

Digital Update of Main Control Panels

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[Replacement of the main control panel]

- A main control panel using recent digital technology is adopted in the latest nuclear power plants.
- The main control panel used in our nuclear power plants consists mainly of analog instruments. The production of many analog instruments has been discontinued. To improve the maintainability of the control panel, we are considering a switch to the latest digital instruments for the main control panel and other panels.

(Plants under consideration: Takahama 1 and 2, Mihama 3)

- The purpose of replacing the main control panel is to integrate and consolidate the functions of the existing main control panel and to reduce the operators' workload and human error by allowing them to perform monitoring and operating activities in a seated position.

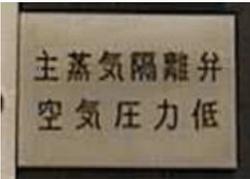
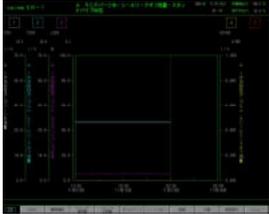
[Compliance with the requirements of the new regulatory standards (for instrumentation)]

- The new regulatory standards additionally require severe accident management measures. The necessary monitoring and operating functions to ensure that the measures to prevent core damage and containment failure will work in the event of a severe accident etc. will be added.

Change in Technology for Main Control Room Panels (1/2)

	1970s-1980s		1990s		2000s																									
Change in main control panel	<p>Takahama 1 & 2, Mihama 3</p>		<p>Takahama 3 & 4</p>		<p>Ohi 3 & 4</p>		<p>(New control panel (latest mock-up verification system))</p>																							
I&C system	<table border="1"> <tr><td>Main control panel</td><td>Hard instrument</td></tr> <tr><td>Protection system</td><td>Analog</td></tr> <tr><td>Control system</td><td>Analog</td></tr> </table>	Main control panel	Hard instrument	Protection system	Analog	Control system	Analog	<table border="1"> <tr><td>Main control panel</td><td>Introduction of CRT</td></tr> <tr><td>Protection system</td><td>Analog</td></tr> <tr><td>Control system</td><td>Analog</td></tr> </table>	Main control panel	Introduction of CRT	Protection system	Analog	Control system	Analog	<table border="1"> <tr><td>Main control panel</td><td>CRT-based operation</td></tr> <tr><td>Protection system</td><td>Analog</td></tr> <tr><td>Control system</td><td>Digital</td></tr> </table>	Main control panel	CRT-based operation	Protection system	Analog	Control system	Digital	<table border="1"> <tr><td>Main control panel</td><td>CRT operation</td></tr> <tr><td>Protection system</td><td>Digital</td></tr> <tr><td>Control system</td><td>Digital</td></tr> </table>	Main control panel	CRT operation	Protection system	Digital	Control system	Digital		
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Main control panel	CRT operation																													
Protection system	Digital																													
Control system	Digital																													
Panel size & panel instrument	<p>(Panel-width controlling factor) M-type switches, OA-type switches: about 600 to 700</p>		<p>Module switches: about 600 to 700</p>		<p>Module switches: about 700, small push button switches: about 100</p>		<p>VDUs (24-inch, 10.4-inch): 11</p>																							
Change in switches	<p>(M-type switches)</p> <p>About 70 mm About 40 mm</p>		<p>(Module switches)</p> <p>55 mm 70 mm</p>		<p>(Small push button switches)</p> <p>Decreased in size by reducing the voltage</p>		<p>(Soft operation)</p> <p>VDU (24-inch screen)</p> <p>Use of a soft switch</p> <p>Screen specification based on the operating procedure</p>																							

Change in Technology for Main Control Room Panels (2/2)

	1970s-1980s	1990s	2000s	
Change in main control panel	 <p>Mihama 1 & 2 (before upgrade) Takahama 1 & 2, Mihama 3</p>	 <p>Ohi 1 & 2, Takahama 3 & 4</p>	 <p>Ohi 3 & 4</p>	 <p>(New control panel (latest mock-up verification system))</p>
Change in alarm indicators used	<p>(Large alarm window)</p>  <p>70 mm</p> <p>50 mm</p> <p>Use of a small size by reducing the height of the center panel</p>	<p>(Small alarm window)</p>  <p>50 mm</p> <p>50 mm</p> <p>Use of a soft switch</p>	<p>(New alarm system/alarm VDU screen)</p> 	<p>Identify important alarms based on alarm causal relationship logic</p>
Change in the indicators used	<p>Lead pipe indicator</p>  <p>Use of electrical signal</p>	<p>Electrical indicator (IH-type)</p>  <p>60 mm</p> <p>150 mm</p> <p>Use of a small size by reducing the height of the center panel</p>	<p>Electrical indicator (MS70KB)</p>  <p>36 mm</p> <p>130 mm</p> <p>Use of a soft switch</p>	<p>(VDU screen)</p>  <p>Display monitoring and operating information in an integrated manner</p>
Change in recorders used	<p>Pen-type recorder (existing)</p>  <p>288mm</p> <p>288mm</p> <p>Use of intelligent electronic type</p>	<p>Pen-type recorder (Intelligent type)</p>  <p>100mm</p> <p>100mm</p> <p>Use of a soft switch</p>	<p>(Record data on computer and display it on VDU screen)</p> 	

