A Mock-up Design for Control Room of the newest Research Reactor

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1. Introduction

Recently, hardware and information processing technology has made great progress for processing a lot of data, such as checking the integrity of equipment using big data and three-dimensional maintenance technology using digital twin. Advances in digital information processing technology have developed and improved the control room of nuclear power plants. The major feature of the control room is that operators monitor the nuclear power plant's overall equipment operation and safety critical parameters using by the large display panel. The operating computers have an ability of early fault diagnosis, automatic operation and operation supporting. All of digital systems are under surveillance and protected against a cyber-attack. In this paper, we describe the terms and conditions for constructing a mock-up of the control room, which is digitized research reactor of the latest newly introduced in a conventional manner.

2. Control Room of the Research Reactor

The control room of research reactor is a comprehensive control center that controls and monitors all of major equipment in the plant. It consists of MCR (Main Control Room) and SCR (Supplementary Control Room) [1].

2.1. Main Control Room

During in the operation of the research Reactor, The MCR is continuously manned, at least two persons (an RO (Reactor Operator) and an SRO (Senior Reactor Operator)). They monitor all equipment of the plant under normal conditions and control to maintain the reactor in a safe condition in the abnormal, and emergency conditions[1].

All of control, equipment situation and instrumentation signals are basically centralized in the MCR.

The equipment installed in the MCR is as follows.

1) Large Display Panel
2) OWS(Operator Workstation) for RO and SRO
3) OWS-Q : safety function operating station
   - RPS(Reactor Protection System) operator modules
   - PAMS(Post Accident Monitoring System) value indicators
   - Manual reactor trip switches
4) Desks, Shelf, etc.

The other facilities for reactor monitoring and control are installed in the instrument room and the list is as follows.

1) Reactor Protection System Cabinet
2) PAMS Signal Splitter Panel Cabinet
3) Alternate Protection System Cabinet
4) Reactor Regulating System Cabinet
5) Plant Instrumentation and Control System Cabinet
6) Information Processing System Cabinet
7) ESF Actuation Cabinet
8) Marshalling Panel etc.

2.2. Supplementary Control Room

If the operator is unable to control the Research Reactor in the MCR due to fire, radioactive contamination, terrorism and other evacuation, the operator switches the control to move the SCR to maintain the reactor in a safe condition. The SCR is equipped with the facilities for safety shutdown and can monitor and control the Research Reactor.

The equipment installed in the SCR consists of an LDP (Large Display Panel), an OWS, an OWS-Q at which the operator module of RPS is mounted, and other facilities[1].

3. Service Condition

Service conditions for configuration of the mock-up are shown as follow;

3.1. Environmental Requirement

The environmental condition for control room shall be maintained as following.

1) Temperature
   A. Summer : 23 ~ 26 ℃
   B. Winter : 20 ~ 24 ℃
   C. Air temperature at floor level and at head level shall not differ by more than 5.5 ℃
2) Humidity
   A. Relative Humidity Levels: 40% ~ 60%
3) Pressure

A. Atmosphere or a little higher

4) Radiation
   A. Negligible
5) Illumination
   A. More than 500 lux in any functional surface in control room

The ventilation system should be capable of introducing fresh air into the control room at a rate of at least 20 cubic feet per minute (0.6m3/min) per occupant.

Air velocities in the main operating area should not exceed 45 feet per minute (13.7m/min) measured at head level and should not produce a noticeable draft.

Background noise should not impair verbal communication between any two points in the main operating area. Accordingly, Background noise levels should not exceed 45 dB(A).

3.2. Seismic Requirement

All of the equipment installed in the control room shall be designed to withstand the effects of the Safe Shutdown Earthquake (SSE) without loss of integrity, OWS-Q shall be designed to withstand the effects of the SSE without loss of function and integrity[1].

During the seismic events no parts of the equipment shall loosen, bend or crack in a manner that impairs proper operation. In addition, no parts of them shall become a missile hazard.

The maximum deflection of the equipment exterior relative to its mounting points shall be less than 2.5cm during the seismic event.

3.3. Power Requirement

The equipment of the control room shall meet all requirements of this specification for the following range of conditions of the power source:

1) Voltage : 120VAC ± 10%, Single Phase
2) Frequency : 60Hz ± 5%
3) Surge: The maximum voltage transient, or surge permissible, is 40VAC riding on the 120VAC. The voltage transient will last no longer than 5 milliseconds at maximum rate of change of 50 volts per microsecond and shall be non-cyclic.
4) Harmonic Distortion : 5%
5) Neutral : floating/ungrounded

4. Configuration of the Mock-up

When we created the mock-up due to the limited space, the layout was partly different from the actual arrangement. Of course, other parts apply only to parts that do not affect the operator.

