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Research on Integrated Protection Technology for Cable Channel Operation

Shishu Wu*, Meng Li, Zhaoyang Lu

State grid Qingdao Power Supply Company, Qingdao, 266002, PR China.
* Corresponding author

Abstract: The emergency protection requirements of cable channel operation involve all levels of the power grid system, including the power production and consumption system composed of power transformation, transmission, distribution and electricity consumption, as well as the installation, maintenance, inspection, inspection and painting operations of substations, converter stations and transmission lines. Due to the difficulty of perceiving the operation status of the power grid cable channel and the high rescue requirements, the emergency protection ability of the construction unit of the cable channel does not match and adapt to the actual situation, and the problems such as habitual violations of the on-site personnel still exist.

Keywords: Finite space; integration; protective equipment; heart dadt; monitor.

1. Introduction

The operation of power network cable channel is relatively narrow and limited, and the environment is complex. In recent years, the operation safety accidents of cable channel are frequent, and the death incidents caused by poisoning and asphyxiation occur one after another. New businesses and new formats led by interconnection, digitalization, informatization and intelligence are developing rapidly, and various cable channel operations are gradually increasing, but the protection and rescue of cable channel operations are difficult, and there are many risk factors. The number of various underground cables, underground cable channels and underground energy storage power stations is increasing year by year, and there are more and more cable channel operation scenarios. In recent years, cable channel operation safety accidents occur frequently, poisoning, suffocation deaths occur one after another, exposing the cable channel operation existing toxic gas monitoring early warning is not timely, the operator's physical condition monitoring is not in place, emergency rescue equipment is not complete, emergency rescue information is not smooth and other problems, it is urgent to strengthen the cable channel operation safety technology innovation, improve safety risk control ability[1,2].

At present, the security control methods for the cable channel operation site are mostly to work on the cable channel before operation according to relevant regulations and standards, manually ventilate the cable channel in advance, detect the gas concentration, strictly implement the "ventilation first, then detection, and later operation", set up the safety channel, safety warning line, safety signs, formulate the relevant operating standards for the cable channel, and prepare the safety measures for the cable channel. Improve the risk hierarchical control mechanism of cable channels, so as to achieve hard control of cable channels such as work sites, personnel and equipment.[3] At the same time, in order to implement relevant measures to ensure the safe and reliable operation of the work site, personnel and equipment, safety disclosure, submission of work tickets, monitoring, safety inspectors and other ways are organized to ensure the safe operation in the field cable channel.

2. Cable Channel Operation Status

According to preliminary statistics, since 2020, there have been 20 major accidents in cable channel operations across the country, killing 62 people. From the seasonal characteristics, entering the summer, the temperature in the cable passage increases, and the risk of poisoning and asphyxia accidents in the cable passage operation increases significantly. From the accident types and places, 17 of the 20 major accidents occurred since 2020 are poisoning and asphyxia accidents, resulting in a total of 53 deaths; There were 16 concentrated in sewage ponds, pumping Wells, basements and other types of cable channels, resulting in a total of 49 deaths.[4,5] From the perspective of industry, the major accidents since 2020 are mainly concentrated in the construction industry and the industry and trade industry, with the number of major accidents and the number of deaths in the two industries accounting for 80.0% and 79.0% of the total, respectively. In terms of casualties, improper rescue is the main cause of the expansion of casualties, since 2020, of the 20 major accidents, 11 were due to blind rescue and improper rescue measures, resulting in the expansion of casualties and upgrading to major accidents, resulting in a total of 34 deaths.[6]

2.1. Security control measures

Although physical and chemical factors such as flammable gas leakage, equipment damage and pipeline failure in cable channels often directly cause accidents, the specific analysis of specific accidents finds that there is no essential safety measures and strict organizational management are often the root cause of accidents, mainly including the following aspects:

No risk analysis is performed before maintenance operations or the risk analysis is not comprehensive enough to identify the risk of chemical reactions between incompatible substances and the risk of anaerobic fermentation of animal and plant waste, household garbage or sewage.

Operation supervision and monitoring is not timely, and facility guidelines or safety measures are not correct.

Lack of safe operating procedures, inappropriate protective

facilities, and no emergency evacuation plan.

Organizational problems related to hazardous equipment guidelines, inadequate work task planning, lack of appropriate tools and lack of understanding of the current situation of facilities can also lead to staff mistakes, which are prone to accidental leakage due to improper operation of valves, containers and other equipment [7].

