

STUDY OF FAULT REPAIR CONTROL MODE FOR DISTRIBUTION NETWORK BASED ON AUTOMATION AND INFORMATION UNDER BIG-MAINTENANCE SYSTEM

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ABSTRACT

The subject addressed is organizational structure mode and control process mode of distribution network rush-repair. Repair control process based on information support platform is built, and the interactive method of various information systems is proposed, providing theoretical and practical references for further improvement of fault rush-repair control in future smart distribution system.

INTRODUCTION

Distribution network fault repair is an important routine work of distribution network production with the characteristics of all-day fault response, face-to-face with customers, fault diversity, and complex working environment. Repair professionalized management enlarges the management range of distribution network and raises the requirement level of the repair process, e.g. reduce recovery time and etc. [1-4]. State Grid Company of China (SGCC) has developed various information and automation systems to improve the reliability of the grid. These systems independently manage various business activities; however, there is not effective linkage and management platform to meet with the integrated business needs of distribution system production recovery. In-depth study of distribution network fault repair control is important for mostly reducing recovery time and improving supply reliability and service level to meet with the need of higher quality and higher efficiency of distribution system fault repair under the big-maintenance system. SGCC is currently carrying out standardized distribution network repair, with their purposes mainly to realize uniformly standardization of repair process, field operation, and configurations of equipment and instrument. However, clear guidelines have not been given for distribution network repair management under the existing automation and information environment. Distribution network fault repair management is studied in-depth in two aspects of repair organization structure mode and repair process control mode. Repair organization structure mode mainly investigates how to realize vertical management and direct dispatching of daily scheduling and preparing all repair resources, and how to realize flattening and professional management of repair tasks. The key research issues of the repair process control mode are repair process improvement, function enhancement of fault repair command platform, and information communication mode of fault repair process.

ORGANIZATIONAL STRUCTURE MODE

The integrity of rush-repair organizational structure plays an important role in commanding and coordination of daily production, operation, scheduling and repairing for urban distribution network. Complete repair organization helps realize horizontal and professional management of repair task, and realize vertical management and direct scheduling of on-duty and backup repair resources.

Commanding Architecture

Distribution network repair involves main functional departments, such as production, operation, maintenance, and safety inspection), transversely coordinates relevant functional departments and various repair resource units, and longitudinally commands rush-repair crew, implements superior instruction and reports repair status. The commanding architecture is shown in Figure 1.

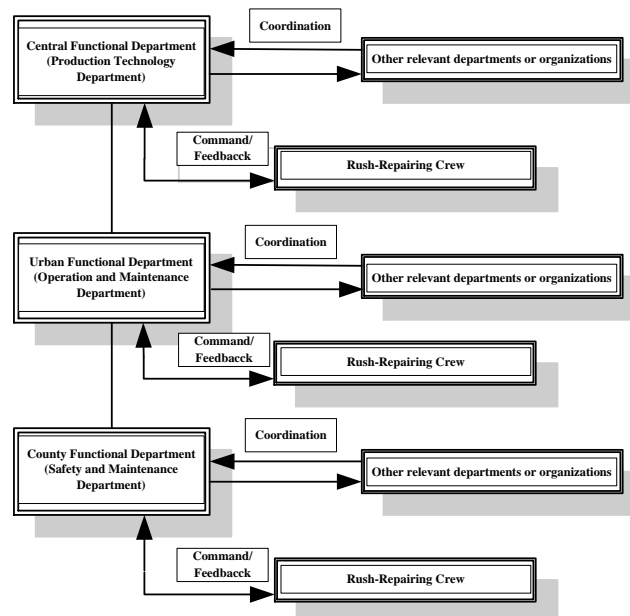


Fig. 1. Rush-repair commanding architecture

Functional Departments

The functional departments include production technology dept., development and construction dept., safety supervision dept., finance department, marketing department, dispatching centre, customer service, transmission and distribution work area and routine office.

Production Technology Department

Production technology department is the management department for distribution network rush-repair. The department responses for setting up rush-repair plan and specific implementation rules, specifying the requirement for repair flow, responsibility division, crew arrival time, prepared materials, transportation, communication, and information release and report. The department is also in charge of selecting outsourcing repair team, signing outsourcing repair contract, vehicle leasing agreement and security agreement, commanding and coordinating cross-area rush-repair, inspecting and supervising the implementation of the rush-repair work, and building and assessing funding plan and usage condition.

Development and Construction Department

Development and construction department is responsible for coordinating purchase and supply of equipment and material for distribution network rush-repair.

Safety Supervision Department

Safety supervision department is responsible for the supervision and management of rush-repair safety. The department also reviews safety qualification of the outsourcing units and the security agreements signed with them, supervises, guides, inspects and assesses the security of the field rush-repair work, investigates, collects and analyses event information, and investigates and processes the accidents caused by external force.

Finance Department

The finance department is responsible for rush-repair costs and purchase costs management of the repair equipment, devices, and materials.

Marketing Department

The marketing department is responsible for processing troubles called by customers, tracking fault repair work and replying the customer.