Development and verification process

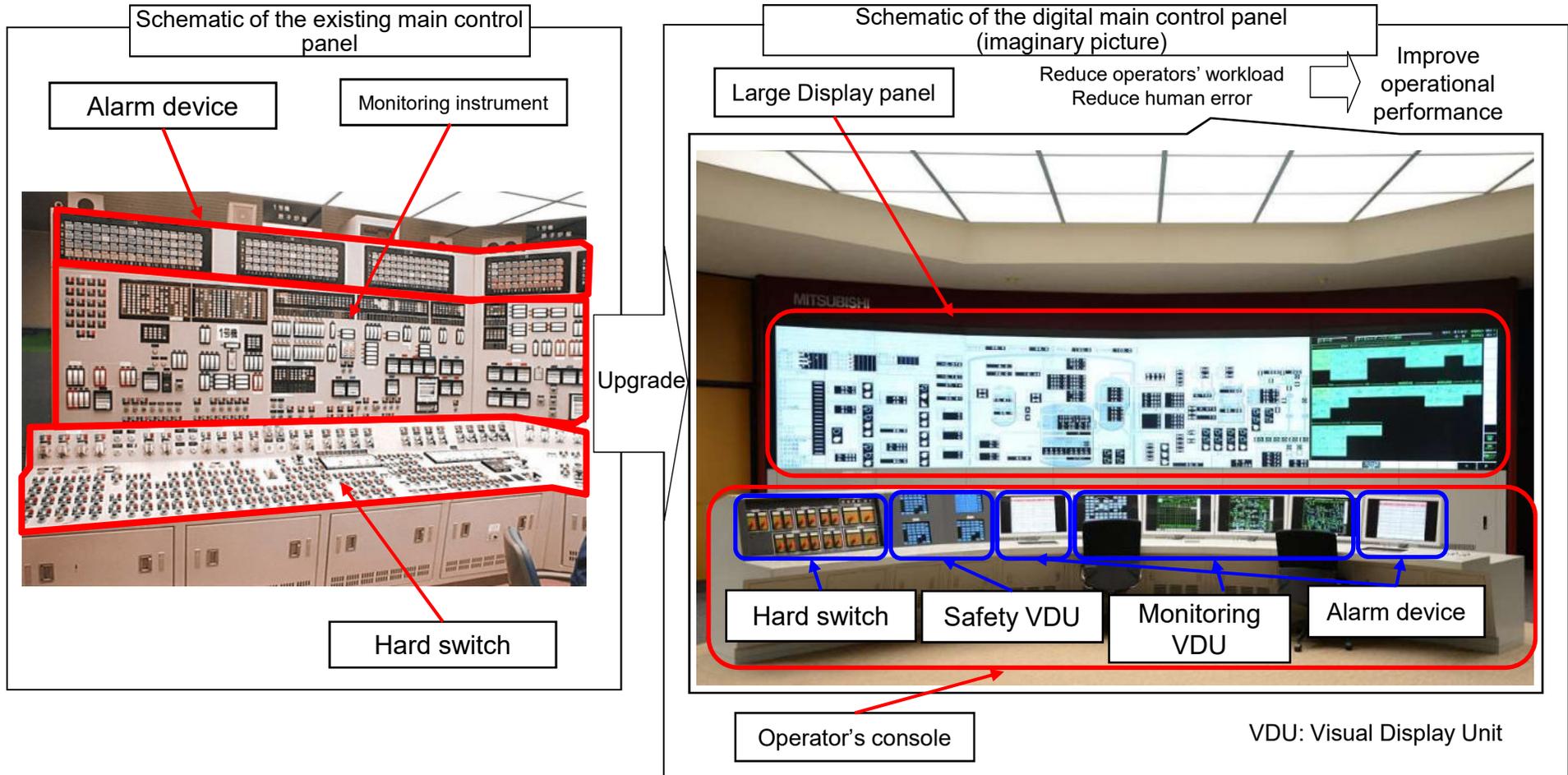
Items	Period	Target of development	HFE V&V
Development of new control panels	1987.4 ~ 1991.3	Conceptual design • Operation based on VDU • Compact console	Static verification test (Total 1 time) Target : 12 teams (total 43 operators) Dynamic verification test (Total 3 times) Target : 12~13 teams (total 39~44 operators)
Development of EOSS※	1993.8 ~ 1996.3	• Plant information diagnostics • Operation guidance system	Dynamic verification test (Total 1 time) Target : 46 teams (Total 138 operators)
Development of new alarm systems	1994.10 ~ 1996.3	• Alarm processing • Display design	Static verification test (Total 1 time) Target : 12 teams (total 24 operators) Dynamic verification test (Total 1 time) Target : 12 teams (Total 34 operators)
Development of new main control panels	1996.10 ~ 2003.3	• Large Display Panels • VDU • Decision support system	Static verification test (Total 1 time) Target : 12 teams (total 36 operators) Dynamic verification test (Total 3 times) Target : 12 teams (Total 37~39 operators)

