Safety Evaluation for the Design of Non-Safety Class Diesel Generator in KJRR

Hagtae Kim [a*], Jun-Yeon Kim [a], Hee-Taek Chae [a]
[a]*Korea Atomic Energy Research Institute*
[*]*Corresponding author: hagtae@kaeri.re.kr*

1. Introduction

A Diesel Generator (DG) is an important emergency electrical system that supplies electrical power to essential non-uninterruptible loads. In the KIJANG Research Reactor (KJRR), the safety class DG is considered an emergency electrical system in the initial stage of the conceptual design, but is not applied due to the cost increase for the manufacturing and qualification of a new small capacity DG. A power supply plan for safety systems including Engineered Safety Features (ESF) is proposed, and the safety of the research reactor is evaluated in this paper to design the non-safety class DG for the KJRR.

2. Design Status

The electrical system of the KJRR consists of a 154 kV power system, primary power system, secondary power system, diesel generator, and a DC power supply and UPS (Uninterruptible Power Supply) system. Among these systems, a 154 kV power system, primary power system, and secondary power system are normal electrical system that supply electrical power during the normal operation, and the rest is an emergency electrical system that supplies electrical power during a Loss of Normal Electric Power (LOEP) [1][2]. In addition, the power supply class based on the electrical system reliability corresponds to Class III. Figure 1 shows the configuration of the electrical system for the KJRR.

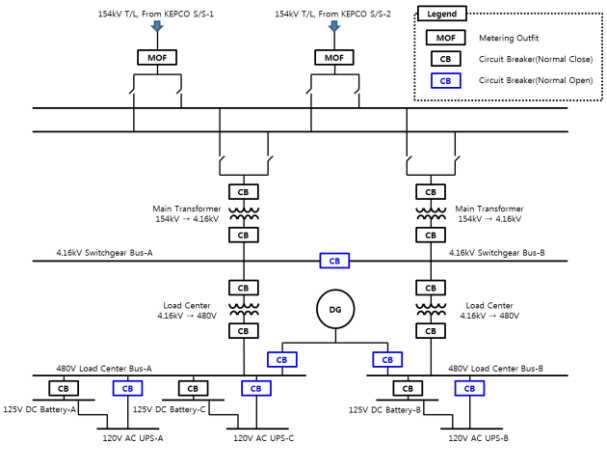

Fig. 1. Block Diagram for the Electrical System of KJRR

The DG is operated automatically when the voltage loss at an essential load center bus is detected, and the electrical power is supplied within 20 seconds by achieving the rated voltage and frequency after the operation signal is received. The DG is not operated in parallel with the normal electric power. Loads are transferred automatically and returned manually.

The DG fuel oil system includes a diesel oil storage tank and a diesel oil day tank and has enough fuel to continuously operate for 24 hours at the rated power. The fuel is transferred from the diesel oil storage tank to the diesel oil day tank through the diesel oil transfer pump, and then supplied from the diesel oil day tank to the DG through gravity.

The classifications of the DG for the KJRR are safety class NNS, Non-Seismic category, quality class T, and electrical class Non-1E. The major loads of the DG are the essential and emergency lighting system, Heating, Ventilating, and Air Conditioning (HVAC) system in the Main Control Room (MCR), the DC power supply, the UPS system, and so on.

3. Power Supply Plan

The IEEE Standard 603 (IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations) advises that Class 1E power should be supplied to the equipment and systems that perform an emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal. The applicable equipment and systems in the KJRR are as follows.

- The Reactor Protection System (RPS) safely shuts down the reactor for the reactor protection and leak prevention of radioactive materials, and actuates the ESF for the mitigation of accident consequences, when a Design Basis Accident (DBA) happens.
- The Confinement Isolation Damper (CID) blocks the release of radioactive materials to the exterior by receiving the signal from the RPS when the fuel damage is detected.
- The Siphon Break Valve (SBV) blocks the continuous loss of coolant by the siphon phenomenon and prevents the core uncovery to the air when the Primary Cooling System (PCS) pipe lower than the core location is broken.
- The Safety Residual Heat Removal System (SRHRS) pump maintains the downward flow while the decay

heat is removed to the safe level when the PCS pump is stopped by the DBA.

Among these equipment and systems, the Class 1E power is supplied to the RPS, SBV, and SRHRS pump from the DC power supply and UPS system in accordance with the IEEE Standard 603. Although functions such as those above are not performed, the Post-Accident Monitoring System (PAMS) also receives the Class 1E power from the DC power supply and UPS system, because the PAMS provides information on the occurrence, process, and condition of an accident to operators during and after DBA to take proper measures. Exceptionally, the Non-Class 1E power is supplied to the CID from the DG to apply the fail close concept considering the safety during a LOEP.

4. Safety Evaluation

As described in the above chapter, most safety equipment and systems receive Class 1E power, and the DC power supply and UPS system are substituted for the DG as a Class 1E power source in the KJRR. A detailed analysis is needed, especially in terms of the duration of the power supply, because there are some differences between the DG and DC power supply and UPS system. Table I compares the characteristic of the DG with the DC power supply and UPS system.

Table I: Characteristic Comparison of the Emergency Electrical System of the KJRR

Item		Diesel generator	DC power supply and UPS system
Classification	Safety	NNS	3
	Seismic	Non	I
	Quality	T	Q
	Electrical	Non-1E	1E
	Power supply	III	I/II
Starting time		Within 20 seconds	Uninterruptible
Operating time		24 hours	1 hour
Major loads		Essential/Emergency lighting, HVAC in the MCR, DC power supply and UPS system	RPS, PAMS, SBV, SRHRS pump

The RPS and SBV are operating within a short time when the electrical power is interrupted by the DBA including a LOEP. Therefore, even though the duration of the power supply is short, the RPS and SBV are able to receive Class 1E power from the DC power supply and UPS system. However, the SRHRS pump should be operated while the decay heat is removed to the safe level. The required operating time for the decay heat removal should be exactly calculated, and then reflected in the capacity of the DC power supply and UPS system.

According to the calculation result of the operating time for the decay heat removal using the critical heat flux correlation, the geometrical shape of the fuel assembly, and conservative decay heat curve for the KJRR, the SRHRS pump should be operated for approximately 20 minutes to meet the acceptance criteria of the critical heat flux ratio [3]. The capacity of the DC power supply and UPS system is determined to be 1 hour by reflecting the calculation result and adding the design margin. As a result, the Class 1E power is able to be supplied to safety systems without the safety class DG.

5. Conclusion

The power supply plan and safety evaluation for the safety systems of the KJRR is proposed in this paper to design the non-safety class DG.

In the KJRR, there are several safety systems that need Class 1E power in accordance with the functional requirement. Among the emergency electrical systems of the KJRR, the power source for Class 1E power is only the safety class DC power supply and UPS system, because the DG is designed as a non-safety class. Therefore, safety systems receive Class 1E power from the DC power supply and UPS system.

The capacity of the DC power supply and UPS system is determined to be 1 hour by considering the operating time of the SRHRS pump that operates for the longest time when a DBA including a LOEP happens. This means that the Class 1E power can be supplied to safety systems that need Class 1E power without the safety class DG.

The results of this paper show that the non-safety class DG does not adversely affect the safety of the KJRR.

REFERENCES

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