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A Computerized Procedure linked to Virtual Equipment

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1. Introduction

Digital, information, and communication technologies have change human's behavior. This is because human has limitation to memorize and process information. Human has to access other information and real time information for important decisions. Those technologies are playing important roles. Nuclear power plants cannot be exception.

Many accidents in nuclear power plants result from absent or incorrect information. The information for nuclear personnel is context sensitive. They don't have enough time to verify the context sensitive information. Therefore they skip the information, as resulting in incident.

Nuclear personnel are usually carrying static paper procedures during local task performance. The procedure guides them steps to follow. There is, however, no dynamic and context sensitive information in the paper. The effect of the work is evaluated once while getting permission of the work. Afterward they are not informed.

The static paper is generally simplified, so that it does not show detail of equipment being manipulated. Particularly novice workers feel difficult to understand the procedure due to lack of detail. Pictures of equipment inserted in the procedure are not enough for comprehension.

A computerized procedure linked with virtual equipment is one of the best solutions to increase the detail of procedure. Virtual equipment, however, has still limitation not to provide real time information, because the virtual equipment is not synchronized with real plants.

2. Design and Implementation

EPRI(Electric Power Research Institute) provided an initiative to develop a computerized procedure linked to a virtual reality. American nuclear power plants have suffered knowledge transfer from experienced workers who will retire soon. EPRI recommended infrequently performed procedures as a target for the computerized procedure. Local leakage rate testing (LLRT) procedure was finally selected because it is performed about every 18 months.

There are two types of approaches for computerized procedure. One is computer based procedure that shows all steps of procedure and their related process information in VDU [1]. The other is based on a main equipment picture without overall procedure. While performing a procedure, steps pop up sequentially. Because there isn't the overview of procedure, operators feel less aware of the task.

This paper combines the advantage of two approaches. The design shows both procedure and equipment equally in Fig.2. The sliding window of procedure is limited to the previous, current and next step. The current step is designed to be highlighted. The previous and next step can enhance the awareness of procedure.

The part of equipment mentioned in the current step is designed to be interactive. They can be opened or closed, or connected or disconnected. Whenever manipulation occurs, appearance of equipment changes.

LLRT computerized procedure was implemented in both HTML and Flash [2] whose product can be easily disseminated over the internet.

Leakage rate can be measured using simple principle. A penetration is pressurized with air or nitrogen. If there is a leakage, the penetration should be compensated with additional air flow. The pressure and air flow are related by the ideal gas equation; $PV=nRT$. The air flow is measured with LLRT meter. The test lasts about 20 minutes.

There are two types of penetration. One is electric penetration, and the other is through isolation valves. Total number of penetrations counts about 200. All the penetrations can be measured in the same method.

Considering the above factors, LLRT computerized procedure can be decomposed into four modules in Fig.1. The first modules is for general testing principle, the second for electric penetration, the third for the isolation valves, and the final module for LLRT summary report.

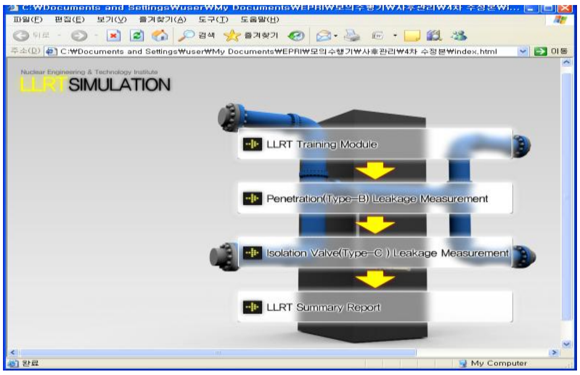


Fig. 1 LLRT consists of four modules

The first module is the main computerized procedure. The procedure and equipment are shown in parallel. Whenever operators perform manipulation correctly as indicated in the step, the next step can be moved with the next button. The correct actions can be informed with OK sign.

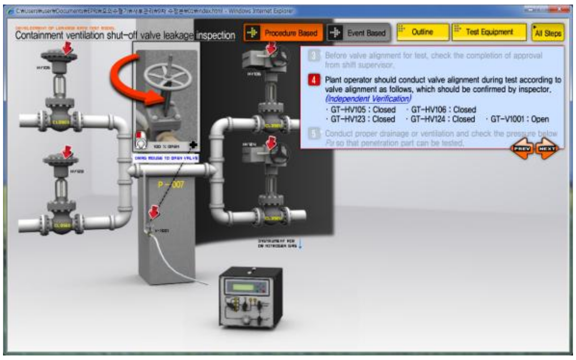


Fig. 2 LLRT computerized procedure with manipulation

Results of step execution are recorded in suitable forms as Fig.3. The values filled in the form are as consistent as those displayed in the simulated equipment, as makes workers understand the procedure correctly.

