RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

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Question No. 08.02-6

GDC 17 states that electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. APR1400 discusses the UATs and SATs in DCD Tier 2, Section 8.2.1.3. IEEE Std.-666-1991, reaffirmed 1996, “IEEE Design Guide for Electric Power Service Systems for Generating Systems,” recommends, in addition to overcurrent and differential current protection, sudden pressure and ground fault protection in order to fully protect large power transformers. This standard is endorsed in RG 1.204 with regard to the protection provided by these protective schemes against lightning strikes. Please discuss the protection schemes for the large power transformers (MT, UATs, and SATs), in regards to the recommendations in IEEE 666-1991.

Response

In the APR1400, the protection schemes including overcurrent, differential current, sudden pressure and ground fault protection for the large power transformers (MT, UATs, and SATs) are provided in accordance with the recommendations in IEEE 666-1991. Detail descriptions of the protection schemes are as follows:

Main Transformer (MT) Protection

A percentage differential relay (87MT) provides the primary protection against phase and high voltage winding ground faults for the MT. Backup protection is provided by the overall percentage differential relay (87U). Both of these relays are equipped with harmonic restraint to prevent tripping due to transformer magnetizing inrush currents.

The neutral of the high voltage winding of the MT may or may not be effectively grounded depending on system operation. A time delay relay (51GN) for overcurrent protection (50/51GN) and a ground differential relay (87GMT) are provided in the transformer neutral to detect ground faults.

A sudden pressure relay (63MT) provides protection against transformer internal arcing faults. It is sensitive enough to respond to the smallest turn-to-turn fault which would not be detected by the differential relays. An auxiliary interposing relay is used with the sudden pressure relay in order to prevent false tripping of the unit due to transients in the control circuitry.

The sudden pressure relay (63MT) is supervised by the sudden pressure blocking relay (50B).

Ground faults in low voltage winding of the MT are detected by the isolated phase bus ground relay (59GB).

The complete list of the MT protective relays is provided below:

Device No.	Description
50B	Sudden pressure relay blocking relay
50/51GN	MT neutral ground overcurrent relay
59GB	Isolated phase bus ground fault relay
63MT	MT sudden pressure relay
87GMT	MT ground differential relay
87MT	MT differential relay
87U	Unit overall differential relay

UAT and SAT Protection

The primary protection against phase faults in the UATs and SATs are provided by percentage differential relays (87AT and 87ST). These relays are equipped with harmonic restraints to prevent tripping due to transformer magnetizing inrush currents. Relay 87ST also provides the primary protection against ground faults in the SAT high voltage windings.

Since the ground fault current on the high voltage winding of the UATs is limited to a few amperes, ground faults in the UAT high voltage winding cannot be detected by 87AT. These differential relays do not provide sensitive ground fault protection for the low voltage windings since the ground fault current is limited by grounding resistors. The operation of the SAT differential relays trip the switchyard circuit breakers and the medium voltage switchgear main breakers associated with affected SAT and initiates deluge system operation as a fire precaution. The operation of the UAT differential relays trip the unit (i.e., generator), fast transfers the UAT loads to the SAT (except during house load operation), and initiates deluge system operation as a fire precaution.

Backup protection against ground faults in the SAT primary windings is provided by the ground differential relay (87GT) located in the high voltage SAT cable protection panel. Operation of this relay trips the SATs.

Protection against ground faults in the UAT primary windings is provided by the isolated phase bus duct ground fault relay (59GB). Operation of this relay trips the unit and transfers the UAT loads to the SAT (except during house load operation).

Sudden pressure relays (63AT and 63ST) provide sensitive protection against transformer internal faults. They respond to the sudden increase in oil or gas pressure that would occur as heat is generated during an internal fault. An auxiliary interposing relay is used with each sudden pressure relay to prevent false tripping of the main transformer. Tap changer protective relays provide protection against faults in the on load tap changers (OLTCs) of the UATs and SATs. The sudden pressure relays supplied with each UAT and SAT trip the affected UAT and SAT. The sudden pressure relays supplied with each UAT trip the unit and cause an emergency transfer of loads from the UAT to the SAT (except during house load operation). Operation of the separate Buchholz relays generates alarms only.