※EOSS : Emergency Operation Support System

Summary and Characteristics of Replacement work of the Main Control Panel

[Purpose of replacement]

Most of the indicators etc. on the main control panel are no longer produced. The entire main control panel will be replaced with a digital type to improve its maintainability. Furthermore, the replacement of the main control panel achieves not only the improvement of the maintainability but also the reduction of the operators' workload and human error so that the operational performance of the plant can be improved.



Operator's Console

Purpose

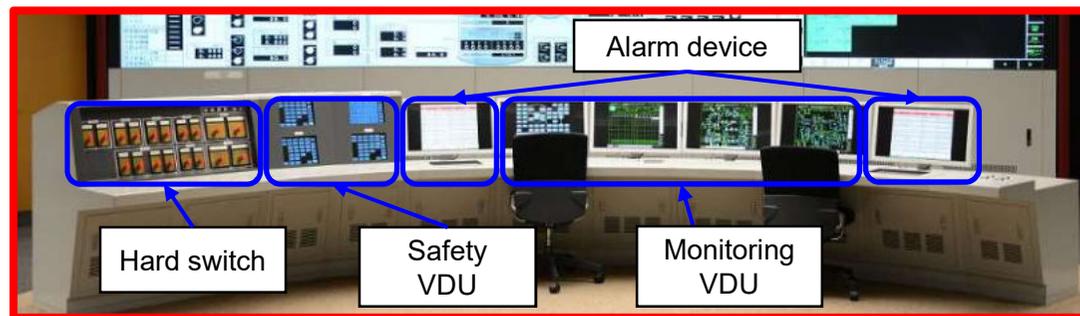
- Integrate and consolidate the functions of the existing main control panel, reduce the operators' workload and human error by allowing them to perform monitoring and operating activities in a seated position.

Components

- The operator's console consists of 4 monitoring and operating VDUs, 4 safety VDUs, 2 alarm VDUs, and a set of hard switches.

Characteristics

- Integration of indicators, recorders, operating equipment, etc.
- Use of a touch display screen
- Use of hard switches for equipment that requires quick actions such as emergency reactor shutdown



Schematic of the operator's console

Alarm Device

Purpose: Improve the operational performance of the plant by displaying alarms based on importance and priority.

Characteristics: As the plant's state develops, the level of warning is displayed in 3 colors as follows:

Alarm (red) : a warning requiring operator action

Caution alarm (yellow): a warning requiring operator recognition

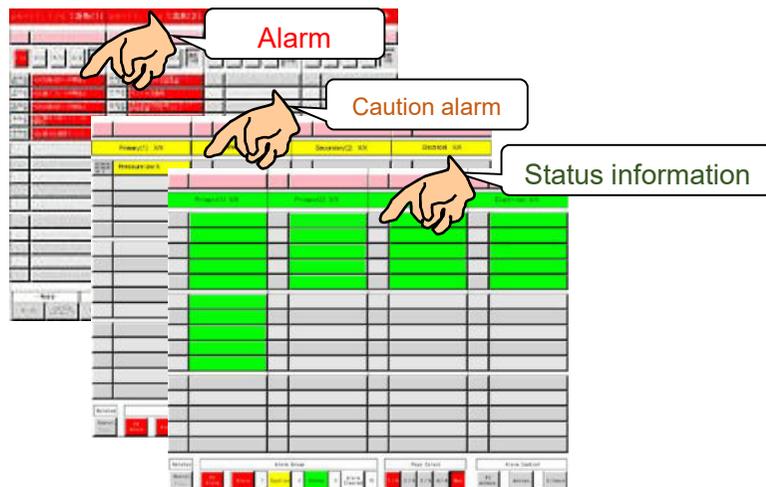
Status information (green): information not necessarily requiring operator action or recognition

[Before] In an accident, many alarms are triggered and alarms requiring operator action may be missed.

