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Areas for Improvement in Digital Technology Applied to Nuclear Power Plants

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1. Introduction

Information pertaining to nuclear power plants comes from not only sensors in the field, but also from personnel and associated documents. Traditionally, the information from sensors is exclusively monitored and used for the operation of a plant. When operators must know the location of a device or its control logic, they refer to paper-based documents or to a separate system. Particularly, maintenance personnel require more design documents and more repair history pertaining to device compared to operators. As nuclear power plants become more reliable and available, nuclear power plant personnel are required to avoid human errors. Therefore, they must operate the equipment and make all decisions based on accurate, just-in-time information.

EPRI has launched a program to make use of (DT) digital (IT) information (CT)communication technology at nuclear power plants. KHNP participates in this program and is performing a project to investigate DT, IT and CT software applied to KHNP nuclear plants. KHNP is also creating pilot software for training purposes. This paper summarizes this project and suggests ideas for improvement [1].

2. DT, IT, and CT Applications

EPRI has analyzed numerous maintenance tasks and has extracted a general workflow of these tasks. The general workflow is shown in Table 1.

Table 1 General Workflow Steps

Step	Description
1	Establish a team
2	Assemble information
3	Assemble related industry information and operating experience
4	Postulate alternate solutions
5	Design task specific tools and/or redesign the work environment and/or process modifications
6	Planning
7	Scheduling
8	Work execution
9	Critique
10	Expand use of concepts

It is difficult to perform the workflow without DT, IT and CT software. For example, an organizational dialog is used to search for experts on a specific field at KHNP. The project analyzes all of the software at KHNP according to the framework. Fig. 1 shows the fleet-wide monitoring system, which is updated with real data and trended with historical data.

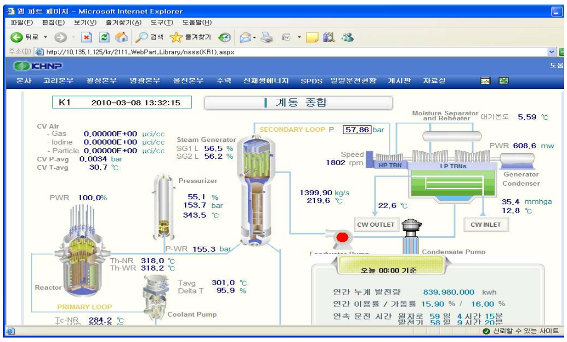

Fig. 1 Fleet-wide monitoring system

The requirements of a task and functionalities provided by task-specific software were compared. The suggested areas for improvement are shown in Table 2.

Table 2 Areas for Improvement

Item	Description
Publish a personal schedule at KHNP	When preparing for a meeting, the team leader could adjust the meeting date through the published schedule.
Maintain the records for qualified experts throughout KHNP	Generally, most test procedures are performed by qualified experts. The qualifications are maintained on paper, but this is not valid when the experts are transferred to another plant.
Management for vendor notice	Vendor notices are published to inform defects and necessary corrective actions. There is no protocol to handle the notices effectively.
Central database for both real-time as well as surveillance data, ISI, and IST.	Real-time data as well as manually logged data are being fed to a central database. Surveillance, ISI(In Service Inspection), IST(Test) should be added.
VR(Virtual reality) nuclear power plant	Traditionally, VR has been used to walk down a plant. A new VR could cover configuration management, training, and prediction of the effect and risk after execution.
Real-time e-documents	Documents should be updated with accurate real-time data from the central database
Compact camera in a helmet	Critical tasks are performed via peer checking. A compact camera in the helmet can be used for peer checking.

3. Simulator for LLRT(Local Leak Rate Tests)

One item from the areas for improvement list is to be selected as a pilot development. A simulator for the LLRT, however, was determined early only for the KHNP pilot because training materials in flash, as shown in Fig. 2, were developed previously at KHNP. This educational material is comprehensive and suitable for those without prior knowledge of the device.

