SAFETY AND ITS IMPORTANCE IN PROTECTIVE RELAYING

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INTRODUCTION

There is an old saying in the industry… "There are bold protection engineers and there are old ones too but there are no old bold ones." Often emphasis is placed first on economics but in truth safety is always of the utmost importance since we are working in an energized high voltage power system which is a hazardous environment. Being safe is a state of mind and closely following a good set of well-established practices; it is necessary to maintain this state of mind as a constant goal. You must fully understand these practices and be extremely well versed in them.

Unsafe practices can result in the loss of revenue and more importantly human life. Unsafe practices or the lack of good practices invariably lead to relay misoperations or the lack of a critical relay operation when required and called upon to operate.

Much of the advice presented here is based upon real life experience such as working at nuclear power plants that follow a highly regimented set of practices that are periodically reviewed and constantly improved over time.

The purpose of this article is twofold to demonstrate the following:

- Good practices for safety as related to protective relaying
- Bad practices or the lack thereof

GOOD PRACTICES

This section provides tips on some good practices for any work related to protective relaying. These suggested practices cover both field work versus an office environment where the protection and control systems are designed.

Field

Proper Training and Practical Understanding
Field personnel should have a practical understanding of work related tasks and be properly trained in advance prior to conducting any tasks to be conducted in the field. A practical understanding means that the field personnel can trouble shoot should any problem arise during a task and not strictly be dependent upon automated test equipment and software.

Direct Access to Supervision
Field personnel should always have direct access to their supervisor(s) should they have any questions related to successfully performing any work task. Supervision should either be able to answer these questions directly or have immediate access to resources that can.

Work Plan
Any time any work is conducted in the field such as testing there should be a detailed step by step work plan in place to follow. Workers sign off on the procedure as each step is completed. Some companies require two individual signatures from independent personnel per step for additional verification.

Error Checking
Field personnel should be able to identify any errors present in the design of new projects and properly communicate these findings to the engineer(s) responsible for the original design so it can readily be corrected.

This is an extremely important skill since this is the last point in the overall process that any possible existing errors can be caught and corrected prior to a misoperation.

Office

System Projects

A good practice is to develop system projects so that the corrections for an inherent design flaw can quickly be implemented throughout the rest of the system once it has identified at one particular location such as due to a relay misoperation. A system project could be as simple as disabling a protection function or as elaborate as replacing an existing relay or entire panel if need be.

Human Performance

Protection and control apparatus and schemes should be designed with the field personnel in mind since they are responsible for installing, operating and maintaining it. Therefore all **schemes should be designed first and foremost with safety in mind**. As an example there should be test switches available to isolate each and every relay voltage and current input from the electrical power system with test connections available for the relay test sets to inject the corresponding test signals. The same also holds true for relay digital inputs and outputs.

Do the Job Right the First Time

Sometimes management pushes the protection engineer to complete the project as quickly as possible. There might for example be a back log of work acting as an impetus to rush. This type of scenario almost always invariably leads to safety related issues. It is the responsibility of the protection engineer to firmly identify the amount of time required to properly complete each project. There is no place for an 80/20 mentality in the design or testing of protection and control. 80/20 refers to only completing the first 80 percent of the job as a means to save time. Often the final 20 percent can take longer to complete than the first 80 percent of the job. This philosophy amounts to willful negligence.

Interdisciplinary

NOTE:

This category is the case when field personnel and designers work directly together side by side.

End-to-End Transmission Line Communication Assisted Tripping Scheme Testing

A good example is the end-to-end field testing of a high voltage transmission line communication assisted protection scheme. The design engineer is often called upon to run short circuit studies for faults both internal and external to the protected transmission line. These test signals are simultaneously injected at each line terminal via GPS synchronization. Often it has been reported that this type of testing leads to relay setting changes that improve the overall reliability and security of the protection scheme. Field personnel and relay designers working directly together is the best case scenario to ensure the protection is fully optimized and properly commissioned.

Off Site Testing

Perform off site testing in a laboratory or similar type of environment. All of the protection and ancillary equipment (e.g., modem, communication processors, etc.) is brought to one location, connected and thoroughly tested to make sure the design is proper and catch any errors prior to installation and on site commissioning.

Third Party Check

A third party check is performed by an independent body outside of the owning electric utility such as a consulting engineer(s). This is an excellent method to procure a fresh set of eyes as a final check. If the third party is procured on a regular basis they can develop an intimate understanding of the end user’s standards and operating procedures.

BAD PRACTICES OR THE LACK THEREOF

This section demonstrates bad practices for any work related to protective relaying. These types of practices cover both field work versus an office environment. Note that there is a third category classified as Enterprise which pertains to a management level decision or actions taken by them.

Field

Unreported Design Changes

A bad practice regarding any change made to an existing design in the field is not to report these back to the design team nor update relevant system drawings. If field personnel should make any changes to an existing design for any reason this should first be communicated to the responsible designer(s) for approval and then the changes should be noted on any relevant drawings (i.e., as-builts). The wiring in the control room should always exactly match the drawings.

Office

Programmable Relay Logic (PRL) Implementation

Modern numerical protection relays have PRL which you can use to augment existing protection functions in order to achieve any standard. While relay manufacturers are responsible to ensure the protection functions meet their stated accuracy and tolerance they are not responsible for the PRL schemes implemented by end users. It should be noted that NERC stated in their 2012 State of Reliability report that more misoperations are occurring in the United States at that time due to relay complexity such as PRL.

If PRL is implemented it should be fully tested in a laboratory environment by the designers before it is sent to the field. Some design groups actually rely upon the field to correct any errors in the implementation which is by definition a bad practice.

Enterprise

Run to Fail (RTF) Maintenance

The simplest maintenance strategy is known as run to failure maintenance. Assets are deliberately allowed to operate until they break down, at which point reactive maintenance is performed. No maintenance, including preventative maintenance, is performed on the asset until the failure occurs. Spare parts must be available to replace the failed part and to maintain equipment availability.

This strategy is useful for assets that, on breakdown, pose no safety risks and have minimal effect on production. While this is okay for a light bulb this strategy does not translate well to electric power systems since for example if a large transformer should fail there is the inevitable outage and the time and labor necessary for a replacement, all of which are major expenses.

The main advantage is minimal planning since maintenance does not need to be scheduled in advance so the requirements are very low. This strategy is also easy to understand. The disadvantages are failures are unpredictable so it is difficult to anticipate when manpower and what parts will be needed for repairs. It is also extremely costly – all costs associated with this strategy must be considered when it is implemented. These costs include production and breakdown costs in addition to direct parts and labor costs associated with performing the maintenance. The maintenance team needs to hold spare parts in inventory in order to accommodate for intermittent failures. Finally it is typical that when one element of a high voltage electric power system fails other interconnected elements in the adjacent area fail as well.

CONCLUSION

This article demonstrates both good and bad practices that are applicable to safety in high voltage electric power system. Much of the advice presented here is based upon real life experience such as working at nuclear power plants that follow a highly regimented set of practices that are periodically reviewed and constantly improved over time. Examples are given for field personnel responsible for testing, design engineers and upper level management at the enterprise level. Unsafe practices can result in the loss of revenue and more importantly human life. Unsafe practices or the lack of good practices invariably lead to relay misoperations or the lack of a critical relay operation when required and called upon to operate.

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Steve has both a BSEE and MSEE from Virginia Tech. He has presented at numerous conferences including Georgia Tech Protective Relay Conference, Western Protective Relay Conference, ECNE, and Doble User Groups, as well as various international conferences. Steve Turner is also a senior member of the IEEE and a member of the IEEE PSRC.