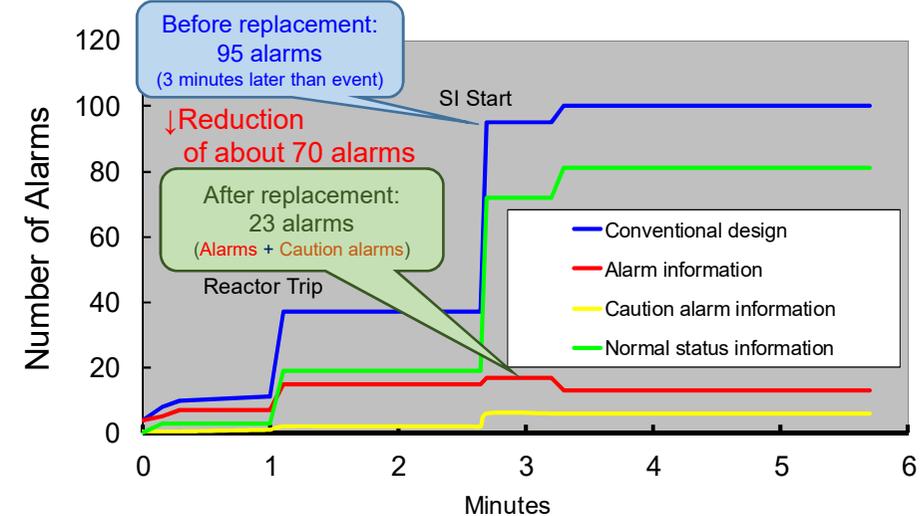
↓ The causal relationship of an alarm is analyzed and the number of alarms (red) triggered is reduced as the plant's state develops.

[After] Prevent alarms (red) requiring operator action from being missed (to make it easier for the operator to recognize the alarms) in an accident that trigger many alarms.

Image of the alarm device display screen



Benefits of reducing the number of alarms (SGTR)



Large Display Panel (1/2)

Purpose

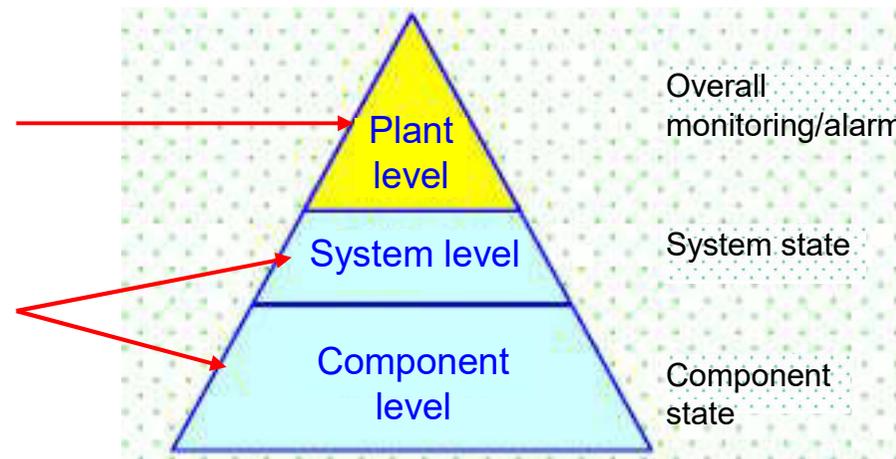
- Main parameters to be always monitored on the system screen and typical alarms are placed to provide general plant information and information to be shared between the operators.

Characteristics

- To monitor the plant as a whole, overall monitoring information on the information system at the highest plant level (3 levels: plant, system and component levels) on the main control panel and alarm information are displayed.

Parameters and alarms that can be monitored on the large display panel

Parameters and alarms that can be monitored on the operator's console



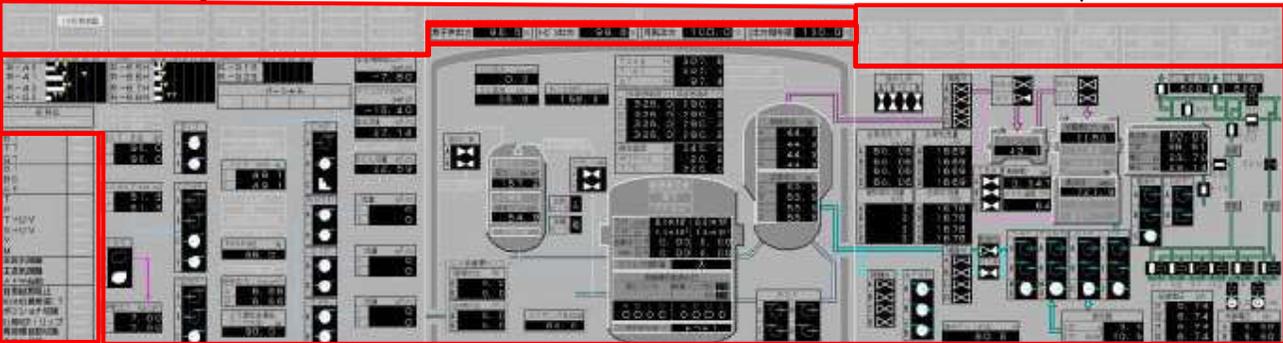
Large Display Panel (2/2)



Integrated display of typical alarms (primary system)

Integrated display of plant output parameters

Integrated display of typical alarms (Turbine system, electrical system)



Automatic display
 (The first alarm-related screens are automatically displayed)
 or
Manual request
 (Any screen is transferred from the operator's console and displayed.)

