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Development of Alarm System link Drawing for Operation Support for APR1400 Digital Main Control Room

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1. Abstract

Digitalized MMI(Man-Machine Interface) including Digital Main Control Room(MCR) and digital I&C system was being applied for SKN 3&4 Nuclear Power Plant(NPP) and subsequent APR1400 NPP type. But, operators can not easily find instrument for alarm immediately. Therefore, Alarm system is required to easily find instrument for Alarm. For this implementation, we will plan system design considering design feature without affecting network load and CPU load. We have developed Alarm system link drawing for digital MCR. In this paper, We introduce system design feature to Alarm system link drawing

2. Introduction

Digitalized Main Control Room(MCR), which is first applied to Shin-Kori(SKN) unit 3 and 4, allows the operators to verify the plant process variables and to control the equipments from their designated seats called Operation Console rather than from the stand-up control panels like the ones in the analog system based MCRs. Operators of the digitalized MCR navigates from their consoles to the drawings related to the plant alarms and their instruments or the operation status. Such method gives cognitive load to the operators having to travel to different locations in finding the related information. Thus it is necessary to reduce the time required to find the instruments and cognitive load in case when an alarm occurs. Therefore, drawing interconnected alarm system is to be applied to the digitalized MCR of APR1400(Advanced Power Reactor 1400) for a reliable and safe operation. Drawing interconnected alarm system is a function allows the operators to access to the instrument status. When an operator finds an alarm from the Operation Console or Large Display Panel(LDP), and clicks on the alarm or enters the alarm number, then the drawing interconnected alarm system displays the certain drawings to find the status of the related instrument. From the displayed information, the operator can verify the equipment trouble and the current status. Therefore, this paper will introduce the development of the drawing interconnected alarm system for the operation support, and will also propose a roadmap in implementing the system.

3. Methods and Requirements

3.1 Domestic Case Research

SKN unit 3,4 Human Factors Engineering(HFE) Guideline displays critical parameter and other critical variables for the users, and activates alarms. However, the critical variables and current status can be identified as figure 1, but the certain instrument name and its number are not shown. Thus, if a condition that does not allow the operators to verify the variables(e.g., out of range, fail, etc), it is difficult to identify the name of the instrument. Therefore, it is determined that an additional criterion addressing the drawing interconnection following the alarm is necessary to the HFE Guideline.

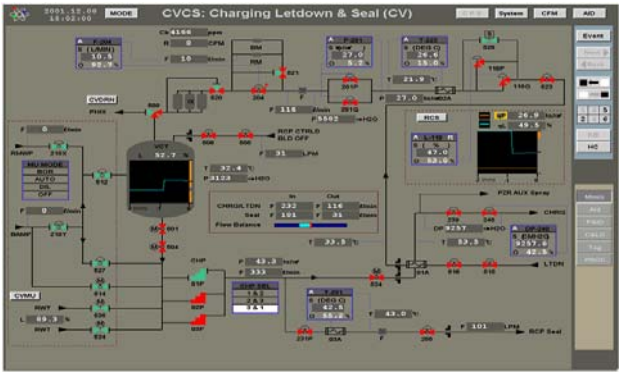

Figure 1. APR1400 MCR Display

3.2 Drawing Interconnected Alarm System Design and Development

3.2.1 Requirements

Equipment and alarm number are required to be created to apply the Drawing Interconnected Alarm System. They will interconnect the alarms displayed on LDP of the first ever digitalized MCR(SKN3,4) to the related drawings.

☞ Occurring alarms should be determined if they are from the digital signal or the analog signal, and the alarms are numbered accordingly. That is, the current alarm list of the alarm display will have an additional column that contains numbers per the alarms.

☞ Alarms that occur as per numbers are shared from the office PC of the Operation Console. With a click on the alarm list will connect the related drawings, and display it on the desired location on LDP and on the other office PCs of fellow operators. Additionally, the

desired drawing will be connected with an input of the alarm number from Operation Console.

☞ Drawing Interconnect Alarms System must be proceeded after the equipment installation of system in case when sharing the currently on-going display

☞ One of the four adjustable LDP areas is designated to display the alarm list, so it must be taken into consideration when developing

☞ System response time and network/CPU load must be considered. Worst case DCS communication load should be reviewed for future drawing interconnection function application.

☞ Existing MMIS reliability should not be diminished even with the application of drawing interconnection function.

3.2.2 Drawing Interconnection Function Design Principles and Display Method

For MMI(Man-Machine Interface) design, the following principles, which are based on the review of operation experience, job analysis, and human performance tools, such as peer check and concurrent review, are applied in designing the MMI related to the screen sharing.

☞ It is necessary to run the drawing interconnection function through the adjustable area of LDP, which allows the operators to monitor situation awareness and plant status change.

☞ Without adding an information FPD, the drawing interconnection function should run from Operation Console.

☞ Additional MMIS network load should be minimized

☞ Human Performance Tools should be able to applied considering the state-of-art MCR features.

When creating alarm numbers, operators and maintenance departments should participate. A design that enables accesses to the drawing interconnection function from two locations within the MCR(LDP and office PC Monitor) should be developed considering the features of the digitalized MCR(see Figure 2).