4.1. Mock-up for Main Control Room

The arrangement of the MCR (Main Control Room) is shown in Figure 1. There is more than 50mm gap between cabinets.

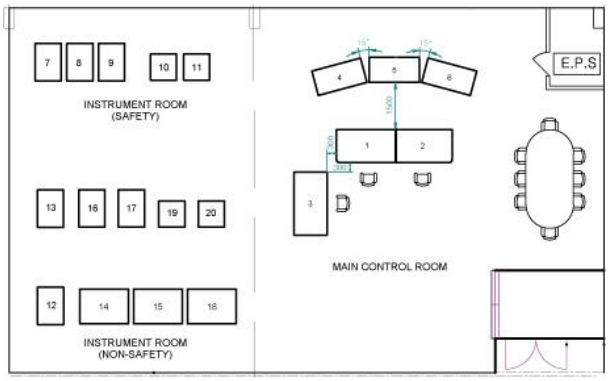

Fig. 1 Mock-up Layout of the Main Control Room

4.2. Equipment of the Mock-up for MCR

The equipment of the mock-up disposed in MCR (Main Control Room) [2] is shown in Table 1.

Table 1 Equipment of the Mock-up for MCR

No	Equipment	Size
1	Operator Work Station (RO)	1,840 x 1,050
2	Operator Work Station (SRO)	1,840 x 1,050
3	Operator Work Station (Q)	1,840 x 1,050
4	Large Display Panel	1600 × 800
5	Large Display Panel	1600 × 800
6	Large Display Panel	1600 × 800
7	Reactor Protection System	700 × 1000
8	Reactor Protection System	700 × 1000
9	Reactor Protection System	700 × 1000
10	PAMS Signal Splitter Panel	700 × 700
11	PAMS Signal Splitter Panel	700 × 700
12	Information Processing System	700 × 1050
13	Reactor Regulating System	700 × 1050
14	Process Instrument and Control System	1400 × 1050
15	Process Instrument and Control System	1400 × 1050
16	Alternating Protecting System	700 × 1000
17	Alternating Protecting System	700 × 1000
18	Marshalling Panel	1400 × 1000
19	ESF-1 Actuation Cabinet	700 × 700
20	ESF-2 Actuation Cabinet	700 × 700

4.3. Mock-up for Supplementary Control Room

The arrangement of the SCR (Supplementary Control Room) is shown in Figure 2.

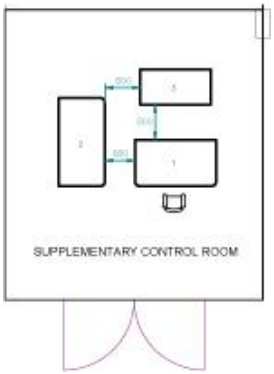

Fig. 2 Mock-up Layout of the Supplementary Control Room

4.4. Equipment of the Mock-up for SCR

The equipment of the mock-up disposed in SCR (Supplementary Control Room) [2] is shown in Table 2.

Table 2 Equipment of the Mock-up for SCR

No	Equipment	Size
1	Operator Work Station (RO)	1,840 x 1,050
2	Operator Work Station (Q)	1,840 x 1,050
3	Large Display Panel	1600 × 800

5. Conclusions

Environment of control room is changed from analog to digital. Accordingly, the interface between man and machine has also been changed.

The MCR of the Research Reactor is able to collect more information than ever before, and using that data, many technologies are being developed for maintenance and operation. By using a lot of digital information for operating the plant, the operator can easily control the plant and monitor the condition.

In this paper, we examined the issues for constructing a digitalized control room model. Therefore, we will build a model based on the results of this paper. Each system's tests, interaction tests, and human system interface assessments are performed. It will be used later for research and education.

REFERENCES

[1] Kim Yong-Juna, Suh Sang-Moona, Lee Hyun-Chula, Park Je-Yuna, "Design of a Control Room for Jordan Research & Training Reactor (JRTR)", Spring Meeting, 2012

[2] Goo-Hyun Ryu, Jun-Hun Lee, Ja-Won Jeng, Youn-Sang Lee, Min-Gyu Kim, " Application Method of Anthropometric Data for Operator Console of Exportable Research Reactor" , Transactions of the Korean Nuclear Society, Autumn Meeting, 2013.