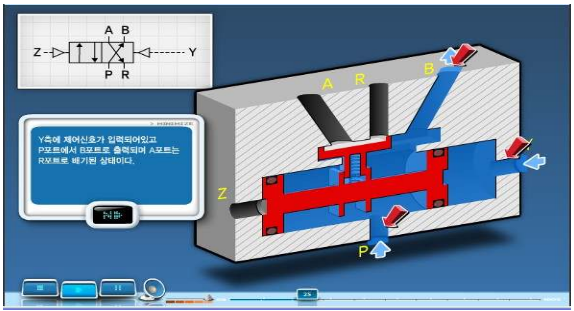

Fig. 2 Training Material

This technique was applied to develop the simulator. The LLRT procedure has many items to be tested. The items were classified as penetrators (Type–B) and isolation valves (Type-C). Type-B and Type-C tests have about 100 items each.

In view of the testing principle, all of the tests are identical. The test starts with the pressurizing of a sealed space within the device and ends when the leak is checked 15 minutes later. Hence, a model device attached to a leak tester was developed. The model is used to understand the principles, operation, and calculation, and to complete report forms regarding leak testing. The model is dynamic in terms of the pressure, valve state, and leaking gas and is interactive with the operator control input.

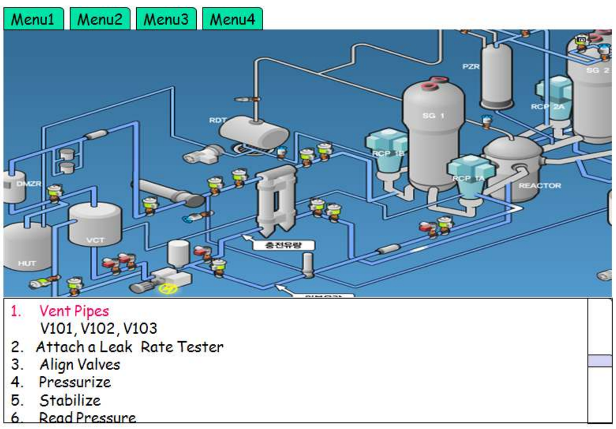

Fig. 3 Model device for a leak test

In addition, the model is controlled by the leak rate procedure displayed in the bottom pane of Fig. 3. Whenever the procedure is performed in a step-by-step manner, the state of the model in the upper pane is dynamically updated. The model is drawn in 3D with rotating and zooming capabilities.

After mastering the model device, trainees are advised to proceed to test-B or test-C. The point of these tests is device specific information rather than principles. The interfaces used in both tests are similar to that shown in Fig. 4.

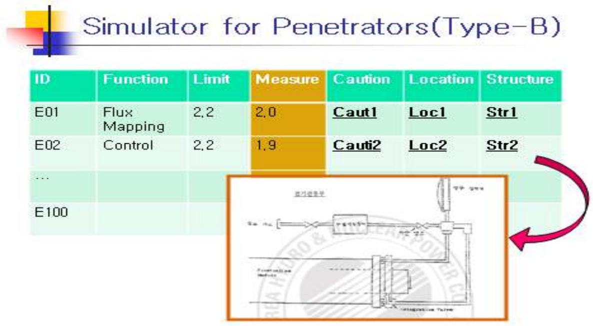

Fig. 4 Simulator for Test-B

Approximately 100 penetrators are listed in the table, and related images and documents are hyper-linked. The displays are rendered in either 2D or 3D. If a virtual containment were built, the appropriate portion of the containment could be linked. Most columns in the table are static and predefined, whereas only the measurement column is automatically filled in at the start of the test.

The original local leak rate test procedure is difficult to understand with many scattered pictures. Thus, EPRI sought the development of a new project. Through the restructuring of the LLRT, the LLRT concept in the simulator now appears simple.

4. Conclusion

Areas for improvement were revealed after analyzing the software applied to KHNP. EPRI now plans to solve any knowledge gaps that were discovered. The pilot software assigned to KHNP was to build a simulator for the LLRT. The test procedure was analyzed and categorized into three parts: the model device, type-B, and type-C parts.

The joint project with EPRI was done to demonstrate DT, IT and CT at nuclear power plants. Numerous pilot programs, including a simulator for the LLRT, will be developed in the future. In addition, pilot applications will be integrated into a virtual nuclear power plant.

REFERENCES

[1]Use of Modern Digital, Information and Communication Technologies for Nuclear Power Maintenance Activities. EPRI, Palo Alto, CA and KHNP, Daejeon, Korea, in preparation, 069586