Design and Application of Temperature Monitoring System for Dangerous Goods Container Yard

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Abstract. Container shipping of dangerous goods can effectively reduce the damage rate of dangerous goods. However, due to the physical and chemical properties of dangerous goods, such as flammability, explosiveness, and corrosion, there are many safety matters that need to be paid attention to when the containers are stored in the yard, especially the temperature. In this paper, a temperature monitoring system (short for TEMP Monitoring System) is developed for the temperature monitoring needs of the dangerous goods container yard. The system is composed of a temperature sensing terminal, a repeater and a terminal processor, which can monitor the temperature of the yard container in real time and effectively improve the level of safety supervision.

1. Research background

At present, China's port dangerous goods containers adopt the centralized management mode, for example, ports generally have special storage yards, where dangerous goods containers are stored and transported in a centralized way. On the one hand, there is unified management, but on the other hand, it also causes greater security risks. The fire cause of the "8·12" fire and explosion accident in Tianjin Port was that the nitrocellulose wetting agent in the container was lost under the high temperature in summer, and the nitrocellulose spontaneous combustion caused the fire in the container. At the beginning of the accident, due to the lack of emergency disposal technology for dangerous goods, the rescue was disadvantageous, which led to more large-scale accidents and huge losses. The occurrence of the accident exposed the weakness of port dangerous goods container safety risk prevention and control technology. Therefore, it is urgent to carry out experimental research on port and dangerous goods accident prevention and emergency technology, improve the safety technology level of water transport industry, and contribute to the port safety development and safe traffic construction in China.

2. Current situation of temperature monitoring for dangerous goods containers

Due to the particularity of dangerous goods, in order to ensure the safety of storage, it is necessary to study and analyze the storage conditions of containers, and the temperature inside the container determines the storage conditions of dangerous goods. At present, the remote monitoring of container working status (mainly temperature) has become the consensus of port management at home and abroad. In order to strengthen the supervision of container temperature, China's port container terminal enterprises have adopted various methods, including manual copying, infrared temperature measurement and so on to strengthen the ability of container temperature monitoring. However, manual copying has some disadvantages, such as high cost, high labor intensity, low production efficiency and
poor monitoring quality. It not only has complicated management process and long monitoring cycle, but also has some problems, such as poor real-time performance and high security risks. Manual copying mode cannot meet the needs of container terminal enterprises for safety control. Infrared thermometer has the advantages of non-contact measurement, wide measurement range, no energy interference and energy loss, and it can measure high temperature and moving targets and so on, which brings new opportunities for port container temperature monitoring. Infrared temperature measurement passively accepts the infrared emitted by the object instead of adding an infrared source to the equipment, so it will not cause other damage and negative impact to the equipment in operation. However, its application is limited due to the shortcomings that infrared thermometer cannot overcome, such as being easily affected by environmental factors (environmental temperature, dust in the air, etc.), having great influence on the temperature reading of bright or polished metal surface, and being inconvenient to measure the temperature inside the object and existing obstacles, etc. Therefore, the design of an intelligent, high-precision contact temperature measurement device is an effective means to solve the current port container temperature monitoring intelligent management.

3. Design of temperature monitoring system for dangerous goods container

3.1. The Function of System
The temperature monitoring system of dangerous goods container yard adopts the way of contact wireless temperature measurement and wireless data transmission, which abandons the problems of high cost, complex circuit and aging of wiring data transmission. The system can carry out real-time monitoring, intelligent analysis, online monitoring of container temperature, and predict in advance when accidents and hidden dangers occur, effectively avoiding accidents. The system can meet the function of accurate and fast temperature measurement, and monitor of dangerous goods container temperature in 24-hour, all-weather and all environment mode, and operate on the same operating platform after the operating systems are seamlessly compatible.

3.2. The Advantage of the TEMP Monitoring System
(1) The software development process takes the compatibility of container yard supervision system as the basic framework. The system can retrieve, record and process the required information, including container storage location, container affiliated units, etc., which effectively makes up for the deficiency of container yard enterprises in the temperature monitoring of dangerous goods containers.

