Design of Underground Integrated Corridor Monitoring System in Yude Road, Liupanshui City

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Abstract: At present, there is limited experience in the construction of environmental monitoring system for urban underground integrated corridors. In order to meet the needs of corridor environment risk management, a comprehensive road condition management system of Liupanshui Yude road was designed. The system hardware system which combines the system workstation with the data transmission module is established, and a software system platform based on environmental monitoring, compression coding, encapsulation and wireless module is designed. A real-time monitoring system for environmental risk sources is established, which integrates environmental monitoring data, and provides a reference for the design of engineering environment and equipment monitoring system.

1. Project overview
Liupanshui Yude road underground pipe gallery project from south to Yude Road(K2+660), north to the Tianhu Road(K5+600), it is about 3000 meters long. Yude Road integrated pipe gallery is divided into three modules: the width of the power cabin is 2m, the width of the thermal water tank is 6.4m, the width of the natural gas tank is 1.4m, and the structure of each cabin is 2.9m high. The mainframe equipment of the environment and equipment monitoring system is placed in the 1# sub control center. The control equipment in each area is placed in the 1#~8# wind machine room. The regional control equipment in each wind machine room is responsible for the power supply, communication, control and other functions of the equipment in the wind machine room and the adjacent tube corridor (about 400 meters). Because of the many kinds of pipelines contained in the underground comprehensive pipe corridor, some pipelines are more dangerous, which can easily lead to electric shock, toxic or harmful or explosive gas leakage in the process of use, which further threaten the normal operation of the corridor. Therefore, setting up environment and equipment monitoring system in the underground pipe gallery of Yude Road is of great significance to prevent accidents.

2. Composition and characteristics of monitoring system of underground comprehensive pipe gallery

2.1 System composition
The environment and equipment monitoring system of the underground comprehensive tube gallery of Yude road consists of four subsystems: environmental monitoring, lighting control, equipment control and expansion interface[1]. The environmental monitoring subsystem includes methane monitoring, hydrogen sulfide monitoring, oxygen monitoring, temperature monitoring, humidity monitoring and water level monitoring unit. The device control subsystem is composed of ventilation monitoring, drainage pump unit and electrical equipment monitoring unit, as shown in Figure 1. The system
function depends on the equipment monitoring system workstation, the industrial Ethernet communication module, the field control unit, the intelligent sensor, the field equipment instrument and the field equipment feedback switch device[2].

![Figure 1. Environment and equipment monitoring system composition diagram](image)

### 2.2 System features

The environment and equipment monitoring system of the underground comprehensive tube gallery of Yude road can realize the simultaneous monitoring of the environment parameters and the operating conditions of the equipment in the tube corridor. The system has the following characteristics:

- Data collection and preservation are carried out through data acquisition system and implementation database [3]. Based on collecting and collating data information, simultaneous monitoring of the operation status of pipe corridors, and realizing safe operation models such as ventilation, ergonomics and working face are realized. At the same time, it integrates all kinds of data to provide analysis and decision support for all levels of management, technology, monitoring personnel and units. It mainly includes comprehensive monitoring, operation scheduling, safety management, data analysis and so on.

- Realize unified authority management of integrated pipe gallery monitoring system. A unified authority management module is developed, which includes functions such as coloring division, authority assignment and so on. Through the equipment monitoring system workstation system, different personnel have different configuration and authority, and the functional interface of the system is different according to their authority.

- Monitoring data collection, classification and long-term storage [4]. The data of environmental parameters and equipment failures involved in the operation of the gallery are collected, classified and stored for a long time, and the functions of simultaneous warning and alarm, input of basic parameter data and on-line monitoring and integration of system data are realized.

### 2.3 Functions of the monitoring system

The environment and equipment monitoring system of the underground comprehensive tube corridor of Yude road can monitor the environment, equipment and operation management in the process of the system, and realize the dangerous warning and safety management in the system operation [5][6]. The main function of the system is as follows:

- Simultaneous monitoring the temperature, humidity, water level, oxygen, H₂S, CH₄ and other environmental factors of the tube corridor through the on-site monitoring station and intelligent sensor, the management, identification, evaluation and control of the hazard sources can be realized so as to eliminate the unsafe factors of the environment.

- Through the field monitoring station and intelligent sensor, the real-time online perception, alarm linkage, remote control and command and dispatch are carried out for lighting equipment,
drainage equipment, ventilation equipment, high and low voltage distribution equipment and anti-intrusion equipment in the wind machine room, so that it is always in a safe state.

