

Borehole docking system design for underground refuge chamber and ground maneuver rescue equipment

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ABSTRACT

In order to target the problems of poor and low efficiency that arise during the borehole docking process of ground equipment and refuge chamber in emergency refuge system, this study presents a borehole docking system designed for ground maneuver rescue equipment. The system includes three parts: the hole docking device and orifice docking device and docking fixation device. The bottom hole docking device is inside the refuge chamber which is designed for three lines: the food transmission pipe, air pressure pipe, and power and signal transmission line. The orifice docking device is mainly for fast docking of ground equipment and emergency rescue vehicles, and the external protection sealing device is designed to protect orifice docking device from harsh outdoor environments. The docking fixation device is the connecting fastening core of the borehole docking device and is responsible for safeguarding system functions such as air pressure, power transmission, and food supply. Field test results show that the system runs well after the docking of emergency rescue vehicle and refuge chamber. Air pressure, water supply, and power transmission run smoothly. The operation of monitoring, control, and personnel positioning systems is normal. The borehole docking system met the needs of the refuge chamber. It enhanced the flexibility and economy of the mine refuge facility.

KEYWORDS: emergency refuge system; refuge chamber; borehole docking system

1. INTRODUCTION

The establishment of an emergency refuge system is an effective guarantee of mine safe production. As the main part of the coal mine safety facilities, the borehole type refuge chamber has the advantage of having high security and no limit to refuge time (Sun, H., 2014). At present, the ground supporting facilities of borehole type permanent refuge chambers are mostly the control rooms. A large number of necessities and rescue equipment are stored in the ground control room, which has led to the high cost of its construction and maintenance. This limits the application of the borehole type refuge chamber (Han et al., 2011; Wang et al., 2011). Therefore, the development of ground maneuver rescue equipment which is suited for underground emergency rescue systems came into being. The ground maneuver rescue equipment matched with borehole type refuge chambers can provide ground emergency rescue for the underground refuge chamber (Ni and Yao, 2014). The current designs of borehole docking systems for ground maneuver rescue equipment are not perfect, therefore, it is necessary to design a new borehole docking system.

On the basis of the original borehole of the refuge chamber, the present study describes the design of a new kind of borehole docking system for the ground maneuver rescue equipment. The system

mainly includes three parts, including the bottom hole docking device, orifice docking device, and docking fixation device.

2. BOTTOM HOLE DOCKING DEVICE

The bottom hole docking device is placed inside the underground refuge chamber and connected with the upper orifice docking device. The upper and lower parts are connected with quick connectors; they can be used to convey wind, water, power, and signal. These transmission functions and physical interfaces are independent of each other (Hu, J., 2010).

2.1 Underground connection mode

The connection modes of the high-pressured air hose, power cable, monitoring and control line, shielded transmission line and food (water) transmission pipeline in the refuge chamber are shown in Figure 1.

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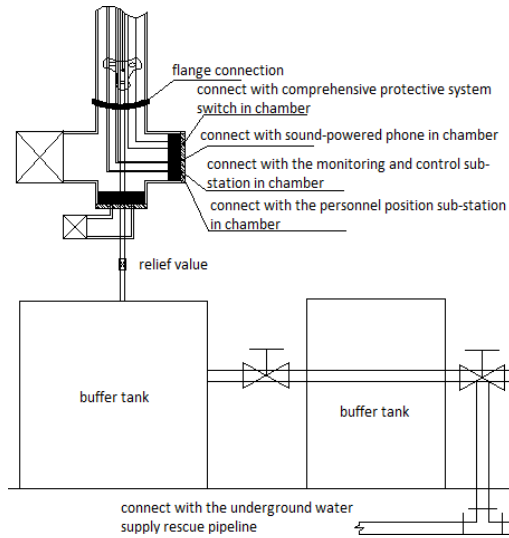


Figure 1: Diagram of underground connection mode.

2.2 Docking device configuration

The structure of the bottom hole docking device is designed to fully take into account the principles of safety and reliability. Bottom hole docking is divided into three lines. At the bottom there is liquid food (water) transmission line interfaces. Both sides are for interfaces of a high-pressure air hose and a power cable. Their internal connections are shown in Figure 2.