↑OK monitor to display sequence operation check information in an integrated manner

↑Display the state of the main parameters under normal operating conditions, unusual operating conditions and accidental conditions

Fixed display area

Variable display area

Image of display on the large display panel

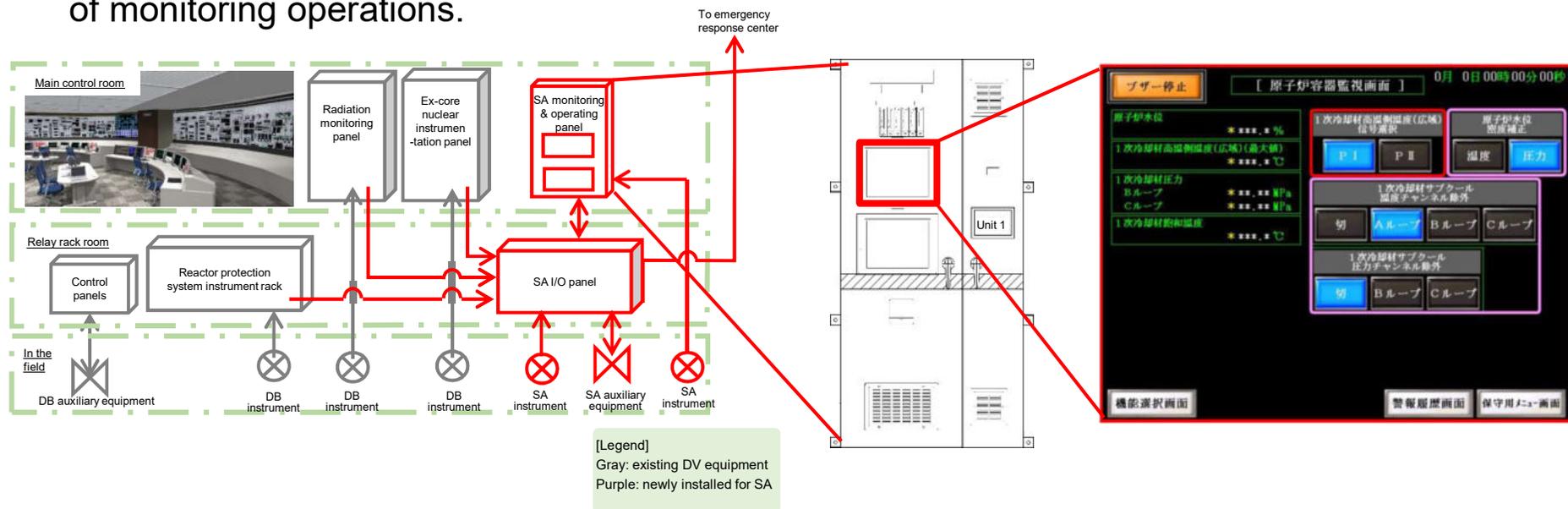
Severe Accident Management Measures for Instrumentation 11

Regulatory requirements

The new regulatory standards require the necessary monitoring and operating functions to ensure that the measures to prevent core damage and containment failure will work in the event of a severe accident etc.

Measures

In addition to a digital main control panel, a digital severe accident monitoring and operation system that integrates the required parameters and auxiliary equipment operations as much as possible will be installed in Takahama 1 and 2 to improve the ease of monitoring operations.