Dispatching Centre

Dispatching centre is the dispatching and commanding centre for fast and accurately fault-processing according to power system dispatching rules and requirements. Its function includes: precisely diagnosis fault range, timely notifies transmission and distribution work area, substation running work area, 95598 customer service centre, and other relevant departments, rapidly starts repair process, timely and correctly adjusts system operation mode, rapidly isolates failure and restore power supply, sends breaker operation order to operation personnel, receives outage application of relevant units, permits and manages the maintenance of power equipment in the range of the dispatching centre, and timely sends restore supply order after repair.

Customer Service

Customer representatives should have rich knowledge on business and be familiar with overall distribution network. When a fault is informed by customer, the customer name, phone number, address, fault behaviours and other fault information should be recorded completely. The customer

representatives should try to get the details of the abnormal equipment (abnormal state, location, range), and timely notify the relevant departments and units to start emergency process, making it convenient to correctly and rapidly process accident. At the same time the customer representatives should interpret and reply to the customer consultation, and maintain the corporate image.

Transmission and Distribution Work Area

The concrete implementation work is executed in the transmission and distribution work area. The work area is responsible for the internal and external repair team management and assessment, manages the reserve of the rush-repair equipment, device, and material of county distribution network, completes the repair equipment receiving, sending, statistics and assessing, and supplements repair teams monthly according to their usage; The work area also executes the acceptance check of on-site repair work quality and the breaker operation adjustment of county distribution network operation mode.

Routine Office

Routine office is responsible for the rush-repair vehicle management, making vehicle supplement plan and releasing rush-repair information to the public.

CONTROL PROCESS MODE

Rush-repair control is important for reducing recovery time and improving supply reliability and service level to meet with the need of higher quality and higher efficiency of distribution system under the big-maintenance system. The key research issues of the repair control process mode are function enhancement of rush-repair command platform, rush-repair process improvement, and information interactive mode of repair process.

Rush-Repair Command Platform

Rush-repair command platform is the key to repair work, which guarantees repair work smoothly processed. The function modules of the platform are shown in Figure 2.

Fault Diagnosis and Locating

Fault diagnosis and locating module is responsible for locating the fault based on the fault information from distribution automation and 95598. Auxiliary fault merger module analysis the fault information from different sources, auxiliaries repair commander merge fault and mark it on the map to avoid repeated orders.

Repair Scheduling and Commanding

Repair scheduling and commanding module manages repair resources, repair scheduling, fault plan and repair summary. Repair resources include repair instruments, vehicles, prepared materials and repair crew. Repair scheduling manages repair work order and repair status. Intelligent scheduling is realized in the platform. Fault plan matching, plan execution analysis and plan maintenance are accomplished by fault plan management. And repair summary concludes fault distribution, dangerous point distribution and repair dynamic situation.

Fault Diagnosis and Locating			Repair scheduling and commanding									Analysis and Evaluation		
Fault Analysis		Fault merge	Repair resource management			Repair scheduling management			Fault Plan Management			Repair summary		
Measurement and control area	Non-measurement and control area		Repair crew	Repair vehicles	Prepared repair materials	Repair instruments	Intelligent scheduling	Repair work order	Repair status	Fault plan maintenance	Plan execution analysis	Plan matching	Repair dynamic situation	Dangerous point distribution
Platform Foundation Module														
Rights management	Log management	System management	Graphic model library management	Report management	Visualization management	Multimedia application management	...							

Fig. 2. Rush-repairing command platform

Analysis and Evaluation

Analysis and evaluation module is responsible for fault repair evaluation, repair comprehensive index analysis and repair report statistical analysis.

Platform Foundation Module

The foundation module consists of rights management, log management, system management, diagram module library management, report management, visualization management, multimedia application management and etc.

Rush-Repair Process

When power failure occurs, 95598 and distribution dispatching and monitoring system are two main channels to get early warning of a fault. In the repair process, rush-repair command centre keeps real-time communication with the field, supervises and guides the repair work, and timely processes possible accidents. Repair time schedule is sent to 95598 and conveyed to the customer. After repair, the repair work is evaluated and summarized. The experience and corresponding improvement measures are put forward. Detailed repair process includes event notification, fault diagnosis, repair planning, fault isolation, work permit, fault processing, result reporting, supply recovery, and repair evaluation.

Event Notification

Rush-repair command centre gets fault information timely through 95598 and electric power equipment real-time monitoring system, and determines the fault location from the monitoring interface based on GIS technology.

Fault Diagnosis

When rush-repair command centre can judge the failure cause based on DMS, 95598 and equipment condition monitoring system, the operation vehicles are arranged to repair field. If it is difficult to judge the fault reason, the centre informs PMS to generate fault tour order, and push it to mobile platform. The inspection car near fault location inspects the failure cause. Inspection cars report 95598 their arrival time when they arrived at the fault location. After tour, they fill out patrol record in the mobile platform, upload it to PMS, and push it to rush-repair command centre.

Repair Planning

According to the patrol record, for the fault that can be repaired by inspection car, PMS directly generates repair order apply for repair permit. For the fault that cannot be handled by inspection car, the repair command platform allocates repair resources according to the fault causes and corresponding plan, and PMS generates fault repair order and sends it to the vehicle mobile terminal.

