RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

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

Docket No. 52-046

RAI No.:	**36-7936**
SRP Section:	**08.02 – Offsite Power System**
Application Section:	**08.02**
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Question No. 08.02-2

DCD Tier 2, Section 8.2.1.3 states that the generator circuit breaker (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 back-feeding 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)."

SRP Section 8.2, Appendix A states:

"Generator circuit breakers should be designed to perform their intended function during steady-state operation, power system transients and major faults. The ratings and required capabilities of a generator circuit breaker are the designated limits of operating characteristics based on definite conditions as defined in IEEE Std C37.013 [Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis] (Reference K in SRP Section 8.2, Appendix A). This standard describes design test procedures and methods that should be performed to demonstrate the ability of a generator circuit breaker to meet the assigned ratings when operating at rated maximum voltage and power frequency."

Provide information on how the APR1400 design follows the guidance found in SRP section 8.2 in Appendix A, "Guidelines for Generator Circuit Breakers/Load Break Switches." More specifically:

1. Describe how the design of the generator circuit breaker complies with the recommendations of Appendix A, including the required capabilities and the test methods to demonstrate the capabilities

2. Describe the synchronizing scheme and whether the synchronizing provision is available at both the GCB and the upstream switchyard breaker

3. Discuss the auxiliary support systems, including additional cooling for such large circuit breakers

4. Describe maintenance strategies for the specific type of circuit breaker (air-blast or SF6) chosen

Response

KHNP provides the information corresponding to each item (numbered 1 through 4) the staff specifically asked in the question, as follows:

1. Compliance with specific guidelines of SRP 8.2, Appendix A

   A. Since the generator circuit breaker (GCB) is designed to be capable of interrupting normal load current and the maximum fault current either from the main generator (MG), or from the grid during transient and various fault conditions, the GCB is used to isolate the MG from the offsite and onsite ac power systems to provide immediate access for the onsite ac power system to the offsite source.

   B. To demonstrate the ability of the GCB to meet the assigned ratings when operating at rated maximum voltage and frequency, the following tests are performed per IEEE Std. C37.013.

Required Capability	Detailed Test Item	Basis for Required Capability (Note 1)	Test Method (Note 1)
Rated Dielectric Strength	• Rated power frequency withstand voltage • Rated full wave impulse withstand voltage	Section 5.4 (Note 2)	Subsection 6.2.2
Load Current Switching	• Minimum number of operations at continuous current switching	Section 5.10 (Note 2)	Subsection 6.2.8
Short Circuit (SC) Current Rating	• Symmetrical interrupting current capability at rated maximum voltage • Asymmetrical interrupting current capability at rated maximum voltage	Section 5.5, 5.8, 5.9, and SC calculation (Note 2)	Subsection 6.2.3
Rated Transient Recovery Voltage (TRV)	• TRV for system source faults - Time-to-crest - Crest voltage - TRV rate • TRV for generator source faults - Time-to-crest - Crest voltage - TRV rate	Section 5.9 (Note 2)	Subsections 6.2.3.7.3, 6.2.4

Required Capability	Detailed Test Item	Basis for Required Capability (Note 1)	Test Method (Note 1)
Short-time Current-Carrying Capability	• Short-time current-carrying capability	Subsection 5.8.2.7 and SC calculation (Note 2)	Subsection 6.2.3.4
Duty Cycle Capability	• Duty cycle	Section 5.5	Subsection 6.2.3.5, Table 11
Transformer Excitation Current Switching Test	• Excitation current switching capability	Section 5.13 (Note 2)	Subsection 6.2.11
Rated Continuous Current-Carrying Test	• Minimum continuous current	Section 5.3 (Note 2)	Subsection 6.2.1
Mechanical Endurance Life Test	• 1,000 no-load mechanical operations 800, 100, and 100 operations are performed at the ambient, minimum, and maximum temperature of the test station, respectively (Note 3).	Subsection 6.2.10	Subsection 6.2.10
Rated Interrupting Time	• Max interrupting time	Section 5.6	Subsection 6.2.6
Short Circuit Current with Delayed Current Zero	• Not required (Note 3) *Rationale: The arc resistance in the short-circuit loop is in series with the considerably smaller resistance of the armature winding of the MG and thus significantly reduces the armature dc time constant. Therefore, considering the high arc voltage of air-blast circuit-breaker, the GCB is guaranteed for delayed current zero fault.*	Subsection 7.3.5.3.5	Subsection 6.2.7