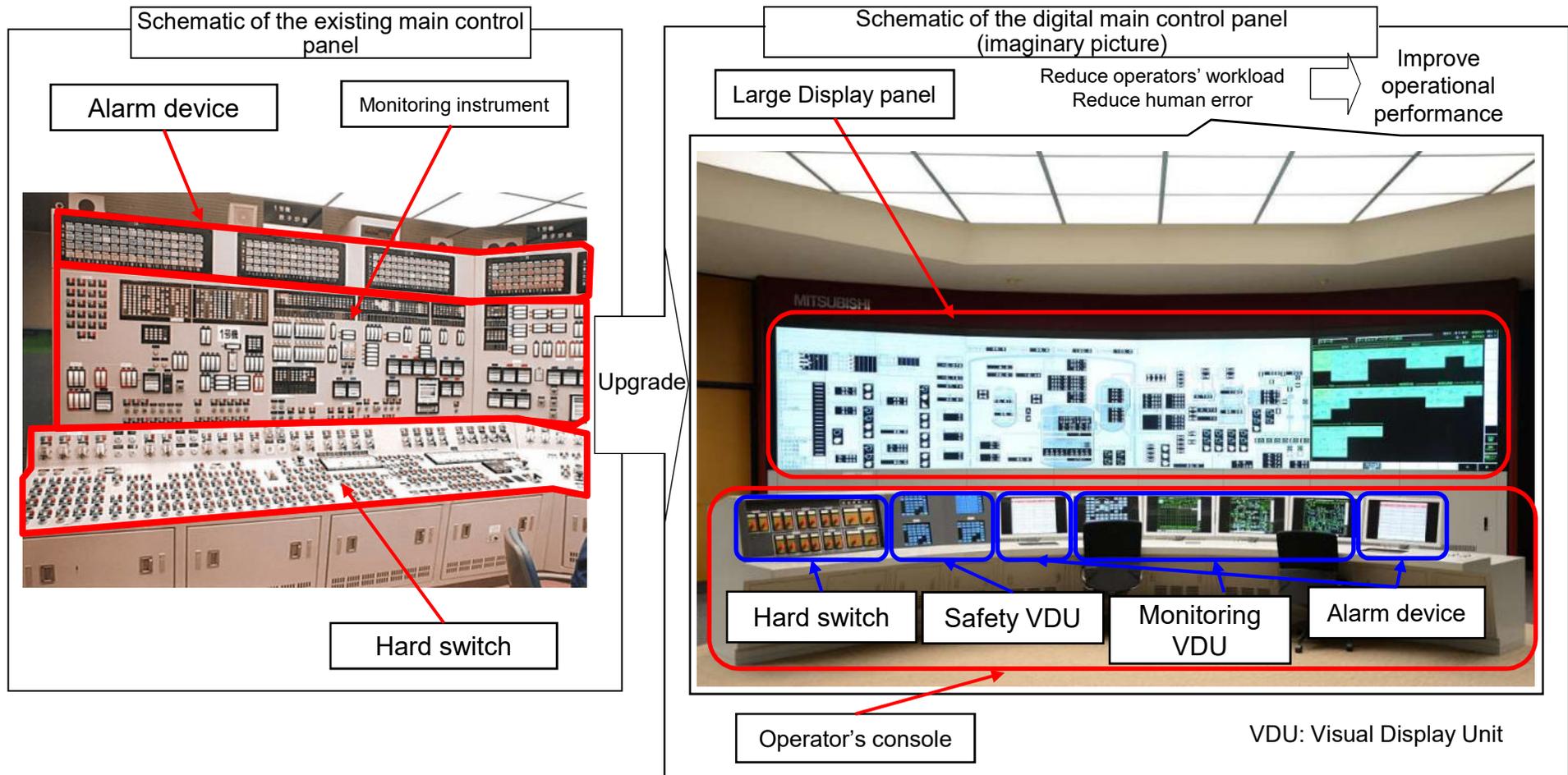


Schematic of the system for the integrated SA panel (Takahama 1 and 2)

Summary and Characteristics of Replacement work of the Main Control Panel

Main work of replacement

- ① Remove the existing main control panels
- ➔ ② Install the digital main control panels
- ➔ ③ Lay cables



Status of replacement work(before and after replacement)

Remove the existing main control panels

(1/13)



Status of replacement work(before and after replacement)