(2) All containers are equipped with separate temperature collection terminals, and the temperature monitoring of dangerous goods container yards is fully covered. Separate temperature alarms and emergency response plans are set up for all containers in the yard, and targeted safety equipment and facilities are set up according to the cargo types of operations, so that the dangerous goods container yard can prevent various accidents and risks.

(3) The display unit in the system has the functions of temperature warning, historical data storage and analysis. All system information has traceability and data information is reliable.

3.3. The Composition of System or system architecture
The temperature monitoring system of port dangerous goods container yard includes multiple groups of wireless temperature sensors (short for wireless TS), repeater and display system. Among them, the wireless temperature sensor is responsible for the collection of container temperature, the repeater is responsible for transmitting the received data to the computer and it consists of a wireless communication transmission module (short for WCRM) and a wireless communication receiving module (short for WCTM). The display system performs online analysis of the collected data and alarms when the threshold is exceeded. This system components are shown in Figure 1 and the installation structure of the temperature sensor is shown in Figure 2.
Figure 1 Composition of temperature monitoring system for dangerous goods container yard

Figure 2 Installation structure of temperature sensor

(1) Design criteria of temperature sensor
According to the working conditions of the site, the structure of the temperature sensor should meet the requirements of stable performance, anti-corrosion, rainproof and the service life should be more than 5 years, which can adapt to the working conditions of the port and withstand a certain degree of object impact.

(2) Material selection of structural parts
The working environment of the port is complex. High humidity and salinity have strict requirements on the material properties of structural parts. In order to improve the service life of structural parts, aluminum alloy oxidation treatment, sheet metal spray treatment or stainless-steel material are selected. Sheet metal material or stainless-steel material is selected due to the cost of aluminum alloy production is too high.

(3) Installation position of structural parts
The main structure of the container is composed of steel frame and maintenance plate which mainly includes the following constructions: longitudinal beam, cross beam, bottom beam, corner column, enclosure plate and corner piece \[7\]. In order to install on the basis without damaging the container structure and fully rely on the steel material characteristics of the existing container structure at the same time, a magnetic installation structure is adopted to adsorb the temperature sensor to the flat position of the container.

3.4. Monitoring process
The process of TEMP monitoring system of dangerous goods container yard is shown in Figure 3.
3.5. System operation mode

The wireless temperature sensor converts the container temperature of the tested equipment into digital signal through the built-in single chip microprocessor control and then transmits it to the wireless temperature measurement relay through the wireless transmitting and receiving module. The temperature measurement relay processes the collected temperature information through the microprocessor and then uploads it to a computer through the communication module. The software installed on the computer monitors the change of each point. The computer collects the operation temperature data of each monitoring point from the wireless communication receiving module and saves them in the database for a long time. The temperature change curve of the monitoring point is displayed and analyzed in real time. The alarm unit starts working immediately once the temperature is overheated or rises sharply to the set alarm temperature.

The sensors responsible for front-end temperature acquisition have set IP addresses which corresponding to the temperature sensor is input to the transmission relay and the transmission relay also has the corresponding setting password to ensure the uniqueness of information identification between the sensor and the relay. The data transmission between transmission relay and display system adopts Modbus communication protocol and protection measures, which has the uniqueness of information identification, are also adopted between them.

The operator installs the sensor recording to the location information of the container at the yard and binds the sensor number and the box location information in the display system to realize real-time monitoring of container temperature information.

4. Conclusion

Compared with the traditional manual recording and infrared temperature measurement, the temperature monitoring system of dangerous goods container yard has the advantages of all day, all-weather, precision and real-time, and the system has good accuracy, stability and reliability in the application process of data information collection, transmission, processing and display, which can meet the requirements of temperature monitoring of dangerous goods container yard. The system can effectively ensure the safety of dangerous goods container yard, play a better monitoring efficiency in related industries or fields and have the ability to comprehensively improve the technical requirements of dangerous goods in safety control, which has a broad application prospect at home and abroad.

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