To this end, the Ministry of Emergency Management of our country issued a document requiring that all regions should urge all kinds of enterprises to attach great importance to emergency management and safety production work, strengthen risk identification status and hidden danger investigation and management, urge all kinds of enterprises to seriously implement pre-job training, effectively improve the safety awareness and emergency knowledge of employees, and do a good job of personal emergency protection in cable channel operations as required.[8] On-site rescue must use detection instruments to continuously detect cable channels, and do a good job of self-breathing and self-rescue rope protection before rescue, and resolutely prevent blind rescue. Therefore, people must carry out risk analysis before cable channel operation, take monitoring, early warning and prevention and control measures, to prevent accidents or at least reduce the consequences of accidents is of great significance.[9]

2.2. Existing problem

At present, the vast majority of safety monitoring systems use wired signal transmission, that is, optical cable, power grid line or signal cable [10]. However, these traditional wired layout methods have the following problems:

The wiring is cumbersome. A large number of optical cables and cables required for installation and maintenance of large monitoring systems are expensive, and laying lines in complex underground environments also requires a lot of manpower and material resources.

Limited coverage. Due to the complex terrain environment, there are a large number of difficult areas in the work environment, wired monitoring system is difficult to spread across the various areas of work, can not achieve comprehensive monitoring, leaving hidden dangers for safety production.

Strong line dependence. The self-repair performance of the wired network is poor, and the damage of local lines is likely to paralyze the entire monitoring system.

All kinds of protective equipment such as ventilation, detection, oxygen supply, and safety rope require cumbersome operations by operators, and are easy to affect each other in a limited space.

In the event of sudden emergencies, on-site operators can not distinguish the situation in time, and blind rescue is easy to occur, resulting in the expansion of the scope of casualties.[11]

At present, the main protective measures for cable channels are:

I Strictly implement the working order of "ventilation first, then detection, and then operation".

II The harmful gas tester is placed in the appropriate position on the job site for real-time monitoring.

III Arrange special personnel at the wellhead to supervise the situation in the cable channel by Shouting at intervals.

2.3. Human protection unit

Firstly, the human health sensing and evaluation sensor structure module is designed and produced. The ergonomic human protection module, support structure module and link structure module are configured with different basic data and models, and optimized and integrated according to the characteristics of space, temperature and humidity, human tolerance, etc., so as to realize the integration of wearable technology and life-saving technology, and meet the ergonomic requirements.[12,13]

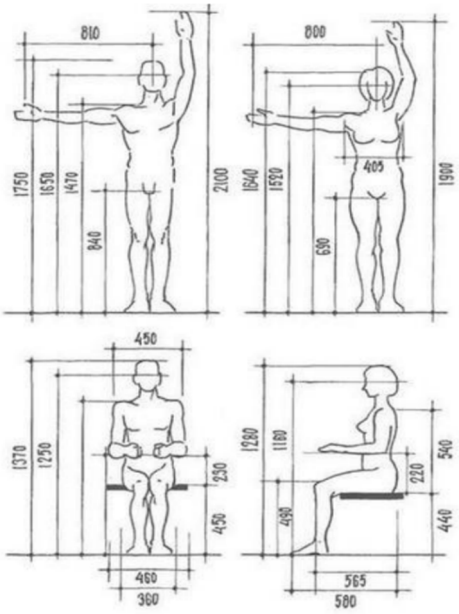


Figure 1. Ergonomic model of Safety protection.

As the cable channel environment is relatively complex, the requirements for data modeling and analysis mode are high, the solution is to carry out modeling analysis and optimization for different environments and human data, and carry out reasonable module design and processing, while considering the influence of multiple factors, and develop a data analysis model suitable for cable channel operations.[14]

3. Integration Technology Development Trend

Foreign research on cable channel security monitoring systems [15] began in the 1960s, such as SCADA system developed in the United States, MINOS system in the United Kingdom, CTT63/40/M system in France, TF200 system in Germany, and Sentrion system in Canada. What these systems have in common is that they are comprehensive monitoring systems, and the focus of monitoring is the safety of the environment, such as gas concentration, temperature, humidity, CO concentration and other factors. The earliest positioning system dates back to 1991 when an automatic monitoring system for underground mine scrapers was used at a South African company's mine [16]. The system, which transmits information to the host computer through infrared radiation and a leaky cable, is inflexible and expensive. In the mid-1990s, an Australian mining company developed a set of underground personnel monitoring system, which is based on radio frequency identification (RFID) technology, can monitor whether there are absenteeism into the restricted area, effectively ensuring the personal safety of staff. The system uses the beacon on the miner's safety hat and the antenna installed in the roadway to communicate, in order to achieve the purpose of monitoring the distribution of personnel.

