1. Introduction

This study is intended to determine whether the external electromagnetic waves, such as electromagnetic pulse could affect nuclear power plants. Electromagnetic pulse (EMP) effects can be divided into radiative and conductive, and radiative paths are transmitted through the space and affect through the openings of the structure and through the concrete structure. The conductive path affects the logic operating device by electromagnetic pulses induced by voltage or current through power cable, control cable, etc.[1].

2. Method

This study refers to NUREG / CR-3069, ITU-T K.81, and IEC 61000-5-9, an international study on electromagnetic pulses [2, 3, 4]. The evaluation criteria were established in order of definition of threat level of external electromagnetic pulse, analysis of coupling to logic operating device through evaluation of electromagnetic pulse transmission path of nuclear power plant, and damage level of electromagnetic pulse. We approached the process of assessing the impact by analyzing the data obtained in each process. Electromagnetic pulse threat level standards are separated by copied and conducting threat and radiated threat IEC 61000-2-9, Mil-Std-461F standards related to conducting threat level standard was used for the parameters specified in the strictest Mil-Std-188-125-1. Fig. 2-2 shows the waveform of the double exponential function, which is divided into the initial electromagnetic pulse waveform and the mid-term electromagnetic pulse waveform. Each parameter is shown in Table 2-2. This criterion is applicable to cables exposed outside of nuclear power plant structures.

### Table 2-1. Radiated threat level criteria

<table>
<thead>
<tr>
<th>Classify</th>
<th>Rise time</th>
<th>Pulse width</th>
<th>Source impedance</th>
<th>Peak value current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early-time</td>
<td>2.5ns</td>
<td>23ns</td>
<td>377Ω</td>
<td>50kV/m</td>
</tr>
</tbody>
</table>

### Table 2-2. Conductive threat level criteria

<table>
<thead>
<tr>
<th>Classify</th>
<th>Rise time</th>
<th>Pulse width</th>
<th>Source impedance</th>
<th>Peak value current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early-time</td>
<td>20ns</td>
<td>Less 500ns</td>
<td>60Ω</td>
<td>5kA±10%</td>
</tr>
<tr>
<td>Intermediate time</td>
<td>1.5us±30%</td>
<td>4ms±2 5%</td>
<td>10Ω</td>
<td>250A±10%</td>
</tr>
</tbody>
</table>


\[ I(t) = K_{DE} \left( e^{\mu t} - e^{\mu t} \right) \quad (2-2) \]

Here, the maximum instantaneous current, \( I(t) \) is the time (s), \( K_{DE}, \alpha, \beta \) are a function of the FWHM, the time it takes to rise from 10% of the maximum current up to 90%. FWHM is 50% of the maximum current. It indicates the time (pulse width) between the branches [13].

3. Results and Discussions

3-1 Radiated effect analysis

The minimum number of formations passing logical operation device through simulation is calculated by multiplying the back shielding performance was analyzed using the design data. Source used for the simulation is analyzed by a waveform showing an electric field intensity in a time domain representation to Fig. 3-1, by applying the waveform E1 of IEC 61000-2-9.

![Fig. 3-1. Source waveform for radiated simulation](image)

3-2 Conductivity effect analysis

Using the Mil-Std-188-125-1, PCI waveforms for the logic operating equipment, the immunity levels for the components are analyzed. In order to apply the setting criteria, the transformer's noise calculation, cable cross-sectional allowable current and cable length were examined. As a result of the frequency response obtained through the conductive threat level based on the simulation and testing to establish a conductive path from the frequency response characteristics can be used to calculate the conductivity of the threat level to the control unit. Further, as compared with the resistance level of controlled device obtained through the test was an electromagnetic pulse effect analysis.

3-3 Part resistance level analysis

Resistance tests were analyzed using the same physical board or component used in nuclear power plants. The lower power input electromagnetic pulse signal (Mil-Std-461F CS115, it was the resistance test to the pulse from the A 51 A in accordance with the evaluation criteria of the CS116. Signal of the PCI test of Mil-Std-188-125-1) The low levels of the board or components were analyzed progressively from level to 1 kA.

3-4 Effect Analysis Comparison

Effects were analyzed by comparing the current conductive transfer parts broken current delivered to the logic operation unit through the simulation. Conducting the safety margin of the logical operation device can be determined by applying a transfer current and a current break in the formula (3-1),

\[ \text{Conductive safety margin} = \frac{\text{damaged current} - [\text{dB}] - \text{transfer current}}{20 \log_{10} \text{transfer current}} \]

4. Conclusions

A study was conducted to analyze whether electromagnetic pulses could affect nuclear power plants. For the analysis of logic operating devices, the evaluation control board, external electromagnetic pulse threat level definition, coupling analysis to control devices through electromagnetic pulse transmission path evaluation, damage level evaluation, and data obtained from each process are analyzed and compared to analyze the impact of electromagnetic pulse. It summarizes the conclusions on the impact of conducted and radiated electromagnetic pulses evaluated through a process of analysis.

We have experienced copy effects logical operation device depend on a structure which is protected by a reinforced concrete structure at least a number of shielding, radiated electromagnetic pulse level to penetrate into the interior structure has been determined to be lower.

Conductive threat voltage level look at the conductive effect is transmitted to the logic operation unit, the current threat level, the peak value was confirmed to be very low when compared with the resistance level of the control board a DC-DC converter of the conductive threat level that is passed to the control unit.

Results safety margin the breakage current and current delivered when compared to the resistance level and the threat level of the logical operation unit is applied to the calculation showed a sufficient resistance to electromagnetic pulse threat level that is passed through a conductive path to a positive value.

Therefore, considering the analysis of the effects of the radiated and conductive electromagnetic pulses, we analyzed the results of the simulation that there was no effect on the operation function of the logic operation device when electromagnetic pulses were generated. Even if exposed to it, could be confirmed that there is no problem in maintaining safety.
REFERENCES