Fault Isolation

Working vehicle organizes repair based on the fault repair order and the standard configuration, isolates the fault in accordance with the standardized work instructions, reports the field condition to the repair command centre and applies for repair permit.

Work Permit

Repair command centre sends the work permit to the distribution network scheduling group after informed with the field information.

Fault Processing

When work permit is obtained from scheduling group, PMS perfects fault repair order and distributes it to mobile terminal. Rush-repair work group notify 95598 the outage area and fault time, and carries out repair work. Repair team updates work order status in time in mobile terminal while dealing with failure, and repair state is passed back into the system. Repair team keeps in touch with repair command platform in case of accidents.

Results Reporting

After the fault repair is accomplished, the mobile terminal records repair course and upload it to PMS. PMS perfects fault repair order and uploads it to repair command centre.

Supply Recovery

Repair command centre sends recovery application to distribution scheduling. Scheduling group sends restore order. After restoration, the repair management centre archives repair information, 95598 informs customer, and PMS perfects equipment maintenance.

Repair Evaluation

Repair command centre assesses the performance of the fault repair, gives the evaluation result, and puts forward the corresponding improvement measures.

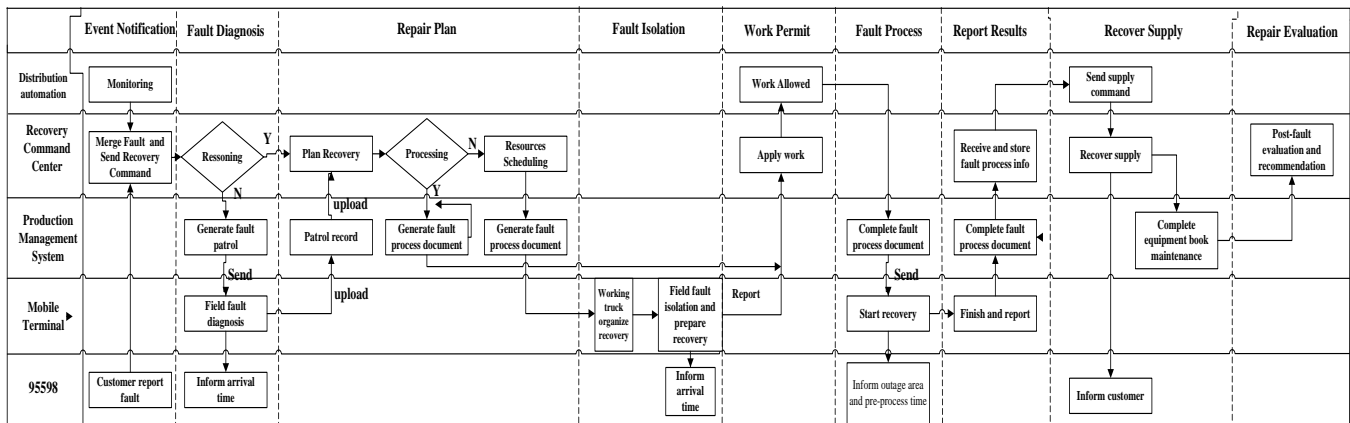


Fig. 3. Rush-repair control process

Information Interactive

Rush-repair command platform exchanges information with related systems through information interactive bus [4, 5].

Distribution Automation System

Distribution automation system pushes switch position, fault and processing information to the command platform. And the command platform accesses on-demand the information of a time section.

Dispatching Automation System

Repair command platform obtains major network real-time information through the interface of the dispatching automation system. Dispatching automation system releases through the bus: switch shift information (real-time), fault information (real-time), real-time information section (fixed cycle, such as 30 minutes once).

Production Management System (PMS)

The repair command platform gets outage plan, worksheet, scheduling ticket, equipment defect and account information from PMS interface and feeds fault and its processing information back to the PMS system. The platform also obtains on-line equipment temperature, switching station environment, SF₆ gas concentration and other on-line monitoring information from PMS interface.

Geographic Information System

The repair command platform obtains graphic model data through GIS interface. Distribution network topology data and graph data should be visualized in the platform. Topology simulation analysis is accomplished relying on GIS topology information.

Marketing Management System

Marketing management system provides equipment parameter searching, customer file searching, and important customer information for command platform.

95598 Customer Service System

The repair command platform receives fault repair work order in real-time from 95598, and feeds repair process information back to the 95598 system.

Electricity Consumption Information Acquisition System

This system actively finds out abnormal power supply,

analysis in real-time the fault location by combining PMS and GIS platform, and pushes fault location information to repair command platform. It auxiliaries repair command personnel determine whether the fault is distribution fault, locate the fault accurately, and provide service support for customer service system.

CONCLUSION

Confronted with the need of higher quality and higher efficiency of distribution system fault repair under the big-maintenance system, study of fault repair control mode based on information support platform can help repair personnel use rush-repair command platform for effective information interactive, speed-up flow, effective linkage of related departments during repairing, and thus mostly abbreviate recovery time and improve the management level of the distribution network.

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