The positioning deviation of this system is very large, and when more miners pass through the antenna at the same time, the situation of personnel missing detection is relatively serious, which makes the information received by the upper computer and the actual situation have a large error.

3.1. Cable channel operator status detection

Therefore, the research to ensure the safety of cable channel operators focuses on the risk assessment and monitoring and early warning of the operating environment [17,18], but this method has two drawbacks:

It ignores the difference of the critical value of individual physiological states in extreme environments;

When the working environment does not reach the critical value, the workers are exposed to low-intensity sustained injuries for a long time, resulting in chronic damage to physiological health and perceptual ability [19]. Therefore, the implementation of real-time monitoring and evaluation of individual physiological conditions is particularly important.

As the most basic physiological signal of human body, Photoplethysmography (PPG) signals contain rich information of hemodynamics and autonomic nervous system circulation, and are widely used in the research and development of small and wearable devices. From 2001 to 2006, Renevey[20], Wartzek[21], Mendelson[30] and others studied the measuring parts of PPG signal acquisition devices and developed wearable monitoring devices in the form of wristbands, finger covers, rings, etc. After that, the technology was widely used in medical treatment, home health care, sports monitoring and other fields. Anliker et al. [22] developed a wrist-worn telemedicine monitor suitable for daily medical treatment. Chuo et al. [23] developed a costume-type human physiological signal detection system for battlefield soldiers; The laryngeal monitoring equipment designed by Zhong Yizhou [24] improved the accuracy of PPG signal acquisition and data analysis in the medical field; The PPG signal monitoring ankle bracelet developed by Jin Xuebin et al. [25] can realize real-time monitoring of infant heart rate, blood oxygen saturation and body temperature. At present, most of the systems and equipment developed in the market are based on the daily medical care monitoring of single indicators, which is one-sided [26]. A comprehensive real-time monitoring and early warning equipment covering the physiological signals of cable channel operators has not been developed.

3.2. Monitoring based on video surveillance technology

Three methods are commonly used to improve target detection in static background: frame difference method, background subtraction method, and optical flow method. From 1996 to 1999, funded by the U.S. Defense Advanced Research Projects Agency, a number of research institutions, including Carnegie Mellon University and the David SARNOFF Research Center, jointly developed video surveillance and surveillance systems [27,28]. The goal of the project is to develop an automated video interpretation technology to facilitate the movement monitoring of personnel in complex environments. VSAM uses three-frame difference time domain method to detect moving targets, adopts adaptive template matching method to track moving targets, and identifies and divides targets by color and shape of targets. The University of Reading [29] in the UK processed the video information and conducted a study on vehicle and pedestrian tracking and interaction recognition. Companies such as IBM and Microsoft are gradually using vision-based gesture recognition technology commercially [30]. Although the relevant research time in China is relatively late, there are also a lot of exchanges and learning. For example, in 2002, the Pattern Recognition Laboratory of the Institute of Automation of the Chinese Academy of Sciences held the "first National Intelligent Visual Monitoring Conference". In 2003, a special issue on visual monitoring of dynamic scenes was published in Acta Automatica Sinica. After years of development, domestic research has become more in-depth and extensive. At present, the research of stereo vision mainly focuses on camera calibration, multi-camera fusion, target detection and tracking, behavior recognition and description, and shadow suppression.

A shadow is an area where the light of an object traveling in a straight line has a certain occlusion. Shadows are often mistakenly detected as moving objects because of their motion consistency and change similarity. The adhesion and deformation of the detection target due to its shadow seriously affect the subsequent analysis. Motion shadow suppression technology has been a research hotspot at home and abroad. Shadow detection was initially applied to shadow processing in remote sensing images [31,32]. Through shadow analysis of detection targets, more features of ground objects can be provided and image information can be increased by discovering objects in the shadow region. In 2003, Parti et al. [33] divided motion shadow detection methods into four categories, selected a representative shadow detection model in each category, conducted comparative analysis with actual experiments, and proposed evaluation indicators relative to shadow detection. In 2012, Sanin et al. [34] considered from the direction of shadow features, classified and compared shadow detection algorithms, and expanded the research of Parti et al. In China, although the shadow detection and suppression started late, through continuous research and efforts, a lot of results have been achieved. Yin Baocai et al. [35] used the principle of texture invariance combined with chroma to detect the shadow of moving targets. Fang Juqin et al. [36] used a method combining local classification and color features to detect shadows of moving targets, which was applied to processing remote sensing images.

