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A Design of Alarm System in a Research Reactor Facility

Jaekwan Park [a*], Gwisook Jang [a], SangMun Seo [a], Yongsuk Suh [a]
[a]*Research Reactor Eng. Div., Korea Atomic Energy Research Institute (KAERI), Daedeok-Daero 989-111, Yuseong-Gu, Daejeon, 305-353, Korea*
[*]*Corresponding author: jkpark183@kaeri.re.kr*

1. Introduction

An alarm is used to warn about an abnormal of system or process to operators so that they can respond. Nowadays, fully digitalized alarm systems are designed for most power plants. The digital alarm system [1-3] has become an indispensable design to process a large amount of alarms of power plants. Korean research reactor operated for decades maintains a hybrid alarm system with both an analog annunciator and a digital alarm display. In this design, several alarms are indicated on an analog panel and digital display, respectively, and it requires more attention and effort of the operators. As proven in power plants, a centralized alarm system design is necessary for a new research reactor. However, the number of alarms and operators in a research reactor is significantly lesser than power plants. Thus, simplification should be considered as an important factor for the operation efficiency. This paper introduces a simplified alarm system.

2. An Alarm System

This paper introduces an alarm system by dividing three sections, an alarm system configuration, alarm processing, and an alarm display.

2.1 Alarm System Configuration

Unlike the alarm system of previous Korean research reactors, it is a fully digitalized system. The alarm system is classified into non-nuclear safety, but is designed with dual redundant architecture to achieve high reliability. The alarm system is the only system that can alert or warn some abnormal situations to operators, and all alarms of the I&C area are centralized and managed by the alarm system. The architecture of the alarm system is shown in Figure 1.

The alarm processing system collects all alarms from the safety and non-safety control systems and provides alarm display systems, such as a Large Display Panel (LDP) and Operator WorkStation (OWS) through dual redundant communication networks. The LDP and OWS are not dependent on each other, and the OWS includes four digital computers that can display alarm information independently. The LDP has at least a mimic display and alarm tile display.

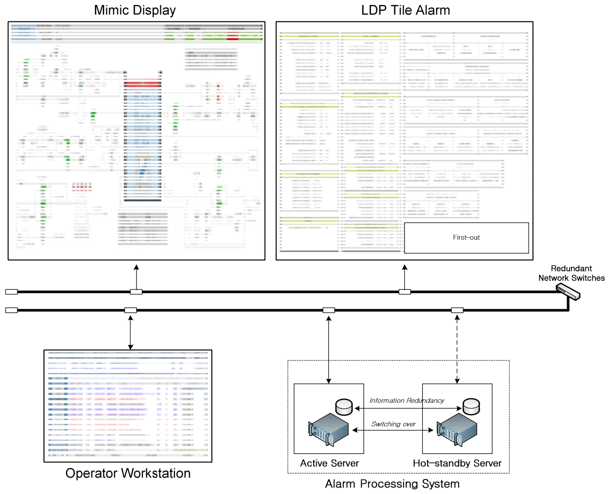

Fig. 1. An alarm system configuration

2.2 Alarm Processing

As simplified alarm levels, there are only two alarm priorities, priority 1 and 2. Priority level 1 is assigned into important alarms associated with a reactor trip, engineering safety features, radiological material release, post-accident monitoring, and the status of safety-related systems/equipment. Priority level 2 is assigned into all alarms except priority level 1 alarms. According to the priority level, display location, indication style, and control sequence for alarms are designed differently. It helps that the attention of operators can be made to more important alarms. In addition, the simplification strategy of the alarm priority by comparing with that of the power plant can reduce the burden of operators when the operators should identify and assess the plant status in an abnormal status.

In addition, simplification is considered an important factor in the alarm control manner. The alarm control location is designed to be allowed in the operator workstation that can check the detailed alarm information such as the description, setpoint, and current value. This can help operators make a decision without a misunderstanding. Normal operator response actions in the situation of a new priority 1 alarm are as follows:

(1) recognizing an alarm flashing in LDP and alarm sounding in auditory device,
(2) checking the detailed status of the alarm in the operator workstation,
(3) acknowledging the alarm and performing corresponding actions,

(4) recognizing the ringback status through visible and audible indications after a change to normal status, and
(5) finally clearing the alarm event.

