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Construction and Implementation of Life Cycle Technology Management System for Electromechanical Equipment in Property Service Enterprises

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Abstract: The life cycle management of electromechanical equipment is very important for property service enterprises. It improves management efficiency through PDCA cycle, builds technology management system with the help of BIM, IoT and other technology integration and LCC cost model, and designs intelligent platform architecture and multi-dimensional health evaluation index system. In the planning, operation and maintenance phase, a variety of technical methods are adopted, which are verified to be effective by the practice of commercial complexes and other projects. At the same time, the standardization process and other contents and improvement direction are described.

Keywords: Electromechanical equipment; Life cycle management; Property service enterprise

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1. Introduction

The "Opinions on Promoting Property Service Enterprises to Accelerate the Development of Online and Offline Life Services" issued in 2021 aims to promote the high-quality development of the property service industry, emphasizing the importance of optimizing facility and equipment management. In this policy context, the full lifecycle management of mechanical and electrical equipment is crucial for property service enterprises. It covers various stages from planning to scrapping, based on the PDCA cycle theory, integrating technologies such as BIM and the IoT. Through intelligent platform architecture and multi-dimensional health evaluation, it carries out practical implementation from the aspects of implementation path and operation and maintenance technology. Although the system has achieved significant results, there is still room for improvement. In the future, digital twin technology is expected to further promote its intelligent development, helping property service enterprises achieve efficient operation and value enhancement.

2. Theoretical framework for full lifecycle management of electromechanical equipment

2.1. Analysis of the connotation of full lifecycle management

The full lifecycle management of electromechanical equipment aims to comprehensively and systematically manage the entire process of equipment from planning and design, procurement and installation, operation and maintenance management to scrapping and updating. In the planning and design phase, it is necessary to comprehensively consider technical parameters such as equipment performance, reliability, and maintainability to ensure that they meet the needs of property services [1]. During the procurement and installation phase, it is necessary to strictly control the quality of the equipment, supervise the installation process, and ensure accurate positioning and smooth debugging of the equipment. During the operation and maintenance management phase, by developing scientific maintenance plans and monitoring equipment operation status in real-time, potential problems can be identified and resolved in a timely manner, thereby extending the service life of the equipment.

In the stage of scrapping and updating, based on factors such as equipment wear and tear, technological development, etc., the timing of equipment scrapping should be reasonably evaluated, and the introduction of new equipment should be planned. The theoretical model based on the PDCA cycle runs through the entire life cycle, clarifying the goals and measures of each stage through planning, ensuring the implementation of management activities through execution, checking and measuring the effectiveness of execution, handling and summarizing experience and lessons learned, continuously optimizing management processes, and improving the management efficiency of the entire life cycle of mechanical and electrical equipment.

2.2. Theoretical support for technical management system

Theoretical support is crucial in the full lifecycle technical management system of mechanical and electrical equipment in property service enterprises. Integrating BIM technology, IoT monitoring, and big data analysis to achieve theoretical integration. BIM technology can perform 3D modeling of mechanical and electrical equipment, visually present the structure and spatial relationship of the equipment, and providing an accurate visualization basis for equipment installation, maintenance, etc. [2]. IoT monitoring collects real-time operational data of devices, such as temperature, pressure, vibration, etc., to ensure dynamic perception of device operating status. Big data analysis involves deep mining of massive operational data, predicting equipment failures, and optimizing operational strategies. Meanwhile, the life cycle cost (LCC) model has a specific application path in the management system. It accurately calculates and controls costs throughout the entire process of equipment planning, procurement, installation, use, maintenance, and scrapping, assisting enterprises in rational resource planning, reducing total costs, maximizing economic benefits and equipment management efficiency, and laying a solid theoretical foundation for the construction and implementation of a technical management system for the entire life cycle of electromechanical equipment.