3. System hardware design
The underground pipe gallery of Yude road consists of three cabins, namely, power cabin, natural gas tank and thermal cabin. There are environmental monitoring field control unit, fan control box and lighting distribution box in Yude road 1#~8# fan room. CH₄ and H₂S parameters are monitored in the fan room. The O₂, temperature and humidity parameters of each module were monitored in the integrated Gallery, and the CH₄ parameters were monitored in the gas tank. The system has extensibility, and it can collect data from the professional monitoring system of pipelines in pipeline corridors, and control the executing agencies of pipelines when necessary. The system function relationship is shown in Figure 2.

![Functional relationship diagram of environment and equipment monitoring system](image)

Figure 2. Functional relationship diagram of environment and equipment monitoring system

3.1 Workstation design of environment and equipment monitoring system
The environment and equipment monitoring system workstation is located in the 1# sub control center. The workstation and the field control unit of the environmental monitoring system monitor the environment and equipment of the wind machine room in simultaneous through the data interaction of the Industrial Switch Ethernet. In addition, the workstation of the environmental monitoring system is used to display the simultaneous data transmission of the field control unit in the wind machine room, and print and transmit the data reports to the work general station and the server of the upper level equipment monitoring system. The field control unit of the environmental monitoring system is equipped in every wind machine room of the underground comprehensive tube gallery of Yude road. The field control unit is composed of the network switch and the field control unit workstation. The field control unit workstation is set up in the 1#~8# wind machine room. The field control unit of each fan room connects the environmental monitoring instruments within the 400m range, and can manage and control the electrical equipment in the area. The field control unit workstation can collect real-time monitoring data of CH₄, H₂S, O₂, temperature, humidity, water level and other sensors, and can control the corresponding equipment through the fan control box, the pump control box and the lighting distribution box. The function relation is shown in Figure 3.
The field control unit is a field control unit system for automatic control, parameter acquisition and network connection, including CPU module, power module, DI, DO, AI, AO module and network communication adapter etc. The main functions of the control station include: (1) Testing the working state and equipment status of the water pump and the fan. (2) According to the real-time detection value of oxygen and temperature and humidity in the fire area, the control of each fan is realized and the working state of the fan is detected. (3) To control the water pump according to the liquid level of the water pit. (4) The real-time monitoring of the parameters of oxygen, temperature and humidity, methane, hydrogen sulfide and liquid level in various fire zones. (5) The field controllable equipment can be transferred to the field control unit for automatic control besides the control of the locale box by the operator. The operation terminal is used as the in-situ man-machine interface. The operator can control the related equipment and modify the related parameters through the operation on the operation panel.

The remote I/O station mainly monitors the equipment and meters in the three adjacent fire compartments. The main equipment is a system for parameter acquisition and network connection, including power module, DI, DO, AI, AO module and network communication adapter.

3.2 Design of monitoring data transmission system

The monitoring data transmission system consists of 100M/1000M industrial switchboard, optical fiber and twisted pair cable. The field control unit uses the main CPU unit to connect the temperature and humidity, oxygen, methane, hydrogen sulfide and water level sensor through the RS485 bus, and collect the real-time data of the related environmental parameters to the equipment monitoring system workstation, which shows the real time status of the related environmental parameters on the equipment monitoring system workstation. In addition, after the equipment monitoring data is collected by the field control unit, the 1000M industrial switch is transmitted to the equipment monitoring system workstation, and then the control signal of a certain stage is set up according to the management authority, and the concrete control operation is carried out in the field control station. The porch monitoring data transmission system is shown in Figure 4.
4. System software design
The software design of the environment and equipment monitoring system for the underground comprehensive tube gallery of Yude road uses the Linux 2.6.1.2 kernel. The software platform is composed of environmental equipment monitoring, compression coding, packaging package, wireless transmission and so on[7]. The system has developed the client application program under the Windows platform. Remote users can access system data through application login system center service platform. The process of establishing a connection between the client and the server is shown in Figure 5.

![Figure 5. Flow diagram of client-server connection](image)

The software is extensible[8]. It can extend system capacity to enterprise level by increasing the number of current control unit and bus type I/O module unit, and extending system capacity does not affect existing service and function. The software platform uses a centralized centralized architecture, and all the relevant configuration data will be stored in the device monitoring system workstation. All other services and applications, such as the municipal external Internet access and the client, will read the corresponding configuration data from the central data server.

5 Conclusion
The environment and equipment monitoring system of Liupanshui city Yude road underground comprehensive tube corridor designed in this paper has realized the intelligent comprehensive management of the environment parameters, the running state of the equipment and the remote control in the operation of the tube corridor. At the same time, the hardware and software design of the system is provided, which provides a reference for the design of the environment and equipment monitoring system of the urban underground pipe gallery.

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