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A Test-Bed approach for the evaluation of sub-systems and components in PPS

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1. Introduction

Design basis threat (DBT) must be renewed every three years based on “the act of physical protection and radiological emergency” in Korea. Nuclear facilities should upgrade their PPS coping with the new national DBT. Redesigning the PPS can be a process of trial and error. The process should be performed by a quantitative analysis considering an effectiveness and efficiency of the PPS. Evaluation is based on the performance tests of series of subsystems and components [1].

However, full testing of the PPS in operational facility may not be easy and practical since the test itself would disturb the operation of the facility. Hence, this paper proposes a Test-Bed approach for the evaluation of subsystems and components in the PPS. The Test-Bed is an experimental platform for assessing the performance of detection and delay systems in the PPS. The paper discusses on the objectives, installation and experimental operation of the Test-Bed.

2. Objectives of PPS Test-Bed

The objectives of the Test-Bed are as follows:

• Analyze vulnerabilities of new components in the PPS, especially on interference with other components.
• Prepare a backup document for installation and operation of the current and future PPS
• Develop a quantitative tool for analyzing and testing subsystems and components in the PPS

3. The Test-Bed Construction

The Test-Bed is currently under construction. The basic structures are shown in figure 1. The dimensions of the system itself are 15 by 15m. The fences are 4m wide and 3m high. A control box which can observe, collect, and analysis sensor data just as one would perform at a real facility is located beside the fences. The sensor bed surface is gravel, because it is an ideal surface material and it is also used at the facilities. Component specifications are similar to those found at the facilities.

The final schematic design of the Test-Bed system is shown in figure 2. It has fences, infrared sensors, fence disturbance sensors, CCTV cameras, and security lights (similar to the type used at real nuclear facilities). The sensors can be movable for finding optimum design of each facility.

Fig. 1. Test-Bed system under construction

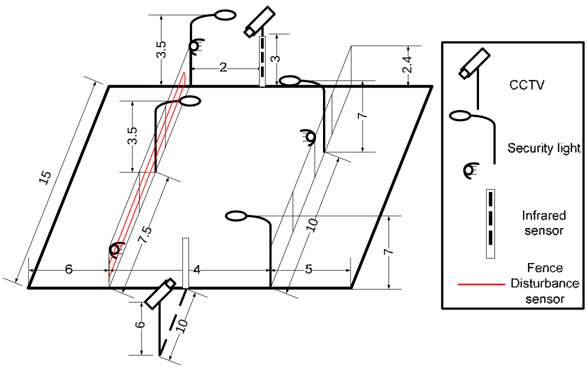

Fig. 2. Final Test-Bed system outline

4. The Test-Bed Operation

4.1 Infrared sensors

An infrared sensor (IR) detects changes in the signal power of a line-of-sight IR beam between a transmitter and a receiver.

Three tests plans are designed for IR sensor test. The first is a performance test on the probability of detection (Pd) and the nuisance alarm rate (NAR), the second is an investigation of the vulnerability to defeat, and the third is an evaluation of the detection zone.

Performance database and test guidelines of IR sensors can be obtained from the performance tests. These results can be used to help create a PPS analysis program similar to that of the SAPE (System Analysis of Physical Protection Effectiveness) program.

Installation guidelines used for Korean nuclear facilities can be obtained from other tests as well. Many nuclear facilities install IR sensors only with the aid of the vendor’s installation guidelines which are optimized to the conditions of their country.

4.2 Fences and Fence disturbance sensors

A fence disturbance sensor is designed to be mounted on a chain-link fence to detect noises or motions generated by an intruder.

The basic test concepts and results of this sensor are similar to those of the IR sensors. Following factors are considered to make test plans: Electromagnetic force is major operational principle, so test focuses on this force. Degradation of the fence structure may lead to a malfunction of a sensor, so fence compatibility (determined by a post pull test and fabric tension test) should be evaluated. The performance of each individual sensor is different depending on the location of the sensor, so it should be evaluated for it unique condition along the entire sensor network.

4.3 CCTV and security lights

Alarm assessments are completed by security personnel determining whether or not an alarm is activated by a real threat or accident. The general method of assessment is conducted by CCTV cameras.

Artificial lighting allows exterior cameras to operate at night. The lights should be installed above the camera, so they do not interfere with video quality. Unfortunately, many nuclear facilities can not satisfy this condition. Therefore, recently it has become a significant security issue at the facilities.

The test focuses on the compatibility of CCTV cameras with security lights. Research data has shown that a light-to-dark ratio of 6:1 should be considered the maximum, with a design goal ratio of 4:1 preferable, and an overall average of 1 foot-candle recommended in the assessment zone [2, 3]. However, this data should be reassessed, since CCTV technology has developed over the years.

The performance of CCTV camera is tested under Korean weather conditions as well. Generally, resolution is measured to estimate the camera's performance using an Electronic Industries Association (EIA) resolution chart. However, using an EIA chart is not easy and simple method to measure the resolution. Therefore, new guidelines for measuring resolution of CCTV cameras are needed. It is expected that efficient guidelines and tools for measuring resolution are obtained from this test.

5. Further Works

The Test-Bed is under construction and will be completed on April. After the construction of the system, a pre-testing will be performed. The normal operation of the system is expected on May, 2009.

The main purpose of the system is to obtain domestic data of the subsystems and components in the PSS considering different environmental conditions such as topography, background noise, climate and weather in Korea. Results such as the nuisance alarm rate and sensor degradation effect would be collected and analyzed after the operation through several years.

The system would help to analyze the vulnerabilities of the system and components in the PPS and finally set up a guideline for redesigning the PPS for future nuclear facilities.

REFERENCES

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[3] Mary Lynn Garcia, "Vulnerability Assessment of Physical Protection Systems", Sandia National Laboratories, 2006.