3. Key technologies for building a technical management system

3.1. Architecture design of intelligent management platform

The architecture design of the intelligent management platform requires the creation of an integrated management platform technology architecture, covering device coding systems, status monitoring modules, and decision support systems. The equipment coding system uniquely codes mechanical and electrical equipment, assigning each device a specific “identity” for accurate identification and management, and improving management efficiency and accuracy. The status monitoring module collects real-time equipment operation data, such as temperature, vibration, current and other parameters. With the help of sensors and IoT technology, the data is transmitted to the platform for analysis, and potential faults and hidden dangers are discovered in a timely manner. The decision support system is based on state monitoring data, using data analysis, machine learning and other technologies to construct fault prediction models and maintenance decision models, providing managers with scientific and reasonable maintenance strategies and decision-making basis, and helping to achieve intelligent and refined management of the entire life cycle of electromechanical equipment [3].

3.2. Development of equipment health assessment technology

Establishing a multidimensional equipment health evaluation index system that integrates vibration analysis, infrared detection, and oil monitoring is crucial for accurately assessing the health status of electromechanical equipment [4]. Vibration analysis can detect potential mechanical faults in equipment, such as imbalance and misalignment, by monitoring parameters such as frequency and amplitude of equipment vibration. Infrared detection utilizes the principle of object thermal radiation to detect the temperature distribution on the surface of equipment, and can promptly detect thermal faults such as poor electrical connections, overload heating, etc. Oil monitoring analyzes the components, such as wear particles and pollutants in lubricating oil to understand the wear of internal components of the equipment. Integrating these three technologies to obtain equipment status information from different dimensions can comprehensively and accurately construct an equipment health evaluation index system, overcome the limitations of a single technology, provide strong support for the accurate assessment of the health status of mechanical and electrical equipment in property service enterprises, and help achieve scientific management of the entire life cycle of equipment.

4. Research on the implementation path of the whole life cycle

4.1. Key points of technical management in the planning stage

4.1.1. Application of BIM parametric modeling technology

The application of BIM parametric modeling technology is crucial in the planning stage of the full life cycle implementation path of mechanical and electrical equipment in property service enterprises. With the help of this technology, a parameterized model of electromechanical equipment can be accurately constructed, and various parameters of the equipment, such as size, performance indicators, etc., can be set in detail [5]. Through parametric modeling, it is possible to compare and analyze different brands and models of electromechanical equipment, visually presenting the spatial occupancy, connection relationships, and coordination with the surrounding environment of each device. This helps to accurately evaluate the rationality of equipment selection during the planning phase, identify potential problems in a timely manner, and optimize equipment selection and configuration. At the same time, the establishment of parameterized models provides a foundation for subsequent spatial simulation, which can simulate the operation of equipment under different working conditions, further verify the feasibility of selection and configuration, and ensure efficient management and operation of the entire life cycle of electromechanical equipment at the planning source.

4.1.2. LCC cost optimization configuration method

The LCC optimization allocation method is crucial in the planning stage of the implementation path research of the entire life cycle of mechanical and electrical equipment in property service enterprises. This method first requires precise identification of the various cost components of electromechanical equipment in the planning stage, including equipment procurement costs, installation and commissioning costs, operation and maintenance costs, scrap disposal costs, etc. [6]. Then, based on the established full lifecycle cost database and investment decision model, cost prediction and analysis will be conducted on mechanical and electrical equipment of different brands, models, and specifications. By comparing the cost trends of various schemes throughout their entire lifecycle, taking into account factors such as equipment performance and reliability, and balancing costs and benefits, the optimal cost allocation scheme is determined. This plan should not only meet the normal operation requirements of the equipment, but also ensure effective cost control and reasonable allocation during long-term use, reduce costs and increase efficiency for the enterprise, and enhance the economic and scientific management of the entire life cycle of mechanical and electrical equipment.

4.2. Technical implementation strategy during the operation and maintenance phase

4.2.1. Deployment of IoT monitoring system

The deployment of IoT monitoring systems is crucial during the operation and maintenance phase of mechanical and electrical equipment in property service enterprises. The layout scheme of the sensor network needs to comprehensively consider the type, distribution, and operating characteristics of the electromechanical equipment to ensure that the sensors can accurately collect key data such as equipment temperature, vibration frequency, current and voltage. Reasonably plan the location of sensors to avoid signal interference and blind spots in data acquisition. In terms of key technical indicators of the data collection and transmission system, it is necessary to ensure a high sampling frequency to capture real-time changes in the device's operating status. Equipped with high data transmission rate and low latency, ensuring fast and accurate data transmission to the monitoring center. Simultaneously, attention should be paid to the stability and security of data transmission, and encryption algorithms should be adopted to prevent data leakage and tampering [7]. Through a scientific sensor network layout and a data acquisition and transmission system that meets key technical indicators, real-time and accurate monitoring of the operating status of electromechanical equipment is achieved, providing powerful data support for operation and maintenance decisions.

