

# DEEP RAPID ACCESS DRILLING: SURFACE CONTROL SYSTEM DESIGN

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Hot water drilling has the advantages of less environmental pollution and fast drilling speed, but due to the wide variety of ice surface equipment, there are problems such as complex coordinated control of multiple systems and difficulty in troubleshooting. This paper presents a centralized surface control system specifically designed for a polar hot water drilling, known as Deep Rapid Access Drilling (Deep RAD). The system integrates multiple functionalities, including status monitoring, video surveillance, independent module debugging, coordinated system control, fault diagnosis and warning, and automated emergency handling, enabling comprehensive monitoring and precise control of the drilling process.

The system incorporates multiple high-definition cameras to monitor the operational status of key components such as the boiler, the winch, and the borehole head in real time. Video data are transmitted via industrial-grade routers and switches to a hard disk recorder supporting dual-disk hot backup, ensuring redundant and highly reliable video storage. The core control unit employs an industrial-grade computer running a custom supervisory application. This system continuously acquires real-time sensor data from multiple subsystems, performs dynamic analysis, initiates threshold-triggered alarms, and executes automated control actions. All operational data is stored in a local database with redundant protection implemented through real-time data mirroring.

The video surveillance system connects to two screens for real-time display of multi-channel monitoring images via a hard disk recorder; the human-machine interaction system uses an industrial computer connected to the other two screens to dynamically display the host computer control interface, data curves, and alarm information using communication protocols like Modbus RTU, Modbus TCP, and S7.NET, thereby ensuring system operation efficiency and data monitoring. A multi-objective centralized control strategy based on a fuzzy PID algorithm was developed, and the dung beetle optimization algorithm was introduced for automatic tuning of the PID parameters. At the same time, an early warning system based on a multi-system fault library was developed, which analyzes and diagnoses according to the constraint relationship between the parameters of each device, displays the corresponding alarm information, and realizes the rapid fault location, automatic alarm and system emergency protection functions under complex polar conditions, improving the overall safety and reliability of the system. All equipments are housed in a dedicated control room, enabling operators to maintain a full overview of system operations.

The system has successfully completed functional and performance testing under laboratory conditions. Full-scale validation tests of DEEP RAD are scheduled for the summer of 2025.

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