For alarm control, two types of alarm control sequences, ringback control sequence and auto-reset control sequence, are designed and are similar with the control manner of the alarm control in [4]. They are used for priority level 1 and 2 alarms, respectively. As described in above example, the ringback control sequence includes one more alarm transition step to identify how and when the abnormal status returns to a normal status. The alarm control sequences are as shown in Figures 2 and 3.

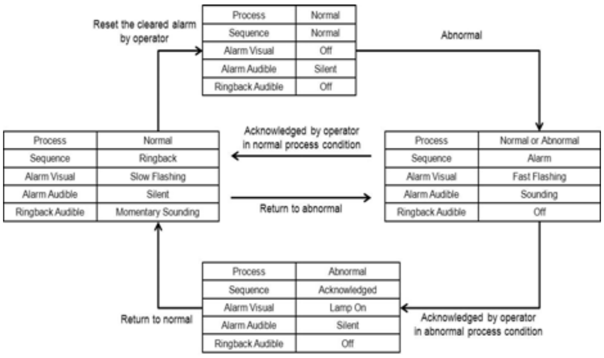

Fig. 2. Ringback control sequence

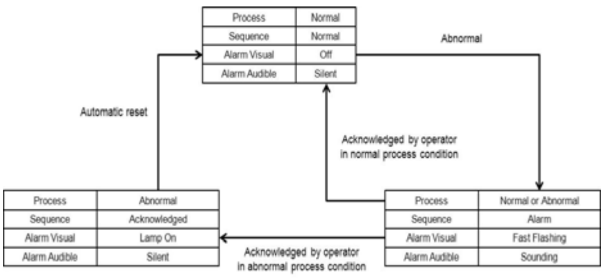

Fig. 3. Auto-reset control sequence

2.3 Alarm Display

Three types of visual alarm display devices are prepared in research reactor. First, a tile alarm display in the LDP is designed to support operators to recognize an important abnormal status quickly and easily. The LDP alarms consist of a set of tiles formatted as a rectangle and a short text. The display does not provide detailed information or alarm control. All alarms displayed in the LDP are priority level 1 alarms. In addition, a first-out alarm indication is provided in the LDP. A first-out alarm is designed to identify the cause of a reactor trip incident, and one of trip parameters is indicated in the first-out indication area within the LDP. In spite of priority level 1, the first-out alarm is indicated so that it is differentiated from other LDP alarms.

Second, a mimic display is designed to provide the alarm display. The mimic display is basically to provide the overall system status including the primary equipment of reactor facility such as cooling pumps and important valves. Thus, any failure or abnormal operation of the equipment is indicated on the mimic display. Using this alarm display, operators can understand the location of abnormal equipment easily. All mimic alarms are classified into priority level 2.

Finally, an alarm list display of the operator workstation is designed to provide detailed information and control alarm sequences. All alarms including priority 1 and 2 are listed on the display in time order, and each alarm row contains some information such as the alarm in time, priority, alarm status, description, setpoint, and current value. Indication rules according to the alarm priority are maintained in this alarm display for consistency with another alarm display. Furthermore, this alarm display includes graphic user interfaces for alarm control (i.e., acknowledge, ringback, test, and silence). Table 1 shows the summary of alarm category and alarm display location.

Table I: Alarm Category and Display Location

	LDP Tile Area	LDP Process Mimic Area	OWS Alarm List	Alarm Control Location
First-out Alarm	O	X	O	OWS
Priority 1 Alarms	O	△	O	OWS
Priority 2 Alarms	X	O	O	OWS
Calculated Alarms	X	X	O	OWS

3. Conclusions

As advances in information technology, fully digitalized alarm systems have been applied to power plants. In a new research reactor, it will be more useful than an analog or hybrid configuration installed in research reactors decades ago. However, the simplification feature should be considered as an important factor because the number of alarms and number of operators in a research reactor is significantly lesser than in power plants. This paper introduced a simplified alarm system for a research reactor. The system configuration, alarm prioritization, control sequence, control location, and display were designed to be suitable for a research reactor.

REFERENCES

[1] US NREC NUREG/CR-6105, Human Factors Engineering Guideline for the Review of Advanced Alarm System, 1997.
[2] US NRC NUREG-0700, Human-System Interface Design Review Guidelines, 2002.
[3] US NRC NUREG/CR-6684, Advanced Alarm Systems: Revision of Guidance and Its Technical Basis, 2003.
[4] ISA 18.1, Annunciator Sequences and Specifications, 2004.