Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 12-13, 2016

Studies of Effect Analysis of Electromagnetic Pulses (EMP) in Operating Nuclear Power Plants (NPP)

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1. Introduction

The effect analysis of electromagnetic pulses (EMPs) has been studied for the past year by the Central Research Institute of Korea Hydro Nuclear Power Co. (KHNP) in order to better establish safety measures in operating nuclear power plants.

What is an electromagnetic pulse (EMP)? As a general term for high-power electromagnetic radiation, it refers to strong electromagnetic pulses that destroy only electronic equipment devices in a short period without loss of life. Accurate records of Dr. Fermi's early electromagnetic pulse phenomenon predictions do not remain, but EMPs were identified when nuclear tests of the 1950s were conducted in the United States. In 1962, high-altitude nuclear tests were conducted over the Pacific Ocean, causing street lights to go out in Hawaii, more than 1000 km away from the testing area, as well as leading to the malfunction or stoppage of emergency communication facilities and various types of electronic equipment. Three EMP threats that can specifically be threats to operating nuclear power plants are shown in Figure 1.

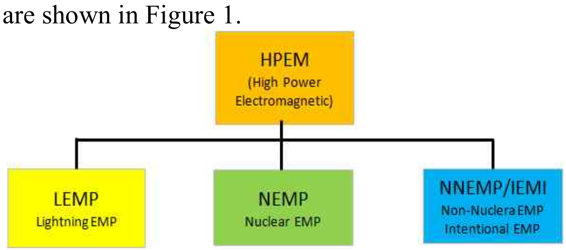

Fig. 1. Three major EMP threats to nuclear power plants

2. Reviews of EMP Research

In this section some of the technical standards and research used to analyze EMPs are described. The technical standards include a review of high-altitude EMP (HEMP) having a signal characteristic.

2.1 Reviews for Signal Characteristics of High-Altitude EMP (HEMP)

Generally, nuclear EMPs (NEMP) can have the most serious impact on operating nuclear power plants. The electromagnetic pulse emitted during nuclear explosions can lead to severe damage of the wider area. Nuclear EMPs are typically measured with E1 (initial pulse), E2 (mid-pulse), and E3 (end pulse) during an explosion over an altitude of 30 Km as well as following signal characteristics. E1 is the electric field of about 50 kV/m during no less than about 1 microsecond (μs). E2 is the hundreds of the electric field in V/m during one millisecond (ms), and E3 is the electric field of several tens of mV/m in about 20 seconds (s). They all have signal characteristics and last as shown in Figure 2. In the influencing frequency band, E1 is the most powerful initial EMP to the GHz band, E2 is similar to the surge waveform kHz band. E3, which contains a frequency component to the band Hz (about 100 Hz), is similar to geomagnetic storms. E1 and E2 damage electronic equipment in computers and communication devices. E3 in several hundred km long power lines or communication lines can influence the transformer and the communication systems [1][2].

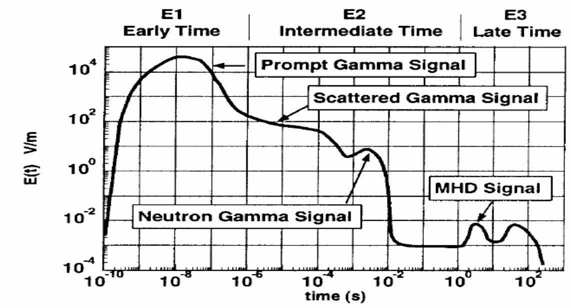

Fig. 2. Frequency characteristics for HEMP

Table 1: EMP occurrence time in frequency bands

	Occurrence Time	Frequency
E1	t < 1 μs	1 MHz ~ 1 GHz
E2	1 μs < t < 1 sec	1 kHz ~ 100 kHz
E3	t > 1sec	~1 Hz

2.2 Research of EMP in US Nuclear Power Plants (NPPs)

The US Nuclear Regulatory Authority (NRC) has already presented the results of an evaluation through a technical report (NUREG/CR-3069) in 1983. In that report, it shows that it is possible to keep a plant safe under shutdown capability for nuclear EMP attack. The EMP propagation path of the nuclear power plant can be regarded as a direct infiltration, with propagation through the ground power grid connected to the power plant. This causes induced current generated at the control network inside of the critical system and power lines in the building of the power plant.

