1. Design Principles of the Safety Management System in the State Grid Corporation of China

1) Paying attention to the theoretical guidance. Considering the complexity of the SMS, system analysis and modeling should be based on system thinking, and apply modern safety management theories with taking risk management as the core content and intrinsic safety as the management goal.

2) Learning from practical experience. In order to ensure that the construction of the system follows the development trend of SMSs with advanced concepts and scientific methods, system construction needs to learn from the form and content of the international SMS standards and the practical experience of some power enterprises.
3) Serving the corporation’s development strategy. The main purpose of the system construction is to transform the State Grid Corporation of China’s safety vision into specific management actions by strengthening leadership and safety culture construction, and perfecting performance evaluation of employees at all levels of the company.

4) Highlighting the characteristics of the safety management in power grid companies. The construction of the SMS should combine the corporation’s management reality, and focus on the full-process risk management of the four major safety subjects of personnel safety, power grid safety, equipment safety, and information safety, and realize the function of safety supervision and guarantee systems.

5) Adhering to the systematic design. The construction of the SMS should comprehensively cover all departments and positions in State Grid Corporation of China in order to realize the safety control by all-staff and whole-process.

4.2. System Analysis and Modeling
Combining modern safety management theory, national laws and regulations, the advanced practice of SMSs at home and abroad, and the current status of the State Grid Corporation of China’s safety management, the system analysis should be carried out from three dimensions of management objectives, methods and processes. Based on the Hall three-dimensional structure model of system engineering, the construction model of the national grid safety management system is constructed, as shown in Figure 1.

From the perspective of system analysis, the State Grid Corporation of China’s safety management is divided into three levels: headquarters, provincial and municipal company, and power supply station. The objects of safety management mainly involve four types of personnel safety, power grid safety, equipment safety and information safety. The safety management method of 3P strategy (Prevention-Pacification-Precetion) [20] is adopted to realize the whole process control. All elements involved in various management objects should follow the management process of ”Plan-Do-check-Act” to achieve the closed-loop management and continuous improvement of the system.

4.3. Determination of the System Elements
Based on the key elements of the SMSs standards, power industry safety standardized regulations, and the system analysis of the safety management in State Grid Corporation of China, the element
A comparison analysis method [21] is used to screen and classify the system elements, and finally determine the key elements of the SMS for the State Grid Corporation of China, as shown in Table 1.

Table 1. The elements of the safety management system for State Grid corporation of China.

| The Primary Elements | The Secondary Elements |
|----------------------|------------------------|
| Policy               | Policy                 |
| Goal                 | Goal                   |
| Concept              | Concept                |
| Commitment           | Commitment             |
| Work Safety Committee| Work Safety Committee  |
| Assurance Agency     | Assurance Agency       |
| Guarantee Agency     | Guarantee Agency       |
| Supervision Agency   | Supervision Agency     |
| Responsibility Mechanisms | Responsibility List   |
| Regulations          | Regulations            |
| Technical Standards  | Technical Standards    |
| Site Procedures      | Site Procedures        |
| Risk Management      | Risk Management        |
| Hidden Danger Control| Hidden Danger Control  |
| Emergency Management | Emergency Management   |
| Accident Management  | Accident Management    |
| Development Planning | Development Planning   |
| Engineering Construction | Engineering Construction |
| Power Grid Operation | Power Grid Operation   |
| Assurance System     | Assurance System       |
| Power Operation and Inspection | Power Operation and Inspection |
| Power Supply Service | Power Supply Service   |
| Network Information  | Network Information    |
| Management of Related Parties | Management of Related Parties |
| Site Implementation  | Site Implementation    |
| Human Resources      | Human Resources        |
| Safety Expenses      | Safety Expenses        |
| Guarantee System     | Guarantee System       |
| Material Management  | Material Management    |
| Technological Support| Technological Support  |
| Traffic and Fire Protection | Traffic and Fire Protection |
| Safety Inspection    | Safety Inspection      |
| Other Routine Work   | Other Routine Work     |
| Performance Evaluation | Performance Evaluation |
| Rewards and Punishments | Rewards and Punishments |
| Continuous Improvement | Continuous Improvement |
4.4. Design of the System Operation Model

According to theoretical research, leadership and the implementation of safety responsibilities play an important role in corporation’s safety management. Considering the integration of international concepts and practical methods for power corporations’ safety management, the operation model of the SMS is optimized based on the typical PDCA management cycle. A safety management process is divided into six stages: Leadership-Responsibility-Plan-Do-Check-Act, as shown in Figure 2.

![Figure 2. Operational model of Safety Management System for State Grid Corporation of China.](image)

5. Conclusion

1) The construction of SMS is an important way to promote the systematization of enterprise safety management and the modernization of safety management capabilities. However, the construction of safety management system of electric power enterprises in China is still in its infancy. Completely compliance with policy guidance, excessive reliance on government supervision, weak leadership and weak execution, lack of system awareness and practice fundamental are the current problems in system construction.

2) This paper summarizes a path for the construction of a SMS that is applicable to most Chinese power companies. Taking the State Grid Corporation of China as an example, the safety management system construction model is designed based on system thinking and the Hall model, which provides useful guidance for system construction.

3) The operation model of SMS is optimized to the Leadership-Responsibility-Plan-Do-Check-Act (LRPDCA) which not only integrates advanced safety management concepts and methods, but also conforms to the Chinese safety management environment. The proposal of the new operation model has a reference significance for the practice in the construction of the SMS for other industries in China.

4) The determination of the elements of the SGSMS integrates the requirements of national and power industry standards, and in combination with the actual work situation of the corporation itself. However, the screening and classification of system elements have some objective limitations which needs to be further verified in pilot applications.
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