Strategy for Ensuring Non-Safety Related DC Power Supply Integrity on i-SMR

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1. Introduction

In the i-SMR, safety related equipment is powered by non-safety related DC sources. Accordingly, a strategy is required to ensure power supply integrity through appropriate electrical isolation and protective measures.

2. Ensuring Power Supply Integrity on i-SMR

2.1. Key Technical Characteristics

The i-SMR incorporates passive safety systems designed to maintain safety functions through natural forces, such as gravity and natural circulation, even under loss-of-power conditions. Under conditions where power is not lost, the reactor safety system(RSS) is provided. When actuation signals from the engineered safety features component control system(ESF-CCS) and the reactor protection system(RTS) are detected through a two-out-of-four(2oo4) logic, the RSS generates a safety function actuation signal.

2.2. Electrical Power Classification

In large nuclear power plants, safety related systems have traditionally relied on active components, such as motor operated valves and pump, to carry out essential safety functions, including reactor shutdown, core cooling, and containment isolation. Therefore, since power supply to active components was essential to achieve safety functions, both the AC and DC power were classified as safety related system. Because the passive safety systems of the i-SMR can accomplish their safety functions even in the event of a loss of power, both the AC and DC electrical power systems are designated as non-safety related systems.

2.3. Isolation Strategy

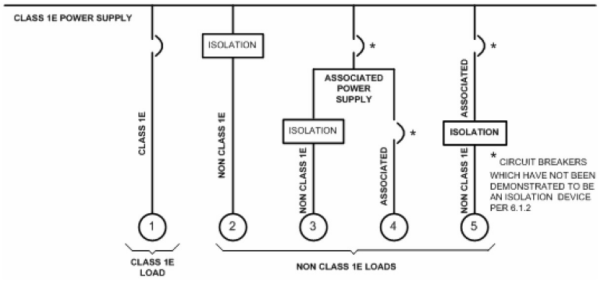
As illustrated in Figure 1, Large nuclear power plants have established, in accordance with IEEE 384, an electrical isolation strategy employing fuses or circuit breakers to preserve the integrity of the safety related power system from the operation of non-safety equipment. For example, the safety related RSS supplies actuation power to passive safety systems incorporating solenoid operated valves(SOVs) and concurrently performs their control functions.

Accordingly, even though the power sources feeding each cabinet of the four independent RSS channels are classified as non-safety related, the design shall ensure single failure tolerance through redundancy.

Furthermore, power quality monitoring circuitry and appropriate isolation devices shall be installed at the RSS system interfaces to isolate only the faulted path upon detection of a failure, thereby maintain continuous power supply to the RSS cabinets via the remaining operable paths. In this context, the isolation device functions as an electrical boundary separating the non-safety power source from the safety related equipment.

This design is consistent with the intent of IEEE 383 to prevent fault energy from being transmitted to safety related equipment by isolating it at the interface boundary, and it complies with the single failure criterion for safety related equipment as specified in IEEE 603.

Figure 1. Examples of association by connection and application of isolation devices



3. Conclusion

Because the electrical power system of the i-SMR is classified as non-safety related based on the design characteristics of its passive safety systems, a distinct approach to isolation device application and power integrity assurance is required, compared to large nuclear power plants that utilize safety related power sources. the i-SMR necessitates a strategy focused on maintaining power integrity despite its non-safety classification. To this end, redundant input power sources shall be provided, and power quality monitoring devices shall be implemented to enable selective isolation of only the faulted circuit, thereby ensuring that degradation of non-safety related power does not impair the actuation of safety functions in safety related equipment. Detailed design considerations for the power quality monitoring devices and isolation devices intended for this purpose require further evaluation.

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REFERENCES

[1] IEEE 384 “IEEE Standard Criteria for Independence of Class 1E Equipment and Circuit”
[2] IEEE 603 “IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations”