Replacement and improvement of Nuclear Instrumentation System (RPN) for Ulchin Nuclear Power Plant Units (UCN) 1&2

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1. Introduction

The BF_3 proportional counter, Compensated Ion Chamber (CIC) and Uncompensated Ion Chamber (UIC) are now used for Nuclear Instrumentation System (RPN) for Ulchin nuclear power plant 1&2 (UCN1&2). These detectors have short lifetimes compared with that of Fission Chamber (FC). Therefore, they must be replaced more frequently due to their short life time during the operation of the power plant. The improved RPN uses one type of detector, which is FC, for Source Range (SR), Intermediate Range (IR) and Power Range (PR). This will standardize the equipment and reduce the cost and personnel radiation exposure. In addition, the improved design for fire protection and the new configuration of RPN will improve the operability and availability of the plant. The detailed features of new RPN and their effects are described in this paper.

2. Methods and Results

In this section, some of the techniques used to replace the existing system with the new improved RPN are described. The scope of the replacement and improvement of RPN is the detector, the cable and the connection, the signal processing drawer and fire protection.

2.1 Detector

The fission chamber based detectors as the neutron sensitive element will be exclusively used in the improved RPN system. This contrasts with the existing RPN where three types of detectors (BF3, CIC and UIC) are used for SR, IR and PR. These BF3, CIC and UIC have a qualified design life of approximately 5 years, 10 years respectively, whereas the FC used in improved RPN will suffer less than a one percent burn-up of the U-235 in 40 years of full power operation. That is, the detector (FC) has a forty (40) years design life and will, therefore, result in less personnel exposure than a detector (BF3, CIC and UIC) which must be replaced periodically.

In new RPN system, the Detector Assembly for SR and IR channels contains two unguarded fission chambers that operate over the full twelve decades of neutron flux. Two fission chambers in the assembly are used for increased neutron sensitivity in the SR, while the one of two detectors in the assembly is used for IR. The two fission chambers are mounted side by side within the detector housing. Each detector assembly for PR channel consists of two (2) guarded fission chambers stacked vertically to permit axial flux measurement like a UIC used in the existing RPN. [Refer to Figure 1 for the configuration of detector assemblies.]

The main advantage of using fission chambers is their long lifetime, which eliminates the preventative maintenance requirement of changing-out UICs every 10-12 years, resulting in significant reductions in cost (replacement hardware and labor) and man-rem exposure. Another advantage of using fission chambers is their superior performance over UICs in the Power Range when it comes to detecting neutrons. In a UIC up to 8% of the signal comes from gammas (not neutrons), which are not compensated for in the Power Range since they are usually proportional to reactor power. However, should an event occur that affects the gamma to neutron flux ratio, the UIC-based system would be inaccurate. With a guarded fission chamber, nearly 100% of the signal is due to neutrons due to its inherent gamma discrimination

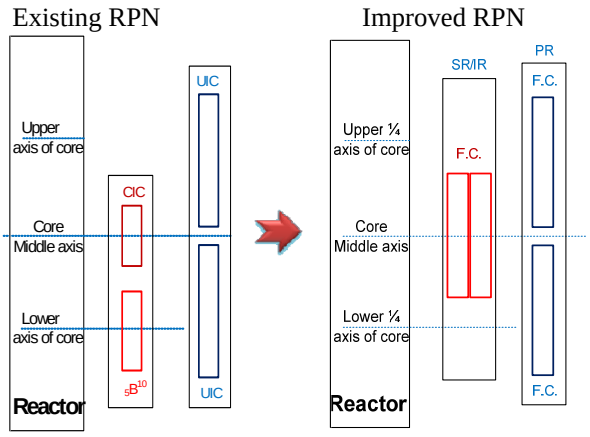

Figure 1. The configuration of detector assemblies for the current RPN and the improved RPN

2.2 Cable and Connection

The detector is connected by an integral coaxial cable to a connection plate located on the top part of the instrument well in the existing RPN system. The place where a connection box is installed makes it more difficult to replace detector assembly and cables since it

is high radiation area, whereas the detector cable connection of the improved RPN will be located within the containment but outside of the secondary shield, and shall serve as an enclosed junction point for the cable between the detector integral cable and the in-containment cable. Therefore, It will be easier to replace and work than existing RPN system.

The individual fission chamber detectors, cables, and connectors within the containment will be protected from the DBE pressure and chemical sprays by the Detector Assembly housing, cable junction box or connection box, and the stainless steel flexible metal hose cable or qualified cable.

2.3 Signal Processing drawer

The improved RPN was designed to be tested with a minimum of effort on the part of the technician. For normal surveillance activities, the equipment may be tested entirely from the front panel without racking out the drawer.

In addition, the bypass and the trip key switches, which will be added to the improved RPN, allows the operator to either block a specific wide range or power range signal or set it to the trip state. By setting the bypass position switch to a particular signal and thereby blocking any possible input for this signal, the operator can change the 2 of 4 circuits to a 2 of 3. With these option switches, one wide range (SR and IR) and one power range signals can be bypassed.

2.4 Fire protection

There is no provision to monitor the nuclear power in other area than MCR or computer room in case of fire in these area in the existing RPN, whereas the remote source range and intermediate range indication in the improved RPN will be possible in the remote area for fire protection in case of fire in the MCR or the computer room according to the Appendix R requirement [1,2,5] for safe shutdown capability from outside the control room. The qualified isolator [4] shall provide a fault tolerant and isolation between the amplifier assembly output to signal processor drawer in the RPN cabinet and the amplifier assembly output to the remote SR/IR signal processing enclosure. Refer to figure 2 for the configuration of improved RPN for fire protection in the control room.

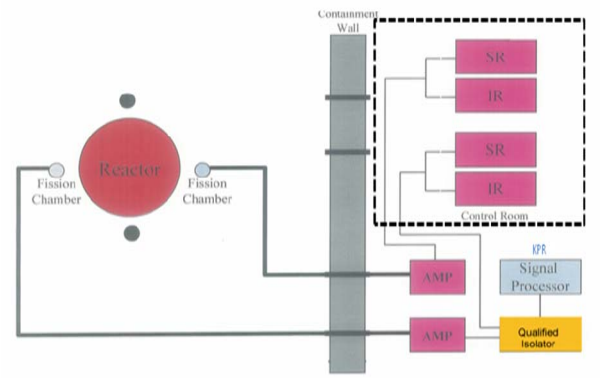

Figure 2. RPN Configuration for fire protection in control room

3. Conclusions

The detectors used in the improved RPN have a 40-year design life, eliminating the need to periodical replacement limited by lifetime of BF-3 SR detector assemblies, CIC IR detector assemblies and UIC PR detector assemblies. In addition, the improved RPN has been designed for satisfaction of Appendix R requirements, ease of installation, operation and maintenance. Therefore improved RPN will bring great benefits into the operation of Ulchin nuclear power plant 1&2.

REFERENCES

[1] IEEE Std. 323-2003, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations".
[2] 10CFR50 Appendix A, January 2000, "General Design Criteria for Nuclear Power Plants".
[3] R.A Dubridge, "Campbell Theorem-System Concept", IEEE Trans. on NS, Feb. 1967.
[4] Thermo Gamma-Metrics Qualification report No.843, “Class 1E Qualification of the remote source and Intermediate Range Appendix R Channel for Korea Hydro and nuclear power company KORI nuclear power plant units 1 and 2.
[5] NUREG-0800 Chapter 9.5.1, "Fire Protection Program", Rev.03, July 1981.