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A Study on the Configuration of the Electric Power System in the Defueled Condition

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1. Introduction

Acquisition of licensing change is mandated by Article 21, Section 2 of the Nuclear Safety Act and Article 17 of Enforcement Regulation according to the decision to permanently shut down Kori unit 1 (2015.06.18). Authorization to operate the reactor or to place or retain fuel in the reactor vessel is removed if licensing change for permanent shutdown is approved. Reconfiguration of the electric power system is required according to a new safety analysis and electric loads in the defueled condition. Thus, this paper proposes an approach to reconfigure the electric power system through a review of the new safety analysis and the design criteria of the electric power system.

2. Determining an Electric Power System Configuration

In this section some of the considerations and decision methods used to reconfigure the electric power system are described.

2.1 Review Design Criteria

Reliability of the power supply is one of the most important factors when designing an electric power system of a nuclear power plant. Operation of equipment for residual heat removal is required even after reactor trip, and engineered safety feature facilities shall be operated with-in seconds after a Loss of Coolant Accident(LOCA). For equipment operation, electric power should be supplied. However, reactor protection and reactor coolant pressure boundary integrity are no longer important. Thus, design criteria that are applied to the operating power plant should be reviewed to assess whether they are valid according to an accident analysis of the spent fuel pool.

10CFR 50 Appendix A GDC 17 and 18 describe general design criteria of the electric power system. In the GDC 17, redundancy, independent and diversity requirements for supplying power to safety-related equipment during Design-Basis Accident(DBA) or Anticipated Operational Occurrence(AOO) conditions are described. According to a safety analysis in the defueled condition, approximately 57.34 hours are available to institute an alternative method of pool cooling from the time normal cooling is lost until the pool level decreases to a level approximately 10 feet above the fuel assemblies. The available time continues to increase with the passage of time from reactor shutdown. Safety of the spent fuel pool is assured by make-up water and Kori unit 1 already has a make-up water plan without electric power during loss of spent fuel pool cooling. Thus, GDC 17 and 18 are no longer applied in the defueled condition because the safety of the spent fuel pool is assured without any operation of electric components during loss of spent fuel pool cooling.

Nuclear Safety and Security Commission Notice 2014-15, "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants" describes safety classification and applied standards. The spent fuel pool cooling system and the supporting motive power system are classified as 'Safety Class 3', and electric equipment in Safety Class 3 shall apply KEPIC ENB (IEEE 308, IEEE 603) and applicable IEEE standards. However, IEEE 603, which describes design criteria of the safety system such as single failure criteria, independency, physical identification, common cause failure, etc. is applied to those systems required to protect the public health and safety by functioning to prevent or mitigate the consequences of design basis events. Thus, the design criteria are not applied in the defueled condition.

2.2 Emergency Power

Two emergency diesel generators are installed for Loss of Offsite Power (LOOP) and one common Alternative AC (AAC) generator is installed for Station Black Out(SBO). Also in addition, a common mobile gas turbine generator is installed in accordance with Fukushima nuclear power plant accident follow-up actions.

In the defueled condition, enough time is available during loss of spent fuel pool cooling but one diesel generator is required considering efficiency of plant operation. However, design requirements such as automatic startup within seconds are no longer applied. Power supply to both 4.16kV buses is possible through a tie breaker because the independency requirement is not applied in the defueled condition. SBO coping time of Kori unit 1 is 24 hours but 57.34 hours are available when loss of power occurs in the defueled condition. Therefore, the AAC generator is not needed in the defueled condition. The mobile gas turbine generator has capacity for continuous operation of 72 hours to cope with a long-term SBO like that which occurred at the Fukushima nuclear power plant. The mobile gas turbine generator should be maintained until the available time increases to over 72 hours.

2.3 Offsite Power System

The generator and exciter are no longer operated and the generator circuit breaker is kept in the open position in the defueled condition. Some design criteria of the offsite power system such as the configuration of two physically independent circuits are not applied in the defueled condition. Thus, design of the offsite system can be more flexible in the defueled condition. It is possible to minimize the offsite power system by reducing the use of transmission line or transformers (UAT or SAT) because electric loads are reduced in the defueled condition. However, the offsite power system of Kori unit 1 will be maintained without any changes considering efficiency of plant operation.

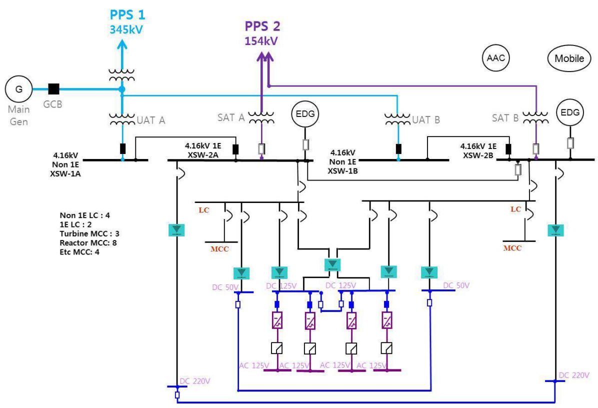

Fig. 1. Electric power system of Kori unit 1

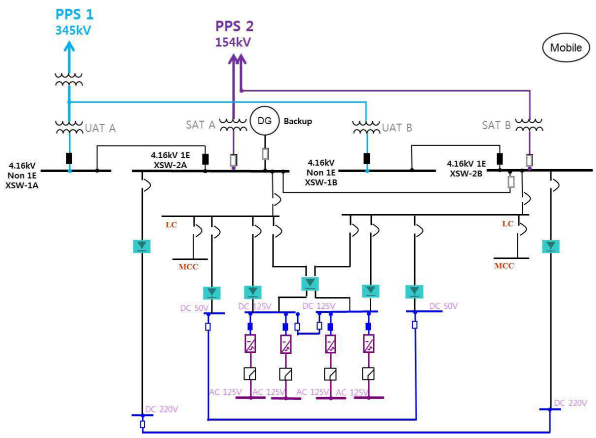

Fig. 2. Electric power system of Kori unit 1 in the defueled condition

2.4 Onsite Power System

The onsite power system provides power to equipment used for plant operation. In the defueled condition, the onsite power system shall provide power to equipment that is needed to operate in the defueled condition or during decommissioning. Some design criteria of the onsite power system such as independency, diversity, etc. are not applied in the defueled condition. Thus, the configuration of the onsite power system can be determined by load locations. It is necessary to make a load list in the defueled condition. The load list should include information regarding each load that is required in the defueled condition or decommissioning. The configuration of the onsite power system can be determined by the load list, and it is useful for the plant operation in the defueled condition.

3. Conclusions

This paper has proposed a method to reconfigure the electric power system through a review of the new safety analysis and design criteria of the electric power system in the defueled condition. Applicability of design criteria has been defined through a review of regulations and the defueled condition.

The configuration of the electric power system of Kori unit 1 in the defueled condition has been introduced considering applicability of design criteria and efficiency of plant operation. The proposed method is useful for determining the configuration of electric power systems for nuclear power plants scheduled to be permanently shut down.

REFERENCES

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