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The Practical Application of Key Skills of Relay Protection for Dispatching Training

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Abstract. It is one of the basic individual qualities that a dispatcher could deal with all kinds of power network faults calmly. With the development of the society and the updating of the power equipment, the efficiency of the dispatchers are decided by the distinguish ability of the abnormal alarm information of the power grid. This paper puts forward three steps of key skills of dispatching training about relay protection, which could help dispatchers to improve their distinguish ability.

1. Introduction
As the commander of the power grid, dispatchers guard and watch the power system, to make sure the system to be operating reliably. Because of this, the professional competence of the dispatchers is highly demanding and the training for dispatchers is quite important. Currently, the limit for the growth and development of the dispatchers is the low distinguish ability of the abnormal alarm information of the power grid, especially those about relay protection. While dealing with large amount of alarm information, it is difficult to catch the key information accurately. Because of this, the process of dealing with the fault would be slowed down, and the security of the grid would be impacted. For maintainers who are on site, they would pay more attention to the principle of the relay protection. However, for dispatchers, they would pay more attention to the result of the relay protection.

2. Three steps of key skills of dispatching training about relay protection

2.1. Fundamental knowledge about relay protection for dispatchers

2.1.1. Types of Relay Protection.
Table 1. Types of Relay Protection.

| Name               | Under 110kV                                      | Over 110kV                                      |
|--------------------|--------------------------------------------------|------------------------------------------------|
| **Line Protection**| Current Protection                               | Whole Line High Speed Protection                |
|                    | Distance Protection                              |                                                |
| **Bus Protection** | Bus Differential Protection                      | Bus Differential Protection                     |
|                    | Key 110kV Substation                             |                                                |
| **Transformer**    | Internal Protection, Gas protection, External    | Non-full Phase Protection, Breaker-failure     |
| **Protection**     | Protection, Current Differential Protection       | Protection                                     |
| **Circuit Breaker**| Transformer Back-up Protection                   |                                                |
| **Protection**     |                                                |                                                |

2.1.2. Status of Breakers.

Table 2. Types of Relay Protection.

| Name               | Under 110kV                                      | Over 110kV                                      |
|--------------------|--------------------------------------------------|------------------------------------------------|
| **Line Protection**| Breakers on the forward direction act while      | 220kV Breakers on the both sides act without    |
|                    | current protection and distance protection act   | time delay                                      |
| **Bus Protection** | All the breakers on the faulted bus act          | All the breakers on the faulted bus and the     |
|                    |                                                  | opposite side act                               |
| **Transformer**    | Breakers on all the thee sides act               |                                                |
| **Protection**     | Bus-tie breaker acts to judge                    | After the non-full phase protection or          |
| **Circuit Breaker**| which is the faulted bus, and the breaker of the | breaker-failure protection acting, the status  |
| **Protection**     | transformer to insulate the fault                | of breakers are the same as the one after bus   |
|                    |                                                  | protection                                      |

2.2. Fault Analysis
Fault analysis is as the following steps:
- Dispatchers should make the pre-fault operating mode clear, including the status of the buses, transformers, and neutral points.
- Dispatchers should check the alarm information clearly, and deduce the relay protection actions.
- Dispatchers should deduce the fault point according to the alarm information.
- Dispatchers should give the dispatching order, check the conditions on the site, and deal with the fault.

It is the most important key point in the above steps that dispatchers should get the information of relay protection action through the alarm information, and catch the fault point.

2.3. Conclusion
Through the macro-study of the theory of the relay protection, dispatchers would learn to check the status of the breakers before and after the fault, and learn to get the relay protection action information through the alarm information. On these basis, it would develop much on the professional competence of the dispatchers through DTS Fault Simulation, and the combination of theory and practice.

3. Process of Practice
The following fault simulation is that the low back-up protection of the transformer acts because of the breaker failure. As is described above, the low back-up protection is the back up protection of the transformer, but the main protection of the 35kV bus. It would be separated to three parts and explained by the three-step learning method above.

3.1. Pre-fault Operating Mode
Figure 1. Operating Mode of Emei Substation

The #1 and #2 main transformers of Emei Substation are operating parallely. The 110kV and 220kV neutral points of #1 main transformer are grounded directly. The zero sequence protection is in operation. The operating mode of both 220kV and 110kV buses is double-bus connection. That of 35kV buses is single bus with two section.

