WECC

Transformer Protection for Sudden Pressure Relays

Relay Work Group

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Sudden pressure relays provide an excellent example of the classical protection dilemma between dependability and security. Although dependable for internal transformer faults, sudden pressure relays have limited security against tripping for external events. Trying to balance the tradeoffs of security and dependability has given rise to a variety of application philosophies. This paper identifies some application considerations and describes some of the approaches that protection engineers use throughout the Western Interconnection.

Introduction

A sudden pressure relay is a protection device used to detect transformer or reactor problems. It detects sudden changes in transformer oil or gas pressure due to internal faults. The sudden pressure relay has an inverse time characteristic such that more severe faults will cause faster operation. The sudden pressure relay may be used with other types of power transformer or shunt reactor protective devices.

There are three types of sudden pressure relays—

1. Flow sensing relays;
2. "Under Oil" relays; and
3. "In Gas" relays

The flow sensing relay, commonly called the Buchholz relay, is used only on transformers with conservator tanks. It is mounted on the oil line between the main transformer tank and the conservator tank. The other two types of sudden pressure relays can be used with any type of transformer. They measure changes in gas or oil pressure. A relay placed above the transformer oil measures a change in gas pressure. The relay placed below the oil measures a change in oil pressure. All of these relays are designed with equalizing pressure to prevent false operations for through faults, oil-pump surges, and temperature changes.

The sudden pressure relay detects some types of faults that other relays, like differentials and overcurrents, typically cannot detect. The sudden pressure relay can detect internal faults, such as turn-to-turn faults. Differential or overcurrent relays are required to detect external faults like bushing faults, trouble outside the transformer tank, or internal faults involving ground.

When a turn-to-turn fault occurs, negative sequence current develops in the transformer windings. Advancements in relaying have shown that negative sequence differential protection may detect turn-to-turn faults below the threshold of sensitivity of phase differential protection and provide high-speed tripping as an alternative to sudden pressure relaying (Sudden Pressure Protection for Transformers).

Discussion

Transformer-tank-mounted sudden pressure relays have had a failure prone history. They have misoperated many times because of vibrations from through faults, earthquakes, trains, and other events not related to transformer faults. Typically, a transformer must be taken out of service and tested after operation of a sudden pressure relay, regardless of whether the operation was a misoperation. The Buchholz relay is immune to such misoperations.

Design improvements made to sudden pressure relays have reduced their tendency to misoperate from through faults or vibration from external phenomena. These changes have improved the security of the sudden pressure relays, but have not totally eliminated possible misoperations. Some relays also have two or more sensitivity settings. Decreased sensitivity makes the relay less prone to failure from external events.

It is important to connect the sudden pressure relay properly to the auxiliary tripping device. Most sudden pressure relays use form C contacts. The normally closed contact shorts out the auxiliary tripping coil, while the normally open contact energizes the trip coil. This design reduces the chance of false tripping for contact bounce.

Options

Some utilities choose not to use sudden pressure relays, which prevents misoperations. Faults that a sudden pressure relay is likely to detect may become more severe. The utility that chooses not to use sudden pressure relays may be risking more severe equipment damage; though, many protection engineers question whether a sudden pressure relay really minimizes equipment damage.

Utilities have conscientiously elected to use sudden pressure relays in many different ways. The following examples are found within the Western Interconnection.

Some utilities use sudden pressure relays for alarm indication only. The transformer may be inspected following a sudden pressure alarm. Other utilities elect to operate in the alarm mode normally, only enabling tripping when other transformer protective relays are out of service.

Some utilities enable tripping only on selected transformers. These may be large extra high voltage (EHV) transformers or generator step-up (GSU) transformers.

Current-operated fault detectors are sometimes used to supervise the sudden pressure relay. The fault detector disables sudden pressure tripping for high magnitude internal and external faults that can be detected by other protective devices. When the fault detector is not picked up, sudden pressure tripping is enabled.

Utilities in high seismic zones often disable the sudden pressure relays for several days following an earthquake. This prevents possible misoperations from aftershocks. Sudden pressure relays in high seismic areas should be equipped with mechanical contacts instead of mercury-wetted contacts, as the mercury in those contacts will move during earthquakes and create false trips.

Some utilities may have several sudden pressure devices on a single transformer, either providing redundant protection or in a voting scheme in which many sudden pressure relays must operate to cause a trip.

Older sudden pressure relays, like the General Electric Type J, are being phased out. This relay is particularly prone to misoperation on vibration. A short time delay should be used with a Type J relay if tripping is enabled. This can be done with a suitably connected auxiliary relay. It has also been reported that plugged orifices in the Type J may cause a misoperation.

Some utilities have also experienced problems with metal defects in the sudden pressure relay housing, which have allowed the relay to draw moisture and subsequently misoperate.

The Buchholz relays on conservator-equipped transformers do not appear prone to misoperations on through faults. Utility experience has shown the security of the Buchholz is much higher than other types of pressure relays. Contact surge protection is recommended for the Buchholz relay to prevent surges on the trip circuit.

There is also some concern regarding liability. If a sudden pressure relay is disabled and a transformer or reactor faults, there may be some problems with warranty repairs.

Maintenance

Maintenance of transformers equipped with sudden pressure relays must be done with care. Taking transformer oil samples does involve some risk of a false sudden pressure relay operation if proper procedures are not followed.

Periodic testing of the sudden pressure relay is recommended. The test procedures should follow manufacturer's recommended procedures and may include pressurizing the device to verify operation or testing the trip output circuit.

NERC standard PRC-005 provides requirements for maintenance of sudden pressure relays, including the required activities and maintenance intervals.

Conclusions

The sudden pressure relay is a useful device for protecting transformers and reactors. The sudden pressure relay has unique capabilities to detect faults not normally seen by other protective devices. Other protective devices may detect a sudden pressure type fault, but only after it becomes a more severe fault.

Buchholz relays have the highest security rating of the available sudden pressure detection devices. There is little or no risk of false operation when tripping is enabled. Buchholz relays are recommended for conservator type transformers.

Newer sudden pressure relays are less prone to misoperations, although not 100% secure. Sudden pressure relays should not have mercury-wetted contacts.

Regardless of the care taken in selecting and installing a sudden pressure relay, there remains some risk of false trip. Utilities must accept the risk of an occasional false trip against the consequences of serious transformer damage when the relay is not used.

References

IEEE PSRC Substation Protection Subcommittee K6 Working Group. n.d. "Sudden Pressure Protection for Transformers."

Version History

Modified Date	Modified By	Description
October 21, 1991	RWG	
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