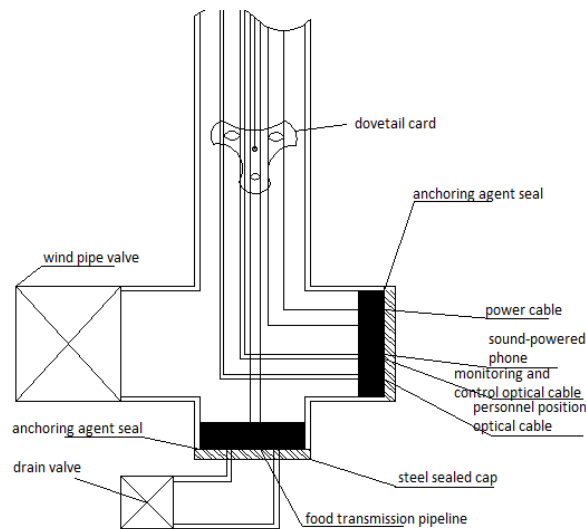


Figure 2: Design of docking device interface connection.

Transmission connections of power supply, communication signal, monitoring, and control signals are achieved using aviation plug fast connections. One end of the cables connected with the pipes is associated with underground docking device interfaces, and the other end is connected with

the rescue platform fast interface panel. The power cable uses a dedicated transmission fast interface. The esophageal flow path uses the threaded hose quick connector and the high-pressure air hose uses a flange bolt connection. The concrete connection mode of these pipelines is shown in Figure 3.

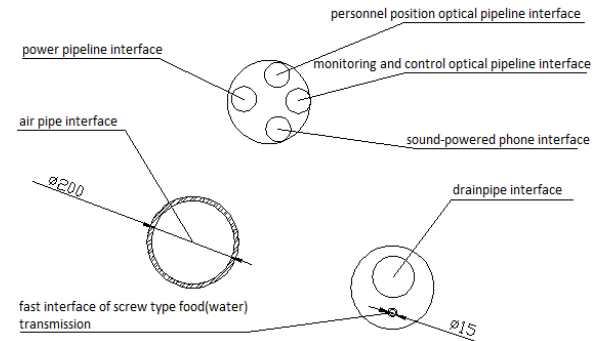


Figure 3: Pipeline interfaces schematic diagram.

3. THE ORIFICE DOCKING DEVICE

The orifice docking device is mainly for fast docking between ground equipment and emergency rescue vehicles. It shortens the connection time because it can help build temporary command places quickly. The location of the orifice docking device should be carefully considered. According to the position of the underground refuge chamber and ground environment, it should be placed in a flat, open area. The design of protection and auxiliary equipment should also be reasonable, easy to open, waterproof and fireproof, with security explosion-proof characteristics.

3.1 External protection sealing devices

External obturator is the establishment of an external protective cover to protect the orifice docking device. It should be waterproof, fireproof, and explosion-proof. At the same time it should have a protective effect on various orifice pipe interfaces and quick connectors. The docking device should be intact when the device is used to dock and it should achieve the best possible effect (Zhou et al., 2013). The design is shown in Figure 4.

In order for the external protection obturator to better fulfill its function, it is constructed of high strength isolating walls as a framework for external protective equipment. It is made up of the four following parts:

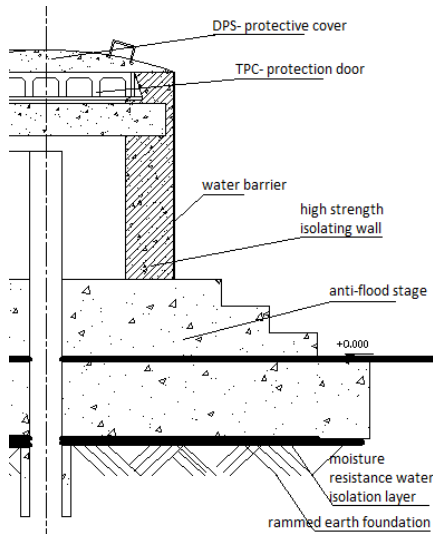


Figure 4: Design of external protection sealing devices.

1) The foundation

External protective devices are generally located in flat areas, where there is small gravel and prime soil compaction. The foundation is excavated to make it solid and reliable, backfilled with the original soil, and then the ground water is treated with high-grade cement.

2) Anti-flood stage

Moisture generated by rainwater can impact all types of electronic devices and internal pipe joints of protection devices. Therefore, they should be built with an anti-flood stage of more than 1m higher than the flood level at the high strength isolating wall. Meanwhile, in order to facilitate the job of rescue workers, treads and drainage ditches need to be established beside the anti-flood stage.