3.2. Alarm Information of the Fault

As is shown in Figure 2 & 3, by comparison, the key alarm information of the fault in Emei Substation is as follows:

- The protection of 35kV E3551 Line acts, but the breaker rejects to open.
- The voltage of 35kV #1 Bus turns to zero.
- The back-up protection of #1 main transformer acts, and the 35kV breaker of #1 main transformer opens.

| No. | Time     | Factory station | Device                                      | State          |
|-----|----------|-----------------|---------------------------------------------|----------------|
| Unconfirm | 2018-05-23 15:51:54:300 | EMei | Service Power_Automatic Standby Supply Exit | Reset          |
| Unconfirm | 2018-05-23 15:51:49:940 | EMei | Fault Signal                               | Reset          |
| Unconfirm | 2018-05-23 15:51:49:100 | EMei | Service Power_Automatic Standby Supply Exit | Action         |
| Unconfirm | 2018-05-23 15:51:47:100 | EMei | 35kV-side of TR-1_3551 Circuit Breaker Bay Fault Signal s | Reset          |
| Unconfirm | 2018-05-23 15:51:45:519 | EMei | 35kV E3551_3551 Circuit Breaker Bay Fault Signal s | Reset          |
| Unconfirm | 2018-05-23 15:51:42:899 | EMei | 35kV E3551_ Protection Exit                | Reset          |
| Unconfirm | 2018-05-23 15:51:42:859 | EMei | TR-1_L-side Back-Up Protection_1_Outlet     | Reset          |
| Unconfirm | 2018-05-23 15:51:42:809 | EMei | TR-1_L-side Back-Up Protection_2_Outlet     | Reset          |
| Unconfirm | 2018-05-23 15:51:42:639 | EMei | 35kV-side of TR-1_3551 Circuit Breaker Bay Fault Signal s | Action         |
| Unconfirm | 2018-05-23 15:51:42:629 | EMei | TR-1_L-side Back-Up Protection_2_Outlet     | Action         |
| Unconfirm | 2018-05-23 15:51:42:529 | EMei | TR-1_L-side Back-Up Protection_2_Outlet     | Action         |
| Unconfirm | 2018-05-23 15:51:42:429 | EMei | TR-1_L-side Back-Up Protection_2_Outlet     | Action         |
| Unconfirm | 2018-05-23 15:51:42:429 | EMei | TR-1_L-side Back-Up Protection_2_Outlet     | Action         |
| Unconfirm | 2018-05-23 15:51:41:429 | EMei | 35kV E3551_ Protection Exit                | Action         |
| Unconfirm | 2018-05-23 15:51:40:909 | EMei | Fault Signal                               | Action         |
| Unconfirm | 2018-05-23 15:51:40:909 | EMei | 35kV E3551_3551 Circuit Breaker Bay Fault Signal s | Action         |
| Unconfirm | 2018-05-23 15:51:40:979 | EMei | 35kV E3551_ Protection Exit                | Action         |

Figure 2. Alarm Information
3.3. Fault Cause Analysis
The fault above is quite simple and obvious, however, there are many tips about relay protection action. For example, while the back-up protection of #1 main transformer acts, and the 35kV breaker of #1 main transformer opens, dispatchers should first consider what kind of fault would make the back-up protection act. Dispatchers should read the alarm information carefully, and consider what is the meaning of the protection action, especially with breaker rejection. It is important to do some self reflection to find out the real fault cause.

According to the alarm information in Figure 2, the protection of 35kV E3551 Line acts. However, according to Figure 3, the breaker of E3551 Line does not open, it means that the breaker rejects to open, and the fault at this moment has already be expanded. Meanwhile, because there is no bus protection on the 35kV buses, the back-up protection of main transformer acts. According to the analysis above, dispatchers could make sure that the fault is on the 35kV E3551 Line, the breaker rejects to open, and then the back-up protection of main transformer acts.

4. Key Tips about Relay Protection Action in This Fault

4.1. The hidden information about the breaker of 35kV side of the transformer open.
- 35kV Bus Fault: Because there is no bus protection on 35kV bus, if the bus fault happens, the back-up protection of main transformer would act.
- 35kV Line Fault: The breaker of the line should open. But if it rejects, the fault would be expanded, the back-up protection of the main transformer would act, the breaker of the 35kV side of the main transformer would open, and insulate the fault.
- Protection Unwanted Action and Breaker Unwanted Action: The results of these two kinds of action are almost the same, but the principles of them have nothing in common. There would be no any alarm information while protection unwanted action happens, but some alarm information about protection action while breaker unwanted action happens.

4.2. How to Find out Breaker Rejection
Dispatchers should check the alarm information to make sure whether the breaker opens while the protection acts. If the protection acts but there is no alarm information about breaker open, it is breaker rejection.
4.3. How to Deal with the Fault with Interference of False Information
The fault simulation above is just one of the typical faults, with broad cross section. The most important problem of this fault is the breaker rejection and fault expansion. While the fault happens, dispatchers would see big amount of alarm information and get themselves into mass. For example, the bus voltage loss is caused by the back-up protection action. It would cause BZT, which is also called automatic stand by power switching device, of #1 station transformer acts.

This kind of interference would hamper the dispatchers. So dispatchers should learn to find out the valid information and ignore the false information.

5. Conclusion
No matter in daily work, or in training simulation, dispatchers pay more attention to the operating order, but not to the actions of relay protection. This kind of work habit makes the process of fault judgement lagged behind. Hence, the dispatching training about relay protection is most and foremost. The training should include practical application and field explanation to get dispatchers to be confident.

The scale of the power grid in the city is so large, and the conditions of faults are so complex that there is not a general method or process to deal with all kinds of faults. The only thing dispatchers should do is to keep on learning, especially the principles of relay protection, and to sum up the experience. One day, these dispatchers would be the greatest shield of the power grid.

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