APR1400 Electrical Power System Conformance to SECY-91-078

Che-Wung Ha*, Yun-ho Kim
KHNP Central Research Institute, 1312-70 Yuseong-daero, Yuseong-gu, Daejeon 305-343, Korea
**Corresponding author: hachewung@khnp.co.kr*

1. Introduction

In the staff requirements memorandum (SRM) of December 15, 1989, the Commission wanted SERs on the EPRI Utility Requirements Document (URD) submitted to ACRS for review and for the Commission to approve policy issues not previously decided. The URD consists of three volumes; Volume II contains 13 chapters for an evolutionary nuclear plant. SECY-91-078 (henceforth referred to as the SECY) dated March 25, 1991, presented the staff's draft SER for Chapter 11, "Electrical Power Systems" and identified two issues in which they proposed departures from current regulatory requirements or felt there was a need to supplement existing guidance: 1) alternate source of power for non-safety loads and 2) connection of safety bus offsite power sources through non-safety buses. Of the two issues that were presented, the second issue pertains to the discussion of this paper.

Enclosure 1 of the SECY provides an overview of the issue and states that the staff concludes that feeding the safety buses from the offsite power sources through non-safety buses or from a common transformer winding with non-safety loads is not the most reliable configuration. Such an arrangement increases the difficulty in properly regulating voltage at the safety buses, subjects the safety loads to transients caused by the non-safety loads, and adds additional failure points between the offsite power sources and safety loads. Therefore, it is the staff's position that at least one offsite circuit to each redundant safety division should be supplied directly from one of the offsite power sources with no intervening non-safety buses, in such a manner that the offsite source can power the safety buses upon a failure of any non-safety bus.

In this paper, the APR1400 electric power system for NRC-DC was described. In addition, the conformance to SECY 91-078 was evaluated.

2. NRC Interaction on APR1400 Design

2.1 NRC RAI related to SECY-91-078

On May 15, 2015, the NRC issued KHNP RAI 16-7915, Question 08.01-1 noting that both safety and non-safety buses are connected to the same UAT, and similarly for the SAT, rendering the emergency safety buses/switchgear vulnerable to potential failure due to a failure of the non-safety bus/switchgear. In addition, the safety loads could be subjected to transients caused by the non-safety loads, and adds additional failure points between the offsite power sources and the safety loads. Therefore, the staff found that the proposed design does not meet the SECY-91-078 requirements. The proposed design does not provide capability to minimize the probability of losing electric power at the safety bus, since there is potential that the safety buses are vulnerable to potential failures as a result of failures of the non-safety buses. Therefore, the staff stated that the proposed design does not meet the GDC 17 requirement. Since this configuration of the power distribution system does not meet the requirement of the SECY-91-078 and GDC 17, the staff finds this power distribution arrangement unacceptable because connecting both non-safety and safety system to common transformer windings compromises the safety system reliability with no electrical separation.

2.2 Justification of the APR1400 Design Compliance with GDC 17 and SECY-91-078

As stated previously, the offsite power source to the APR1400 has direct connections to the safety buses such that the offsite power supply to the safety buses will not be impacted even upon a failure of any non-safety bus. The direct connection is normally maintained for the APR1400 design as shown in Figure 1 and also adequately secured in the event of a problem with any non-safety bus by proper isolation of the faulted non-safety bus.

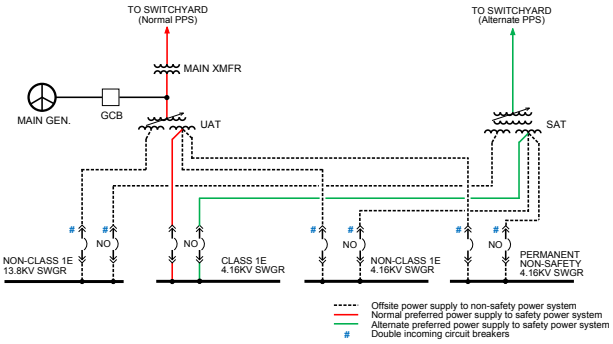

Fig. 1. Simplified Single Line Diagram of APR1400 Offsite Power Circuits

Concerns on the common transformer windings were raised in the discussion of SECY-91-078. However, viewing in the context of the overall plant electrical design, the concerns were not finally included in the final (staff's) position of SECY-91-078. The EPRI ALWR design feature, which was accepted by the staff, also provides common transformer windings for the

safety and non-safety loads when the loads are being fed from either UATs or RAT, as stated in EPRI ALWR Design section above.

