Research on the principle of distribution network fault handling

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Abstract. Compared with the transmission network, the distribution network has a wide distribution area, a large number of electrical equipments, a complex operating environment and a high probability of fault. According to the operation characteristics and common fault types of distribution network, this paper first describes the main task and basic mentality of distribution network fault handling, and then puts forward the handling principles of distribution line fault, single phase-to-ground fault and voltage transformer fault, which provides technical support for dispatchers to deal with distribution network fault reasonably.

1. Introduction
Compared with the transmission network, the distribution network has a wide distribution area and a complex operating environment, which is more vulnerable to the impact of various emergencies and even causes faults, interrupting the normal power supply to users. Under the objective situation that the distribution network fault can not be completely avoided, dispatchers need to have the corresponding fault emergency disposal ability to achieve accurate and rapid disposal, timely restore the power supply of users, and reduce the impact and loss of distribution network fault as much as possible. Literature [1] summarizes the research results of distribution network fault handling in the past 20 years, but that paper mainly discusses the research progress of Feeder Automation(FA), distributed intelligence based Distribution Automation(DA), robust fault location approaches and other related technologies, and does not put forward the general principles of distribution network fault handling. This paper first describes the main task and basic mentality of distribution network fault handling, and then puts forward the handling principle of distribution network typical fault, which provides technical support for dispatchers to deal with distribution network fault reasonably.

2. Main task of distribution network fault handling
The procedure of distribution network fault handling is shown in Figure 1. The main tasks include quickly limiting the development of fault, eliminating or isolating the root cause of fault, removing the threat to personal and equipment safety; maintaining the normal power supply to users as much as possible according to the system conditions; quickly restoring power supply to users who have been cut off, especially giving priority to the restoration of station service and security power of important users; adjusting the operation mode of power system to return it to normal.
3. **Basic mentality of distribution network fault handling**

In case of distribution network fault, dispatchers and operators shall deal with it according to the following ideas:

The operators shall report the time, phenomenon, equipment name, equipment number, relay protection action, automatic device action, voltage, current change, etc. of the fault to the dispatchers quickly and correctly.

In the process of fault handling, each department shall first answer the dispatching call. Non fault department shall strengthen fault monitoring, report fault phenomena concisely, and do not rush to inquire about fault conditions, so as to avoid occupying dispatching telephone and affecting fault handling.

In case of fault handling, the normal switching operation in the relevant system shall be stopped immediately. In the process of fault handling, the regulations of issuing orders, repeating, reporting and recording must be strictly implemented, and unified dispatching terms and operation terms shall be used[2].

In order to deal with the fault quickly and prevent the fault from expanding, the dispatchers of regional dispatching can issue the instruction over the level, but the dispatchers of county dispatching shall be informed as soon as possible afterwards.

During fault handling, except for relevant leaders or professionals, other personnel shall be evacuated from the dispatching room. When necessary, dispatchers can inform other relevant professionals to come to the dispatching room and negotiate to solve the problems.

When the fault handling is over, the dispatchers shall report the fault to the leader in charge quickly, and report to the superior dispatchers when the equipment under the control of the superior dispatchers is involved.
After the fault handling is completed, the dispatchers shall fill in the fault record in detail for the fault handling process, equipment damage, important customers of power failure, etc., and timely write the fault analysis report, organize discussion, summarize the experience and lessons of fault handling, and take necessary measures.

Dispatchers should be calm, decisive, accurate and quick in fault handling. They need to take every detail carefully and seriously, be familiar with the operation mode, rules and regulations of distribution network, accurately grasp the key points and development direction of fault, prevent fault expansion and avoid human fault[3]. When issuing the order, it is strictly prohibited to exceed its own jurisdiction.

During fault handling, operators shall obey the dispatchers' command and execute the dispatchers' instructions rapidly and correctly. Operation time shall not be delayed unless in special circumstances. The operation of the equipment under the jurisdiction of dispatching shall be carried out according to the instructions of the dispatchers or with their consent.

In order to deal with the fault quickly and prevent the fault from expanding, the operators of the fault department does not need to wait for the dispatching instruction under the following circumstances, but report to the dispatchers as soon as possible afterwards: when there is a threat to the safety of people and equipment, measures shall be taken according to the site regulations; when the fuse of voltage transformer is broken, relevant relay protection shall be stopped; isolate the damaged equipment when there is no possibility of incoming power.

4. Principles of distribution network fault handling

4.1. Principle of distribution line fault handling

The classification of distribution line fault types is shown in Table 1. When the distribution line circuit breaker trips and the reclosing fails, the distribution automation system starts the automatic judgment and isolation procedure. When the power supply of some users is interrupted, the dispatchers shall timely inform the operators of the fault situation, including the trip line, time, fault impact, power outage scope, relay protection and automatic device action. Dispatchers shall inform the distribution network emergency command team meanwhile[4].

| Classification standard | Type                           |
|------------------------|--------------------------------|
| fault phase            | single phase-to-ground fault; phase-to-phase fault |
| fault pattern          | short circuit; transmission line disconnection |
| fault property         | transient fault; permanent fault |

After receiving the notice, the operators shall quickly go to the site for patrol inspection. The faulty line shall be considered live. The emergency command personnel shall take corresponding measures to minimize the impact caused by power failure[4].

If there is live-wire work before the fault line trips, the person in charge of the work shall contact the dispatchers immediately after finding the power cut of the line for any reason to explain whether the fault is related to the work.

The dispatchers shall analyze comprehensively according to the distribution network wiring, load nature and relevant operation regulations, combined with the maintenance work at that time, weather conditions and other factors.