3) High strength isolating wall

A high strength isolating wall is constructed with masonry and concrete made of high index cement. Orifice size is determined according to the specific conditions of each mine. The thickness of the wall is generally around 0.3 m, with a height of no less than 1.2 m. After the masonry wall is built to waterproof the wall outside, waterproof coating can be brushed in the wall, or the pasted tarpaulins approach can be used.

4) Protection door

The TPC-protective door needs to be airtight. One side of the door should lock, as rescue personnel need to unlock the door. Due to the inaccessibility to non-staffs, after opening the TPC-protective door, staff can perform regular maintenance.

5) Protective cover

Because of harsh protection conditions outside, setting the TPC-protective cover over the DPS- protection door can be more effective to protect it

from corrosion and other damage due to rain and sunlight all year around. After finishing the TPC-protective cover, a circular bottom arch is poured on the high strength of the wall. The arch radius is consistent with the radius of the high strength wall.

3.2 System docking device

The analog bottom hole docking device and orifice system device can be divided into three parts: the liquid food (water) pipeline interface, high-pressure air hose interface, and the power signal line interface. Except for the intermediate part of the orifice that sets aside space for the connection, the space is connected with the closed holder (Jin et al., 2012; Wang, 2013). The design is as shown in Figure 5.

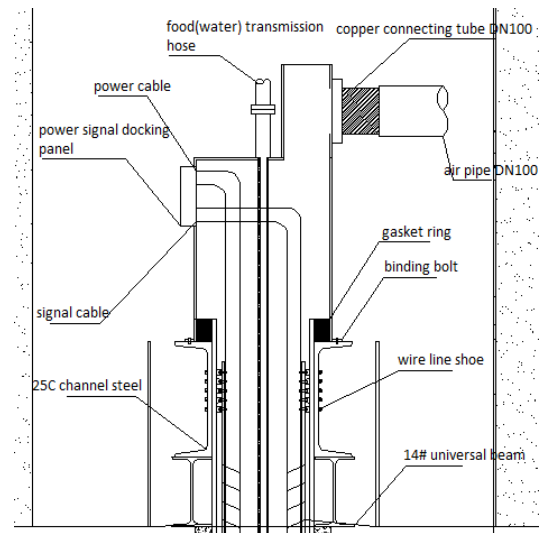


Figure 5: Design of docking system device.

1) Water pipe docking

(1) Liquid food transmission pipeline

One end of the liquid food delivery pipeline is connected with the orifice docking system by screw-type quick connector; the other end is connected with the maneuver rescue platform using D-type quick connectors.

(2) Chamber water-rescue system switching device

When the underground water system is damaged or the water pressure gauge displays abnormally in the refuge chamber, and the water quality is significantly turbid, the water rescue valve can be turned on, taking advantage of the rescue platform to help deliver water.

2) Air pressure and oxygen supply pipeline docking

(1) Gas transmission pipeline

After the mine disaster, the gas transmission pipeline (the main source of chamber's oxygen) is capable of transporting a steady stream of fresh air to

the chamber in order to prolong the survival time of the trapped personnel. To ensure the interface works effectively and to extend the service life of the interface, when not in use the interface must be sealed with a Jacob locking plug to prevent foreign matter entering the system to pollute the water.

(2) Oxygen self-help system switching device in chamber

When the return air system is damaged or the draft indicator shows that the air may be mixed with poisonous gases, and air transportation is significantly decreased, the air pressure supply value can be turned on, taking advantage of the rescue platform to provide enough air to the chamber.

3) Power system docking

(1) Power signal cable

The power signal cable that connects the rescue platform with the refuge chamber has the Mining Products Safety Approval and Certification. It has good insulating performance, stable transmission, the external protective layer is waterproof, anti-wet, and has protective ability.

Taking into account the scene of the rescue complex, the length of the pipeline should be appropriate, multiplied by the number of not less than 1 of the rich coefficient, in order to prepare for use.

(2) Power system switching device in chamber

Normally the power of the underground refuge chamber is connected to underground circuits through comprehensive security lines. After the mine disaster, underground substations may be damaged and the power ring network may not supply power normally. The independent power supply line of the maneuvering rescue platform will be turned on to supply power. For operation, one must open the power system switching device. The power generation unit on the rescue platform will provide power in the chamber.

4) Monitoring and control, personnel positioning, communication docking device

The device integrates all the interfaces used for monitoring and control, personnel location, and telephone communication. Generally it is divided into two parts: the power docking interface and signal docking interface.