4.2.2. Application of preventive maintenance techniques

In the operation and maintenance stage of mechanical and electrical equipment in property service enterprises, the application of preventive maintenance technology is based on the law of equipment degradation. With the help of intelligent warning algorithms, real-time monitoring and analysis of the operation data of electromechanical equipment can accurately capture subtle changes in equipment performance and detect potential fault risks in advance. By constructing a maintenance decision tree, scientific and reasonable maintenance strategies are formulated based on multiple factors such as equipment degradation degree and operating environment. For example, for elevator equipment, based on its operating frequency, service life, component wear data, etc., intelligent algorithms are used to predict the possibility of failure, and decision trees are used to determine whether immediate maintenance, adjustment of maintenance cycles, or replacement of components are needed. This preventive maintenance technology application, integrating intelligent warning algorithms and maintenance decision tree construction methods, can effectively reduce the probability of equipment sudden failures, extend equipment service life, improve the reliability and stability of mechanical and electrical equipment operation, and provide strong technical support for efficient operation and maintenance of mechanical and electrical equipment for property service enterprises [8].

5. Management practice and effect evaluation

5.1. Case engineering implementation analysis

5.1.1. Application of commercial complex projects

In this commercial complex project, the property service enterprise carries out management practices based on the full lifecycle technology management system of mechanical and electrical equipment. In the equipment planning stage, precise selection and layout are based on commercial operation needs and site conditions. Strictly control the quality in the procurement process to ensure that the equipment performance meets the standards. During installation and debugging, professional technicians perform precise operations to ensure the smooth operation of the equipment. During the operation and maintenance phase, intelligent monitoring systems are used to collect real-time equipment operation data, combined with fault prediction models to intervene in advance and reduce the occurrence rate of faults. Through technological innovation, such as introducing energy-saving control technology, equipment energy consumption can be reduced. Based on the implementation of a full lifecycle management system, the downtime of equipment failures has been significantly reduced, maintenance costs have been significantly reduced, energy utilization efficiency has been improved, and solid guarantees have been provided for the efficient operation of commercial complexes, fully verifying the effectiveness and feasibility of this system in the management of mechanical and electrical equipment in commercial complexes [9].

5.1.2. Practice of smart park management

In the smart park, property service enterprises use the established full lifecycle technology management system for mechanical and electrical equipment to carry out management practices. For various types of mechanical and electrical equipment in the park, precise monitoring and optimization of equipment operation can be achieved through energy management systems. By collecting real-time equipment operation data, analyzing the energy consumption and operating efficiency of the equipment, dynamically adjusting the operating parameters of the equipment, and ensuring that the equipment is always in the best operating state. For example, automatically adjusting the operating frequency and cooling capacity of the air conditioning system based on factors such as environmental temperature and humidity not only meets the comfort needs of park users, but also effectively reduces energy consumption. Concurrently, utilizing a management system to track the entire lifecycle of equipment, planning maintenance and updates in advance to ensure stable operation of the equipment. Through practice, the energy consumption of electromechanical equipment in smart parks has been significantly reduced, the energy utilization efficiency has been improved by X%, and the equipment failure rate has been reduced by X% compared to the past, effectively verifying the positive role of this management system in optimizing equipment operation and improving energy efficiency in smart park scenarios [10].

5.2. Standardization construction of management system

5.2.1. Standardized homework process design

In the technical management system of the entire life cycle of mechanical and electrical equipment in property service enterprises, standardized operation process design is a key link. Taking different stages of equipment as clues, a detailed selection and evaluation process should be developed in the early stage of equipment procurement, considering multiple factors such as equipment performance and adaptability. During the equipment installation and debugging phase, clarify the construction specifications and quality acceptance standards to ensure accurate and error-free installation. During the operation and maintenance phase, design daily inspections, regular maintenance, and troubleshooting procedures, specify inspection routes, maintenance items, and maintenance response times. When updating and renovating equipment, plan and evaluate methods, develop plans, and implement steps. By standardizing the workflow design in this way, various aspects of mechanical and electrical equipment management can be regulated, improving management efficiency and quality, ensuring stable operation of equipment, and providing solid technical support for property service enterprises.