Remove the existing main control panels

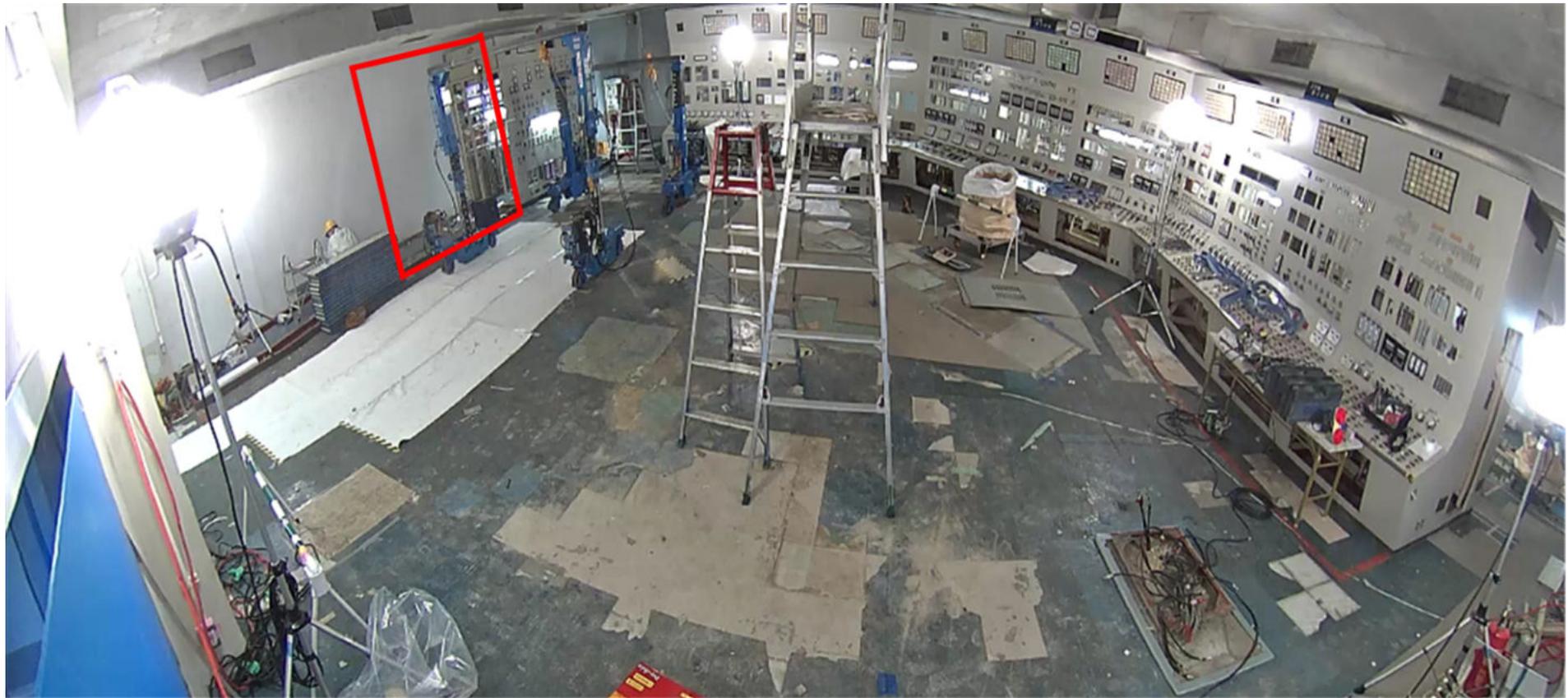
(2/13)



Status of replacement work(before and after replacement)

Remove the existing main control panels

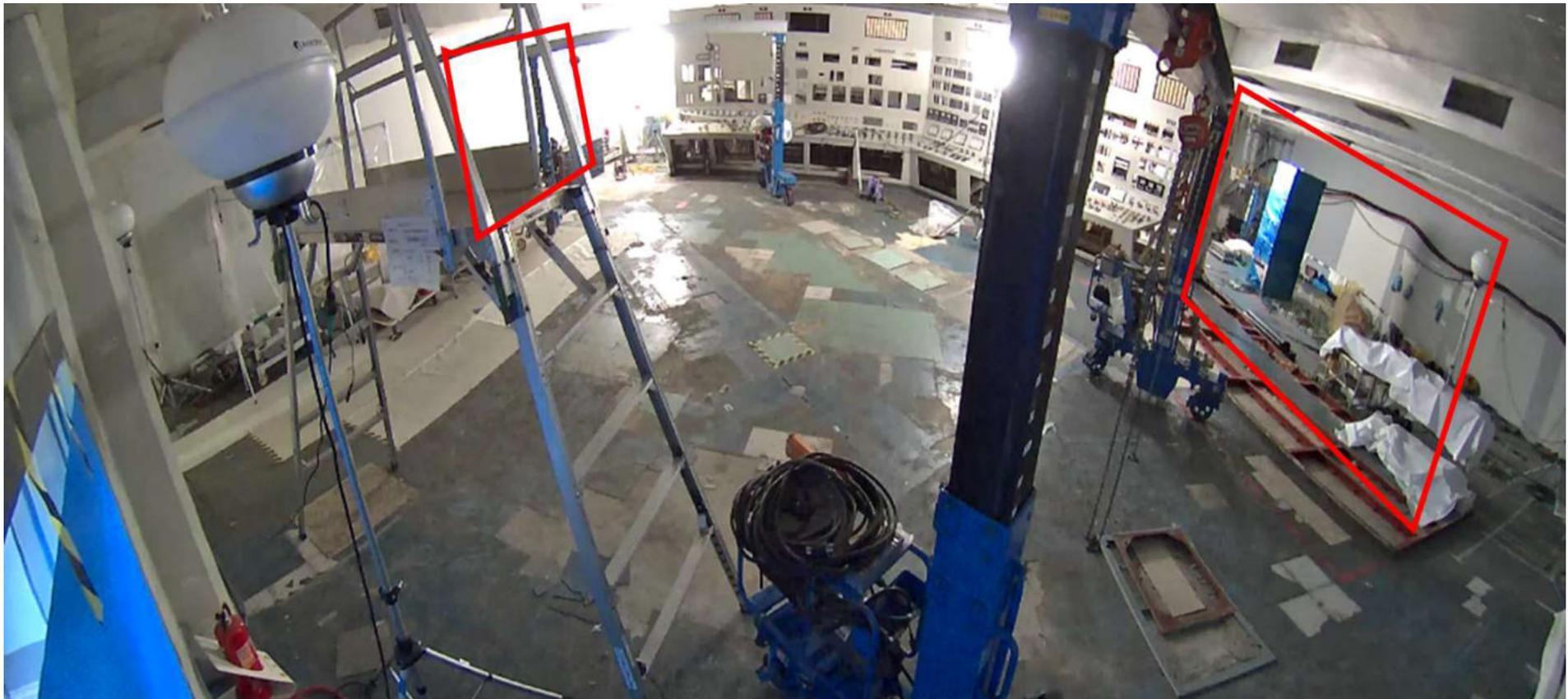
(3/13)