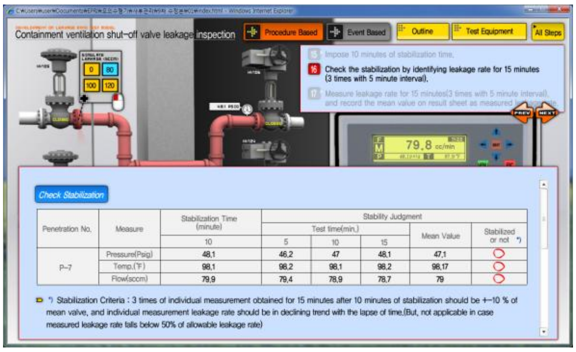
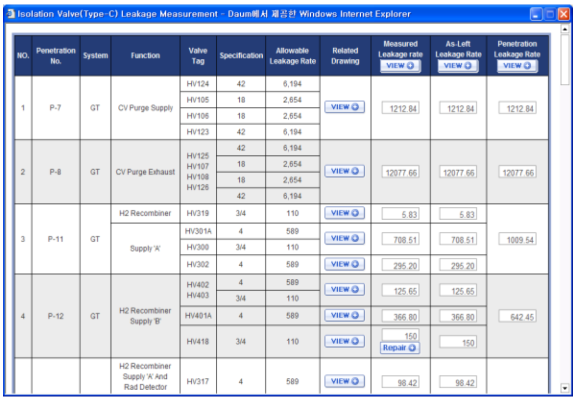


Fig. 3 LLRT computerized procedure with table

The second and third modules are designed and implemented as tables. Each row represents a penetration, of which measurement is repeated in the same method. The penetration specific data include location of penetration, shape or isometric drawing, and permitted leakage rate. The physical data such as shape can be hyper linked from the cells of table in Fig.5. If the measured leakage rate exceeds a permitted rate, trainee can see a movie to dissemble and assemble the penetration. After repair, LLRT is measured again.



Isolation Valve(Type-C) Leakage Measurement - Daum에서 제공한 Windows Internet Explorer

NO.	Penetration No.	System	Function	Valve Tag	Specification	Allowable Leakage Rate	Related Drawing	Measured Leakage rate	As-Left Leakage Rate	Penetration Leakage Rate
1	P-7	GT	CV Purge Supply	HV124	42	6,194	VIEW	1212.84	1212.84	1212.84
				HV105	18	2,654				
				HV106	18	2,654				
				HV123	42	6,194				
2	P-8	GT	CV Purge Exhaust	HV125 HV107 HV108 HV126	42	6,194	VIEW	12077.66	12077.66	12077.66
					18	2,654				
					18	2,654				
					42	6,194				
3	P-11	GT	H2 Recombiner	HV319	3/4	110	VIEW	5.83	5.83	1009.54
			Supply 'A'	HV301A	4	589	VIEW	708.51	708.51	
				HV300	3/4	110				
				HV302	4	589	VIEW	295.20	295.20	
4	P-12	GT	H2 Recombiner Supply 'B'	HV402 HV403	4	589	VIEW	125.65	125.65	642.45
					3/4	110				
				HV401A	4	589	VIEW	366.80	366.80	
				HV418	3/4	110	VIEW	150 Repair	150	
			H2 Recombiner Supply 'A' And Rad Detector	HV317	4	589	VIEW	98.42	98.42	

Fig. 4 Interface with tables

3. Verification and Validation

This computerized procedure was verified and validated by designer, LLRT expert, and EPRI engineers. The design reviewed and suggested overall and detail implementation. Consistency of data with ideal with gas law is also verified by designer.

LLRT expert evaluated the system as a good training material, but penetration specific information is not enough.

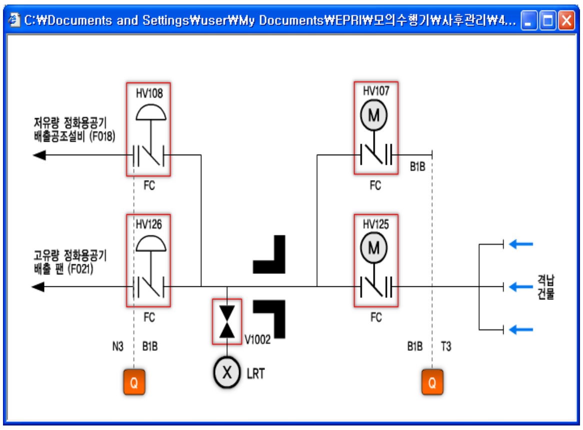


Fig. 5 Penetration specific drawing

Four EPRI engineers participated in the review and suggested 20 recommendations. They followed all the steps thoroughly and pointed out vague manipulations. EPRI wants to continue this type work in large scale.

4. Conclusion

LLRT computerized procedure is a useful knowledge transfer tool. It takes an hour to learn the LLRT principles in this module instead of a week in tradition procedure.

Developing cost in Flash is about $100,000. Similar projects with valves are being performed by other divisions. This technique seems like surely a good attempt, but its cost is too high. Therefore it is necessary to find an efficient framework to develop a computerized procedure with a virtual plant. The virtual plant inherently equipped with physical and thermodynamic engines can be a good candidate.

REFERENCES

[1] Yeonsub Jung, PoongHyun Seong, Mancheol Kim, A Model for computerized procedures based on flowcharts and success logic trees, Reliability Engineering and System Safety, 2004

[2] J. Naser, Yeonsub Jung, EPRI TR-1022987, Use of Modern Digital, Information, and Communication Technologies for Nuclear Power Plant Maintenance Activities, 2011