Notes

1. Section or subsection number of IEEE Std. C37.013.
2. Based on the design ratings and/or manufacturers' specific information of the MG, main transformer, and unit auxiliary transformers as applicable.
3. Typical design conditions which are subject to change according to specific design aspects of a manufacturer upon agreement with the client (COL applicant).

C. Trip selectivity

Selectivity of protection between the switchyard power circuit breakers (PCBs) and the GCB is ensured by combined license information 8.2(5) in DCD Tier 2, Chapter 8.

2. Synchronizing scheme and provision

   MG synchronization is performed automatically or manually by the turbine/generator (T/G) control system.

   The automatic synchronizing used in the T/G control system consists of automatic speed matching, voltage matching, and commanding the GCB or a selected switchyard PCB to close within a predetermined band of positive slips.

   For manual synchronization of the MG to the network lines through the GCB or a selected switchyard PCB, the T/G control system and the separate synchronization devices, such as synchro-scope, manual synchronizing relay, synchro-check relay, and synchronism check indicator, are used to assist the operator's manual synchronization operation.

   The synchronism check relay compares the phase angle between the MG terminal voltage and the running bus voltages (isolated phase bus or switchyard bus), with the selection of permissible closing angle. It also compares the magnitude of the MG terminal and the running bus voltages within selectable limits. The close operation is initiated by the manual synchronizing relay when the phase angle and voltage amplitude differences are within the preset limits.

   As mentioned above, the MG synchronizing provision is available for both the GCB and the switchyard PCBs. The controls of the GCB and the switchyard PCBs are provided for MG synchronization to the network. Normally, the GCB is selected for MG synchronization to the network. A switchyard PCB is selected for MG synchronization to the network when the synchronization to the grid network is necessary during house load operation (HLO).

3. Auxiliary support systems, including additional cooling for such large circuit breakers

   Typically, the GCB of the APR1400 is designed to have the following auxiliary systems and components which are subject to change according to specific manufacturer design upon agreement with the client (COL applicant).

   - Breaker Cooling System

     The GCB is furnished with its own integral cooling system to reduce the main conductor temperature and housing temperature to levels consistent with IEEE Std. C37.013. The cooling system is complete with all filters, piping, deionizer, and accessories required for continuous operation.

   - Circuit Breaker Enclosure

     The circuit breaker enclosure is a rigid, self-supporting, welded structure, completely of isolated phase bus construction. It is designed to withstand the

effect of a three-phase short circuit. Being located in the turbine building, the enclosure is dust-tight and drip-proof.

- Instrumentation and Control

  A control cabinet is provided for local operation of the breaker, contains gauges and indicating lights, and is of NEMA Type 12 construction.

  Several alarms are provided as a minimum for local and remote annunciation - high operating pressure alarm, low operating pressure alarm, operating system ac power supply failure, breaker cooling failure, and so forth.

4. Maintenance strategies for the specific type of circuit breaker

   The general inspection and maintenance of the GCB are conducted during overhaul (O/H). In addition, it is recommended to let the manufacturer completely disassemble and inspect the GCB about every 5 to 7 years.

   During general inspection and maintenance of an air-blast type GCB, the tests include at a minimum:

   - Visual examination of GCB
   - Circulation fan and cooling fan tests
   - GCB check tests
   - Auxiliary electrical equipment check tests
   - Alarm tests
   - Control panel check

   KHNP will add IEEE Std. C37.013 in DCD Tier 2, Subsections 8.1.3.3 and 8.2.4, and add a description on application of IEEE Std. C37.013 in Subsection 8.2.2.3.