(1) Power docking interface

The power interface is provided with a fast interface of three-phase four wire system. It can provide 660 V, 380 V, 220 V, 127 V stable AC power supply, and provide power for the maneuver rescue platform and refuge chamber.

(2) Signal docking interface

The signal interface includes three kinds of interfaces: monitoring and control, personnel location, and telephone communication. Their functions are the establishment of the communication

between the maneuver rescue platform and the underground refuge chamber, the real-time monitoring of the indoor personnel, the change of the environment parameters. They also provide detailed information for the field rescue.

4. DOCKING FIXATION AND OTHER ANCILLARY DEVICES AND FIELD TEST

4.1 Docking fixation device

The docking fixation device is the connecting fastening core of the borehole docking device. The device controls the oxygen pressure to the chamber, power transmission, liquid supply, monitoring and personnel positioning, telephone communication function. The device is mainly composed of H steel, high strength bolts, dovetail card, wire rope, and other components. The specific layout is shown in Figure 6.

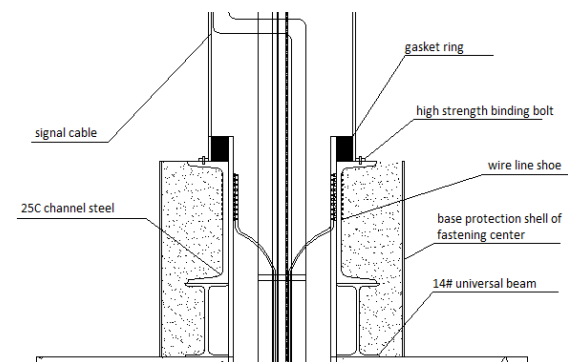


Figure 6: Internal connection diagram of the system.

4.2 borehole docking accessory device

The accessory device of the protection of the borehole is mainly made of two kinds of surface protective coating and outdoor rescue equipment.

1) Surface protective coating

In addition to the external orifice brush waterproof coating, it can also be brushed with anti-corrosion, rust-proof, non-toxic, anti-aging lipids ester paint. The paint safety level is adequate to satisfy the regulation of *Standard for Hygienic Safety Evaluation of Equipment and Protective Materials in Drinking Water* which is issued by the Ministry of Health P. R. China. It can prevent coating due to prolonged exposure, weathering, and erosion as a result of potential harmful ingredients from the orifice pipe into the refuge chamber.

2) Outdoor rescue equipment

(1) Military tents

The standard hexagonal military tent is chosen in outdoor rescue equipment. It is made of steel pipe

frame. Its structure is simple and reliable and is quick and easy to disassemble. The tent is wind resistant and the waterproof performance is good, with a large interior space. It has a compact structure and a collection of special canvas bags. It can be placed on the platform side of the toolbox, for instant access and long-distance transport.

(2) Explosion proof lamp

The case is made of a special aluminum alloy material. It can withstand strong impact, lighting protection class up to IP66. The lamp has a turning angle of 360°, tilt angle of 135°, and any position can be illuminated via hand-held lamp. It has an optional tripod, lifting in the 1.2 m to 3 m height range. The lamp can be adjusted in height by an optional handle, to meet the needs of various rescue work site lighting.

4.3 Field test

After connecting the emergency rescue vehicle with orifice docking device, rescuers can clearly observe real-time data of refuge chamber monitoring and control, personnel positioning and other facilities. At the same time, through the phone or via video communication, the rescuers can quickly and conveniently communicate with the underground experimenters. After turning on the control mechanism, the pressure of the air, the water, and the power supply run smoothly, meeting the design requirement of the refuge chamber.

5. CONCLUSIONS

The borehole docking system to connect ground maneuvering rescue equipment with underground refuge chambers consists of three parts: the bottom hole docking device, orifice docking device, and docking fixation device. The system is mainly connected to the ground and underground for air, food (water), power, monitoring and control, personnel positioning, communication and other functions.

All components of the system have been tested strictly in the field. The system can satisfy the needs of rapid orifice docking after underground emergency situations. The system has a low cost, high mobility, good compatibility, and is safe, reliable, and easy to maintain. It improves the convenience and economy of permanent refuge chamber.

The underground docking device and orifice docking device developed for ground maneuvering rescue vehicles can connect ground supply system and underground rescue system in a short time, improving the rescue efficiency.

6. ACKNOWLEDGEMENT

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