3.3. Monitoring based on laser scanning detection technology

The monitoring scheme based on laser scanning technology needs to build a large number of laser scanning devices, and the installation process is very complicated. At the same time, due to the limitations of laser scanning itself, once the emitted laser is blocked by moving personnel and other equipment, it will produce data false positives. This technology has high requirements on the monitored area, which makes it more difficult to monitor in the actual operation. The scheme of scene scanning reconstruction is similar to that of intelligent video surveillance technology. Its principle is to use laser to scan complex scenes [37], perform data concatenation and de-noising processing, and restore virtual scenes to obtain safe distance information. This scheme also has higher requirements for algorithms and hardware facilities, and there are difficulties in dealing with blocking phenomena.

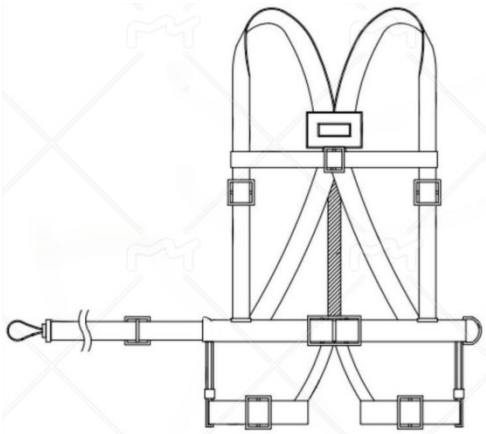


Figure 2. Diagramof Seat belt model.

Based on the analysis of common cable channel disasters in urban areas, it is proposed to arrange various structural or environmental state sensing devices on the channel structure [38]. Establish a real-time wireless monitoring data transmission network, state perception data storage, intelligent analysis using AI and big data, and cable channel digital twin technology to establish an efficient and timely channel disaster prevention and reduction digital management system. It is proposed that the cable channel operation and maintenance management department should apply the disaster prevention system [39] and cooperate with the government's emergency management department, fire protection department, municipal transportation, city appearance management and other urban public emergency and safety management functional departments to jointly formulate safety strategies for maintaining the urban power lifeline channel [40].

In the future, the new mode of intelligent operation and inspection management of cable channels in the distribution network will follow the important instructions of the construction goals of the world-class city distribution network, break the traditional cable and channel operation and maintenance management mode [41,42], comprehensively improve the digital management level of cables and channels, improve quality and efficiency, and iteratively upgrade, and effectively achieve "one source of data, one grid map, and one business line". With the intelligent control and inspection mobile terminal system of cable channel as the core, the online approval and application of cable channel resources are realized. At the same time, intelligent instruments and equipment and modern information technology are used to strengthen the daily inspection and management of cable channel, including: intelligent monitoring device of cable channel, intelligent detection device of cable channel [43], RFID electronic identification [44]. The data of the intelligent device is uploaded to the mobile terminal system synchronously, which completes the management of one platform and the application of multiple scenarios. Through this mode, multi-link and multi-dimensional control of the whole process of distribution network cable channel is realized, and the goal of lean, visual and intelligent active operation and maintenance management is achieved [45].

4. Conclusion

Based on the integration technology, the ventilation unit, oxygen supply unit, life protection unit, lighting unit, gas detection unit, communication unit, etc. are optimized and integrated, and the ventilation, oxygen supply and safety protection unit are integrated in a single/multi-channel composite mode. The lighting unit, gas detection unit and communication unit are integrated with single/multi-function composite mode. At the same time, this project combines the actual environmental conditions and working methods of different cable channels to carry out targeted configuration, reducing the complexity of protection operations. In order to further improve the safety protection of the cable channel operation site, the project also tested and applied the integrated protective equipment, conducted a comprehensive analysis of personnel status, working status, working time, operating procedures and other data, judged the feasibility and reliability of the integrated protective equipment, and amended and improved it. Improve the applicability, versatility and reliability of various cable channel operations.

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