

## Analysis of EMI Test on Digital System for Integral Reactor

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### I. Introduction

Due to the recent development of computer engineering and digital technology, modern digital instrumentation & control systems are being innovatively developed in industrial plants and the conservative atomic energy related I&C systems in nuclear power plants are also showing a tendency to replace some analog equipment with digital one through restrictive introduction of new technologies.

Because of high operating frequency and low operating voltage, digital equipment is recognized to be weak in electromagnetic interference compared with analog equipment. As most I&CS system in Integral Reactor such as SMART are composed of digital equipment which is relatively vulnerable of environmental conditions. The inspection of instruments against electromagnetic interference is indispensable.

The I&C equipment & system should be designed and tested to verify the compatibility with requirements of electromagnetic interference in Reg. Guide 1.180 and EPRI-TR-102323

This paper involves the test details and result analysis according to the standard of electromagnetic waves targeting on some equipment of the Integral Reactor digital I&C systems, and the test result analysis will be used in designing each equipment.

### 2. Test & Equipment Requirements

#### 2.1. Test Requirements

##### 1) Nuclear Energy Regulation Guides

-Reg. Guide 1.180 (Jan, 2000)

Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems

-EPRI-TR-102323 Rev. 1 (Jan, 1997)

Guidelines for Electromagnetic Interference Testing in Power Plant

##### 2) Test Details

According to Reg. Guide 1.180, an electromagnetic interference testing standard, the electromagnetic interference testing details are as follows;

-Conduction Emission Test

-Conduction Compatibility Test

-Radiation Emission Test

-Radiation Compatibility Test

#### 2.2 Test Facilities

- Shielding Room

Shielding facilities, which shut out the noises of electromagnetic waves outside the testing space, should secure the minimum space necessary for operating EUT & testing equipment as the picture below, and the noise level of each testing room should be lower than each limit level by 6dB.

- RF Shielding Material

When testing RE & RS, RF Shielding Material should be attached to the surface of a wall and the ceiling round EUT(Equipment Under Test) & antenna in order to minimize the reflection of electromagnetic waves inside the shielded room and to improve test accuracy and reproduction. Material requirements are as follows.

Table 1. RF Shielding Material Requirements  
(Normal Incidence)

Frequency	Minimum Absorptions
80MHz - 250MHz	6dB
Over 250MHz	10dB

### 3. EUT Operation Requirements

#### 3.1 EUT & MMI Equipment

##### 1) EUT Outline

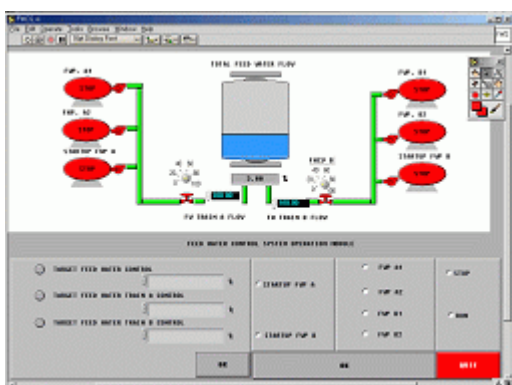
EUT conducts some functions of output control and water control and operates by means of both manual and automatic control.

In manual control way, an operator manipulates objects using MMI equipment and this order is delivered to I&C System in order that the I&C System may analyze the delivered order and control the objects demanded.

In automatic control way, as the control amount is programmed according to the operating mode, I&C System controls objects by means of the programmed control amount according to the current operating mode.

##### 2) MMI Equipment Outline

MMI equipment provides reproduction of the incoming signal of EUT output & water control system. It also monitors the output signal of the output & water control system in order to confirm the state of output & water control. Picture 1 is about MMI Screen for water control. An operator performs operating mode control, output control and water control through MMI equipment. MMI equipment, which is composed of output & water control system rack, Interface rack and industrial PCs, is offered the incoming signal and sends the output signal via Interface rack.



Picture 1. Water Control MMI Screen

#### 4. Test Result Analysis

Digital I&C system should have soundness against electromagnetic interference in plant environments in order to carry out its essential functions. Therefore, the test of I&C system verification equipment was conducted according to the standard of electromagnetic waves, and after undergoing valuation and complement, the test result will be used in designing.

Total 8 kinds of tests were conducted for the electromagnetic interference test of I&C system verification equipment. The tested verification equipment was composed of an output control system rack, a water control system rack, and a fan for ventilation including a cabinet, and the electromagnetic interference test was conducted inside the shielding room with the limit of the number of persons as in the Picture 2.

Out of the total 8 tests, 6 test results were suited to the standard, but 2 were not. The result of CE102 test exceeded the standard level by 2dB within the range between 10kHz and 20kHz, and the result of RE102 test exceeded the standard level by maximum 35dB within the range between 1MHz and 200MHz. The noise produced by the arcnet card of 5Mbps for communication was confirmed as a cause of noises.



Picture 2. RS103 EMI Test

According to the test result, complementary measures are required in some aspects. The cabinet input device needs a minute filter to remove the conducted noises by way of the power cable. And currently, the open piercing hole for the power cable & signal cable at the lower part of the cabinet and the fan at the upper part of the cabinet should be shielded.

#### 5. Conclusion

As digital equipment should conduct its normal functions and performances in ambient environments, inspection of instruments is indispensable in the course of changing analog equipment of I&C systems into digital equipment. Digital equipment is recognized to be very weak in electromagnetic interference. Therefore, tests should be carried out necessarily according to the standard of electromagnetic waves related to the nuclear plants.

Test result will be applied for instrument & control system for integral reactor.

#### REFERENCES

- [1] Regulatory Guide 1.180, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems" 2000.
- [2] EPRI-TR-102323, "Guidelines for Electromagnetic Interference Testing in Power Plant" 1997.

#### Acknowledgements

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