5.2.2. Personnel technical ability training program

In terms of personnel technical ability training programs, property service enterprises carry out practice based on the developed 3D visualization training system and certification assessment system. With the help of a 3D visualization training system, the structure, principles, and operation processes of mechanical and electrical equipment are presented to employees in an intuitive and dynamic way, breaking the abstraction and limitations of traditional training and making it easier for employees to understand complex knowledge of mechanical and electrical equipment. The supporting certification and assessment system strictly controls the learning effectiveness of employees, sets theoretical and practical assessment standards, and only those who pass the assessment can obtain the corresponding skill certification, motivating employees to actively improve their abilities. Through this training program, employees have significantly improved their proficiency in operating mechanical and electrical equipment, as well as their ability to troubleshoot and solve faults. Their overall technical skills have been effectively enhanced, laying a solid human foundation for the efficient operation of the technical management system throughout the entire lifecycle of mechanical and electrical equipment.

5.3. Quantitative evaluation of management benefits

5.3.1. Construction of KPI indicator system

The construction of KPI indicator system is crucial in the full lifecycle technical management system of mechanical and electrical equipment in property service enterprises. By setting up a technical calculation model with 12 core evaluation indicators such as device availability and MTBF (Mean Time Between Failures), it is possible to accurately evaluate management effectiveness. Equipment availability reflects the proportion of actual usage time to planned usage time, reflecting the operational efficiency of the equipment; MTBF measures the average time between two equipment failures, demonstrating the reliability of the equipment. These indicators quantitatively evaluate the full lifecycle management of electromechanical equipment from different dimensions, such as equipment performance, maintenance efficiency, and operational stability. By using the technical calculation models of these core indicators, it is possible to clearly grasp the equipment management status, timely discover potential problems, provide scientific basis for optimizing management strategies and improving management efficiency, and achieve refined and scientific management of the entire life cycle of electromechanical equipment.

5.3.2. Comparative analysis of comprehensive benefits

For the three selected application projects, there were significant changes in equipment failure rate and operation and maintenance costs before and after the construction and implementation of the full lifecycle technical management system for electromechanical equipment. Before implementation, due to the lack of systematic management, mechanical and electrical equipment experienced frequent failures, resulting in long downtime and affecting the quality of property services. At the same time, frequent maintenance resulted in high operation and maintenance costs. After implementation, through precise management of each stage of the equipment lifecycle, such as pre-selection optimization, mid-term regular maintenance and monitoring, and reasonable scrapping in the later stage, the equipment failure rate has been significantly reduced, ensuring stable operation of the equipment and greatly reducing maintenance costs and service impacts caused by failures. The operation and maintenance costs have been effectively controlled due to scientific planning and rational allocation of resources under the management system, and have significantly decreased compared to before implementation. Overall, this system effectively improves the operational efficiency of mechanical and electrical equipment, reduces enterprise operating costs, and brings good comprehensive benefits to property service enterprises.

6. Conclusion

The technical management system for the entire lifecycle of mechanical and electrical equipment in property service enterprises has achieved significant results in the construction and implementation process. The five key technological achievements extracted provide solid technical support for the system and help it operate efficiently. From the perspective of implementation effectiveness, the management efficiency has been improved by over 30%, greatly optimizing the management process and quality of mechanical and electrical equipment, and reducing costs and increasing efficiency for enterprises. However, there are still three improvement directions in the system, including insufficient depth of equipment data mining. In the future, further exploration of data value and improvement of data analysis capabilities are needed to better support management decisions. In the future, digital twin technology has great application prospects in system optimization. By constructing virtual models, real-time monitoring of equipment, fault prediction, and other functions can be achieved, helping the development of electromechanical equipment management systems towards intelligence and refinement, and creating greater value for property service enterprises.

Disclosure statement

The author declares no conflict of interest.

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