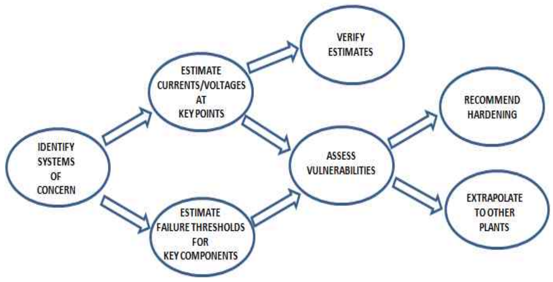

Fig. 3. Approach to the impact analysis of EMP in NPPs

The reactor safety stop system was selected as the target of the EMP impact analysis at Watts Bar NPP, Tennessee, USA, and the approach to this is shown in Figure 3[3]. In addition, the EMP threat from sabotage and terrorism in a commercial nuclear power plant was excluded because of the small intensity threat and low regional threat. The results of EMP effect analysis show less possibility of failure in the tested individual equipment. It was also confirmed that there is no possibility of simultaneous failure for devices in charge of the safety shutdown in the NPP. The spread of electromagnetic pulses in buildings of seismic Grade I was identified as very weak.

2.3 Technical Standards of EMP

MIL-STD-188-125-1 presents design goals and the minimum requirements for the protection of major facilities (C4I, Command, Control, Communication, Computer, and Intelligence) from high-altitude electromagnetic pulses (HEMP). The shielding performance (SE, Shielding effectiveness) test of protection facilities against emitted HEMP, and the opening of the structure, such as for a communication line and a power line (POE, Point of Entry) induced pulse current through the NPP (PCI, Pulsed Current Injection) are reflected in technical standards for testing, as shown in Figure 4[4]~[7].

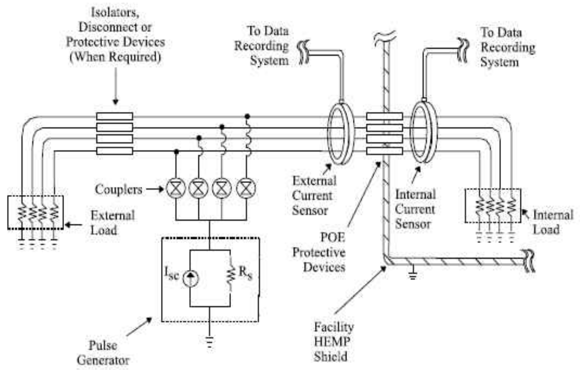

Fig. 4. Typical PCI test configurations

Tests should be conducted for demonstrating that the installed HEMP protection subsystem provides the required HEMP hardness. Such tests should be performed after the construction and acceptance testing are complete and after the equipment is installed and functioning to determine if the operational system suffers mission-aborting damage or upset due to simulated HEMP excitations.

3. Conclusions

The effect analysis of EMPs in operating NPPs and their corresponding safety measures in terms of selecting target devices against EMP impact have been examined in this paper. In general, domestic nuclear power plants do apply the design of fail-safe concepts. For example, if key instruments of a system fail because of EMPs, the control rods of a nuclear reactor are dropped automatically in order to maintain safe conditions of the NPP. Reactor cooling presents no problem because the diesel generator will adopt the analog starting circuit least affected by the electromagnetic waves. Therefore, developing nuclear EMP-effect operating scenarios and evaluation criteria are expected to establish the safety measures as a result EMP effect analysis.

REFERENCES

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