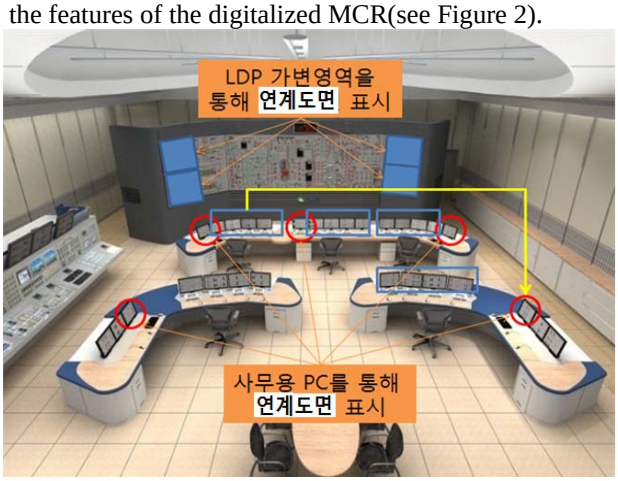

Figure 2. Drawing Interconnection Function

Drawing Interconnection Function can be divided into two functions as shown in Figure 2. The first function executes the drawing interconnection using the adjustable area of the LDP. The other function utilizes the office PC monitor for the drawing interconnection. For the application of software drawing interconnection function, the MMI function should be organized with the minimum effect on the DCS network.

3.3 Screen Sharing System for Drawing Interconnection Function Application

As shown above, the software modification can be considered in applying Drawing Interconnection Alarm System. However, an equipment for the screen sharing function, which can be operated from office PC, should come first if the operators are to enter the alarm numbers or to designate the alarm area from their seats. To minimize additional loads on digital MMIS networks and CPUs, a screen sharing equipment which utilizes the hardware but not the software. Thus, to realize Drawing Interconnection Alarm System through LDP adjustable areas and office PC monitor, a system should be configured with a screen sharing like Figure 3 is available. Screens can be sent to LDP adjustable area and other operator's screen using a screen sharing system like Figure 3 from MMI system.

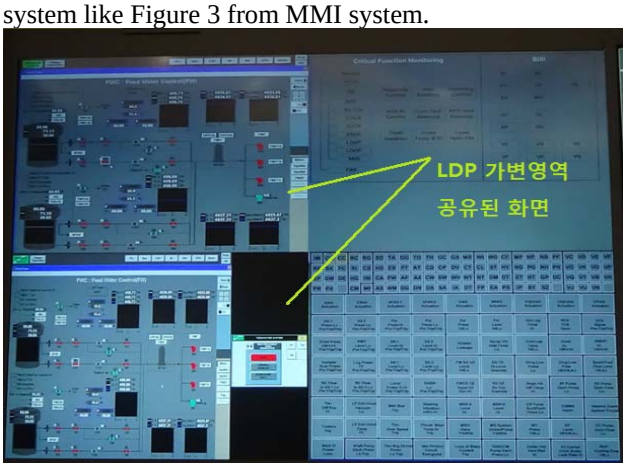

Figure 3. LDP Adjustable Area Sharing Screen

3.4 Operator Alarm Screen for Using Drawing Interconnection Alarm Function

Drawing Interconnection Alarm Function uses activated alarm list. In order to do so, a column should be added to the alarm screen like Figure 4. When the alarm number on the left side of Figure 4 is selected, the screen pops up the drawing that the operator desires, and the screen can be shared through LDP adjustable area or the operation console.

To do so, the blocks for selecting either LDP or other operators screen should be created on the right side.

That is, if the operator is Reactor Operator(RO), he/she can send the drawing on RO office PC to Turbine Operator(TO) office PC, or to LDP adjustable area so that every operator can share the same drawing.

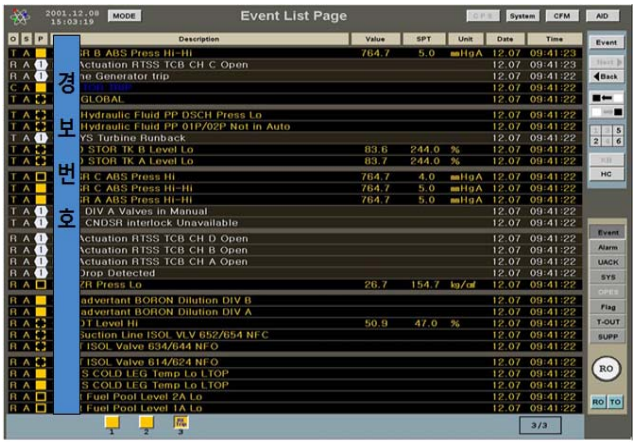

Figure 4. Shin-Kori unit 3, 4 Alarm Screen

4. Conclusion and Future Research Plan

Screen Sharing System, which is the fundamental technique for Drawing Interconnection Alarm System is close to completion, and it should be functionally tested and verified by the human factor engineering. For the actual application to the operating plants, the drawings to be interconnected to the alarms and the opinions from the operators/maintenance departments for designating alarm number should be surveyed, Also, another function that allows the access to the alarm-related drawings not only from the MCR but also from the other offices. Drawing Interconnection Alarm System is a technology needed by the operators in MCR and maintenance engineers, and it is a technology that can step up the operation reliability and safety to another level. It is expected that such operator and maintenance support function can be applied to future developed nuclear plants.

REFERENCES

[1] Shin-Kori 3,4 Human Factor Engineering Guideline (Doc. No. : 9-750-J410-001. Rev 7)
[2] NUREG-0700 Human-System Interface Design Review Guidelines(Rev 2)