Trial transmission is not allowed in case of distribution line fault under the following circumstances: if the whole line or more than 70% of it is cable; if the line is user's special line and has special requirements; if the line has obvious fault phenomenon or may endanger the safety of people and equipment; if the line fault is caused by live-wire work, in addition, the person in charge of the work has made it clear that forced transmission or trial transmission is not allowed; it is not suitable to directly use oil circuit breakers for trial transmission of the fault line.
The dispatchers shall make further disposal according to the result of forced transmission or trial transmission of the line. If the forced transmission or trial transmission of the line is unsuccessful, the dispatchers shall inform the distribution operation and maintenance department and the customer management department to conduct a thorough inspection. If the forced transmission or trial transmission is successful but the line fault changed to permanent single phase-to-ground fault, it may be handled as single phase-to-ground fault when the weather is good and there is no danger to the safety of people and equipment.

4.2. Principle of single phase-to-ground fault handling
If the single phase-to-ground line has been determined by the small current single phase-to-ground line selection device, it shall be confirmed first\(^{(5,6)}\). If confirmed, inform the relevant department to inspect the fault point.

If the distribution line sends out single phase-to-ground signal and it is confirmed, the dispatchers shall notify the relevant department to inspect the fault point.

The single phase-to-ground substation with double bus or double power supply running in parallel can be divided into two parts to narrow the scope of searching fault line. Before operation, the adaptability of relevant relay protection and whether the transformers will be overloaded shall be considered.

Open the circuit breaker of capacitor and no-load line in the single phase-to-ground substation.

When there is no small current single phase-to-ground line selection device in the substation, the dispatchers shall find out the fault line by themselves.

If no single phase-to-ground fault has been found after all the lines of the substation have been inspected, the operators shall conduct a detailed inspection on the bus and relevant equipments.

The dispatchers shall follow the following principles in the process of finding the single phase-to-ground line: it is strictly prohibited to cut off the single phase-to-ground equipment with disconnectors; it is strictly prohibited to cut off the arc suppression coil, voltage transformer and station transformer with disconnectors during the existence of single phase-to-ground fault; if the single phase-to-ground point is on the distribution transformer, the high-voltage drop fuse can be opened to isolate the fault; the single phase-to-ground system shall not be paralleled with the normal one in principle; priority should be given to no-load lines, long lines and lines with many branches\(^{(7)}\); the line confirmed to be permanently single phase-to-ground can no longer be powered on in principle, and relevant important customers shall be informed; if the single phase-to-ground line is necessary to continue operation due to special circumstances, the approval of the leader in charge of relevant departments shall be obtained; try to shorten the time of search fault, the allowable operation time of single phase-to-ground system shall not exceed 2 hours generally\(^{(8)}\).

The operation and maintenance department shall find and dispose the single phase-to-ground fault in time, eliminate the fault as soon as possible, and prevent the insulation damage of other equipment in the same system from developing into short circuit fault.

In case of permanent single phase-to-ground fault, the dispatchers shall immediately cut off the power supply and inform the line operation and maintenance department to check and dispose the fault point when they receive the report that the fault threatens personal safety.

4.3. Principle of voltage transformer fault handling
It is forbidden to operate the disconnector at the high voltage side of the voltage transformer locally.

It is strictly prohibited to parallelize the secondary of the abnormal voltage transformer with the normal one.

Cut off the secondary load of the abnormal voltage transformer in time.

If the disconnector at the high voltage side of the voltage transformer can be operated remotely, it shall be isolated.

If the disconnector at high voltage side cannot be used, the power supply of the bus where the voltage transformer is located can be disconnected, and then operate it.
In case of resonance in the process of abnormal handling of voltage transformer, immediately destroy the resonance condition or disconnect the power supply of bus to prevent voltage transformer explosion.

The voltage transformer withstanding over resonance over voltage shall be out of operation and taken to relevant test.

5. Conclusion

According to the characteristics of distribution network fault, this paper first expounds the basic mentality of distribution network fault handling, and then puts forward the handling principles of distribution line fault, single phase-to-ground fault and voltage transformer fault. The research results can provide reference for dispatchers to deal with distribution network fault accurately, quickly and reasonably.

References

[1] LIU Jian 2015 Advances on Distribution Network Fault Processing Technology Distribution & Utilization vol 4 pp 8-15

[2] JIAO Zhongjie and CHENG Dongqi 2009 Analysis and pre-control of dangerous points in power grid dispatching CHINA ELECTRIC POWER EDUCATION vol 21 pp 249-250

[3] YANG Mengyao 2016 Research on efficient management of power grid regulation and safe, stable and economic operation of power grid Technology Innovation and Application vol 35 p 252

[4] CHEN Yong 2015 Analysis on the method of quickly judging faults in the command of distribution network emergency repair KEJI YU QIYE vol 19 p 194

[5] ZHAO Chuang 2018 Current situation and control measures of small current grounding line selection device Architectural Engineering Technology and Design vol 24 p 2662

[6] Bi Huijing and ZHANG Hongyan 2012 Analysis and handling of single-phase grounding fault in small current grounding system CHINA ELECTRIC POWER EDUCATION vol 24 pp 123-124

[7] TAN Xianzhu 2013 Judgment and handling of voltage unbalance fault in 10kV distribution network Guangdong Science & Technology vol 20 pp 70-71

[8] XUE Yanbo and WANG Guomin 2007 Fault classification and search of 10kV distribution line RURAL ELECTRICIAN vol 15 p 22