Thus, KHNP considers the APR1400 design satisfies the staff's position stated as a minimum requirement in SECY-91-078.

From the discussions addressed in the SECY (Enclosures 1 and 2), it is clear that the issue of concern is the safety related loads having a reliable and available offsite power supply and the reliability of offsite power not being challenged by failures that the non-safety bus could cause. Based on the above, it is shown that the current configuration of the APR1400 satisfies the staff's minimum requirements, and also properly addresses the staff issued concerns beyond the minimum requirement: voltage regulation of the safety buses, ensuring transients caused by non-safety loads do not impact the safety buses, and ensuring that failure points between the offsite power supply and the safety buses are minimized and can be accommodated. Details on how the design addresses these concerns are provided as follows.

1) Voltage regulation of the safety buses

Technical report APR1400-E-E-NR-14001-P "Onsite AC Power System Analysis" includes a description of the voltage regulation study that was performed on the framework of the onsite power system analysis. The on-load tap changers (OLTCs) that are equipped at the primary side of the UATs and SATs ensure that the voltage regulation at the MV safety buses is maintained in the range of 97.5% to 102%. The voltage range of the MV safety buses satisfies the criteria for acceptable operating voltage conditions of the safety loads under design conditions.

2) Transients on the safety buses caused by the non-safety buses

The safety buses have the potential transients to be caused by a variety of accidents or operating occurrences on the non-safety buses such as large motor starting, motor re-acceleration during a bus transfer condition, or a short circuit accident on a non-safety bus. The potential impact of transients from the non-safety loads were properly identified and assessed for the APR1400 design. A large motor starting study has been performed and the results of the study demonstrate that voltage variation at the safety buses is maintained within acceptable limits during the non-safety large motor starting condition. The transient effect of re-acceleration of non-safety motors during a bus transfer is assessed by the fast bus transfer study and the result of the study concludes that the reacceleration of non-safety motors do not hinder the re-acceleration of the safety motors.

A short-circuit event is another non-safety load transient condition that could have a potential impact on the safety loads. When a short-circuit event occurs (such as a phase fault or ground fault) on a non-safety load or bus, the event can cause a temporary voltage dip on the safety buses which share the same transformer winding with the faulted non-safety load or bus. To prevent unintended tripping of the safety buses during a temporary fault condition, a time delay is provided for the protective devices (i.e., under-voltage relays) on the safety buses such that the safety buses remain connected during the fault clearing time of the non-safety circuit. These relays are Class 1E, which have proven to be reliable in the industry and will be periodically tested.

3) Additional failure points between the offsite power sources and the safety loads

Unlike the EPRI ALWR design, the safety buses of APR1400 are directly connected to offsite power source through the normal and alternate PPS circuits. Since the offsite power source is directly connected to the safety power system, there is no electrical bus and its associated components (e.g. circuit breakers, relays, etc.) that constitute a failure point between the offsite power source and the safety buses.

With the current design, a failure at the connections from the SAT or UAT secondary windings to non-Class 1E buses is possible. The coverage of UAT (or SAT) protection zone encompasses the connections to Class 1E and non-Class 1E buses. An electrical fault (short circuit fault or ground fault) at a connection to safety or non-safety bus will be detected by UAT (or SAT) differential relay or UAT (or SAT) neutral ground overcurrent relay and this will result in tripping of the upstream circuit breaker (e.g., generator circuit breaker and switchyard circuit breakers, as applicable) and causing a swap of the power to the alternate PPS.

3. Conclusions

The APR1400 does not have an intervening non-safety bus in the current offsite to onsite electrical configuration; however, the design does include non-safety and safety buses coming from the same secondary side 4.16 kV transformer winding.

Nevertheless, the APR1400 has designed the electrical interface system between offsite and onsite power with enhanced reliability measures to ensure that the non-safety system will not impact the safety loads. The design complies with GDC 17 and also conforms to SECY-91-078.

REFERENCES

[1] APR1400-E-E-NR-14001-P Rev.0, "Onsite AC Power System Analysis," November 2014.

[2] 10 CFR Part 50, Appendix A, General Design Criterion 17, "Electric Power Systems," U.S. Nuclear Regulatory Commission.

[3] SECY-91-078, "EPRI's Requirements Document and Additional Evolutionary LWR Certification Issues", 1991.

.