Impact on DCD

DCD Tier 2, Subsections 8.1.3.3, 8.2.2.3, and 8.2.4 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.

- IEEE Std. 1023, “IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities,” 2004.

- IEEE Std. 1050, “IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations,” 1996.

- IEEE Std. 1313.2, “IEEE Guide for the Application of Insulation Coordination,” 1999.

- IEEE Std. C37.010, “IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis,” 1999.

- IEEE Std. C37.04, “IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers,” 1999.

- IEEE Std. C37.13, “IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures,” 2008.

- IEEE Std. C37.14, “IEEE Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures,” 2002.

- IEEE Std. C37.16, “IEEE Standard for Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage AC (635 V and below) and DC (3200 V and below) Power Circuit Breakers,” 2009.

- IEEE Std. C37.20.1, “IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear,” 2002.

- IEEE Std. C37.20.2, “IEEE Standard for Metal-Clad Switchgear,” 1999.

- IEEE Std. C37.21, “IEEE Standard for Control Switchboards,” 2005.

- IEEE Std. C37.23, “IEEE Standard for Metal-Enclosed Bus,” 2003.

Add

- IEEE Std. C37.013, "IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis," 1997.

NRC Regulatory Guide 1.204

NRC RG 1.204 (Reference 21) is related to the guidelines for lightning protection of nuclear power plants.

The lightning protection of the APR1400 is described in Subsection 8.3.1.1.8. The APR1400 is designed to meet the requirements related to the lightning protection of nuclear power plants in IEEE Std. 665 (Reference 22), IEEE Std. 666 (Reference 23), IEEE Std. 1050 (Reference 24), and IEEE Std. C62.23 (Reference 25).

8.2.2.3 Conformance with NUREG-0800

Standard Review Plan, Section 8.2, Appendix A

The APR1400 has a GCB that is designed and tested in accordance with the SRP Section 8.2, Appendix A. The GCB is designed to perform its intended function during steady-state operation, power system transients, and major faults.

BTP 8-3, "Stability of Offsite Power Systems"

Add

The COL applicant is to analyze the stability of the offsite power systems, as described in GDC 17 (COL 8.2(6)).

BTP 8-6, "Adequacy of Station Electric Distribution System Voltages"

BTP 8-6 (Reference 26) is related to adverse effects on the Class 1E loads that are caused by sustained low grid voltage conditions when the Class 1E buses are connected to offsite power. The APR1400 provides a second level of undervoltage protection with time delays to protect the Class 1E equipment from sustained undervoltages. Conformance with BTP 8-6 is addressed in Subsection 8.3.1.1.3.12.

The ratings and required characteristics of the GCB are the designated limits of operating characteristics based on definite conditions as defined in IEEE Std. C37.013 (Reference 28).

22. IEEE Std. 665-1995, “IEEE Standard for Generating Station Grounding,” Institute of Electrical and Electronics Engineers, 1995.

23. IEEE Std. 666-1991, “IEEE Design Guide for Electric Power Service Systems for Generating Stations,” Institute of Electrical and Electronics Engineers, 1991.

24. IEEE Std. 1050-1996, “IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations,” Institute of Electrical and Electronics Engineers, 1996.

25. IEEE Std. C62.23-1995, “IEEE Application Guide for Surge Protection of Electric Generating Plants,” Institute of Electrical and Electronics Engineers, 1995.

26. NUREG-0800, Standard Review Plan, BTP 8-6, “Adequacy of Station Electric Distribution System Voltages,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

27. NUREG-0800, Standard Review Plan, BTP 8-3, “Stability of Offsite Power Systems,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

Add

28. IEEE Std. C37.013, "IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis," Institute of Electrical and Electronics Engineers, 1997.