A final line of defense is provided by overcurrent relays operated by the primary current in the UATs and SATs (50/51). Because of the need to maintain coordination with downstream overcurrent relays, operation of the time overcurrent relays is quite slow and the instantaneous overcurrent relays are not very sensitive. Additional neutral ground overcurrent relay (51GN) in the neutral of the SATs is provided for the detection of ground faults in the SATs primary winding and provides alarm only.

The SAT overcurrent relays trip the SAT. The UAT overcurrent relays trip the unit and causes the loads to be fast transferred to the SAT (except during house load operation).

Protection against ground faults in the secondary windings or in the connections between the UATs and SATs and the medium voltage switchgear main circuit breakers is provided by overcurrent relays located in the neutrals of the 13.8 and 4.16 kV windings (51GN) on both the UATs and SATs. These relays are set to coordinate with the downstream ground fault protective relays. Operation of the SAT ground fault relays trip the SAT. Operation of the UAT ground fault relays trip the unit and transfers the loads from UAT to the SAT (except during house load operation).

The complete list of the UAT and SAT protective relays is provided below:

Device No.	Description
50/51	UAT/SAT overcurrent relay
51GN	UAT/SAT neutral ground overcurrent relay
59GB	Isolated phase bus ground fault
63AT	UAT Sudden pressure relay
63ST	SAT Sudden pressure relay
87AT	UAT Differential relay

87GT	SAT Ground differential relay
87ST	SAT Differential relay

KHNP will add a description of the large transformer protection schemes in DCD Tier 2, Subsection 8.2.1.3.

Impact on DCD

DCD Tier 2, Subsection 8.2.1.3 will be revised as shown in the attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

closed and the MG is connected to the transmission system through the MT and also supplies power to the UATs. The alternate preferred circuit is connected to the high-voltage side of the SATs. In case the power supply is unavailable from the UATs, the power supply is maintained because the onsite non-safety-related and safety-related bus connections are transferred automatically from the UATs to the SATs. When the normal preferred power supply is restored, the transfer from the SATs to the UATs is accomplished manually. The UATs and SATs are three-winding transformers connected to the onsite non-safety-related and safety-related buses through their low-voltage side windings. Both non-safety-related and safety-related buses are normally supplied from the UATs.

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The IPB is used to connect the MG to the GCB. The IPB provides the electrical connection among the GCB, the MT, and the two UATs. The MT is composed of three single-phase transformers that are connected to the two UATs through the IPB.

The GCB is used as a means of providing immediate access of the onsite ac power systems to the offsite power system by isolating the MG from the MT and the UATs and allowing backfeeding of offsite power to the onsite ac power system. The GCB is capable of interrupting normal load current and maximum fault current during transient and various fault conditions. The APR1400 is designed to follow the guidance in Appendix A of Standard Review Plan (SRP) Section 8.2 (Reference 6). After the MT is connected to the transmission network by closing the switchyard breakers with the GCB open, the UATs supply plant startup power to auxiliary and service loads of the APR1400. As part of the normal turbine-generator shutdown process, the GCB is opened to separate the MG from the switchyard when the MG output has been reduced to almost no-load condition. After the MG is disconnected from the switchyard by opening the GCB, the MT remains connected to the network system and backfeeds plant shutdown power to the APR1400 through the UATs during plant shutdown.

The COL applicant is to design the offsite power system to detect, alarm, and automatically clear a single-phase open circuit condition at the primary sides of MT or SATs in accordance with NRC BL-2012-01 (COL 8.2(7)) (Reference 7).

The COL applicant is to describe how testing is performed on the offsite power system components (COL 8.2(8)). The ratings of the MG, GCB, MT, UATs, SATs, and IPB are shown in Table 8.2-1.

The protection schemes including overcurrent, differential current, sudden pressure and ground fault protection for the MT, UATs, and SATs are provided in accordance with the recommendations in IEEE Std. 666 (Reference 23).