Status of replacement work(before and after replacement)

Remove the existing main control panels

(4/13)



Status of replacement work(before and after replacement)

Remove the existing main control panels

(5/13)



Status of replacement work(before and after replacement)

Remove the existing main control panels

(6/13)



Status of replacement work(before and after replacement)

Install the digital main control panels

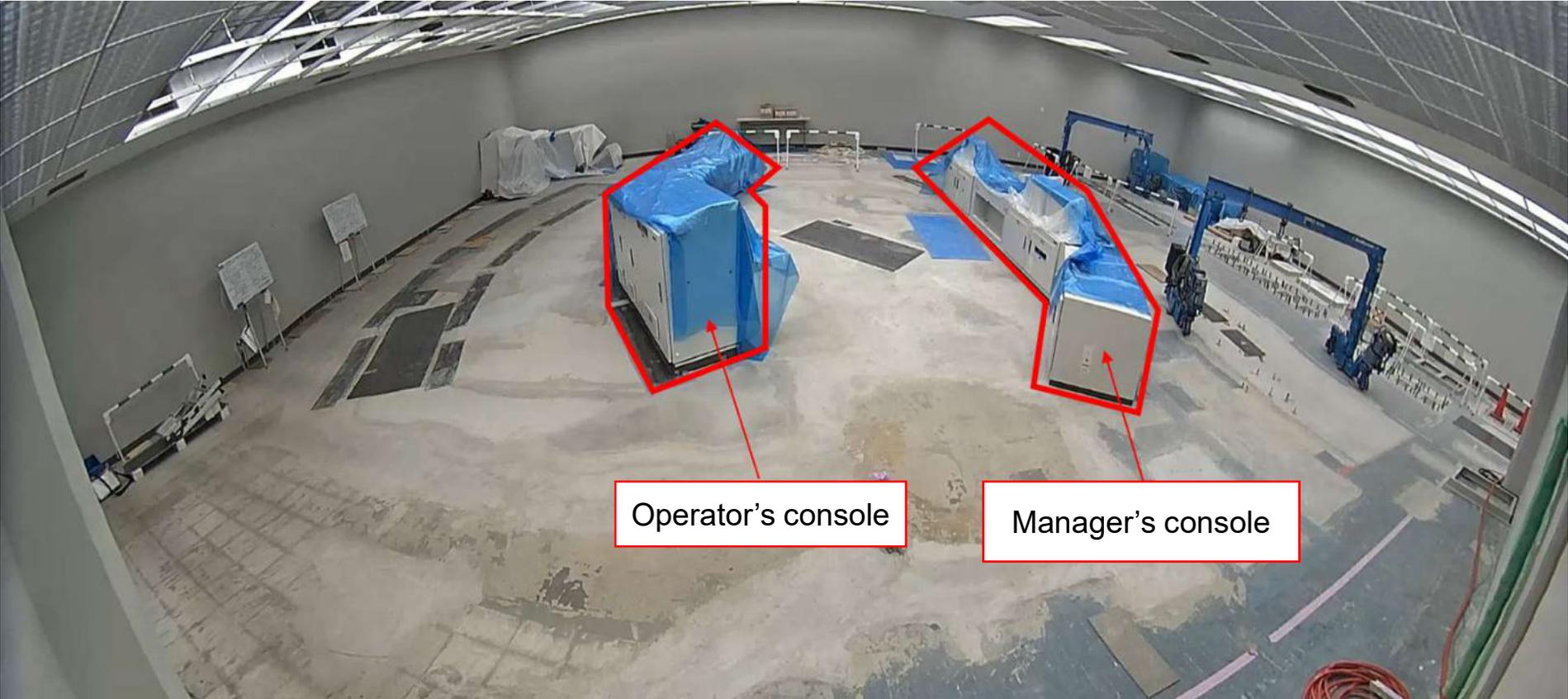
(7/13)



Status of replacement work(before and after replacement)

Install the digital main control panels

(8/13)



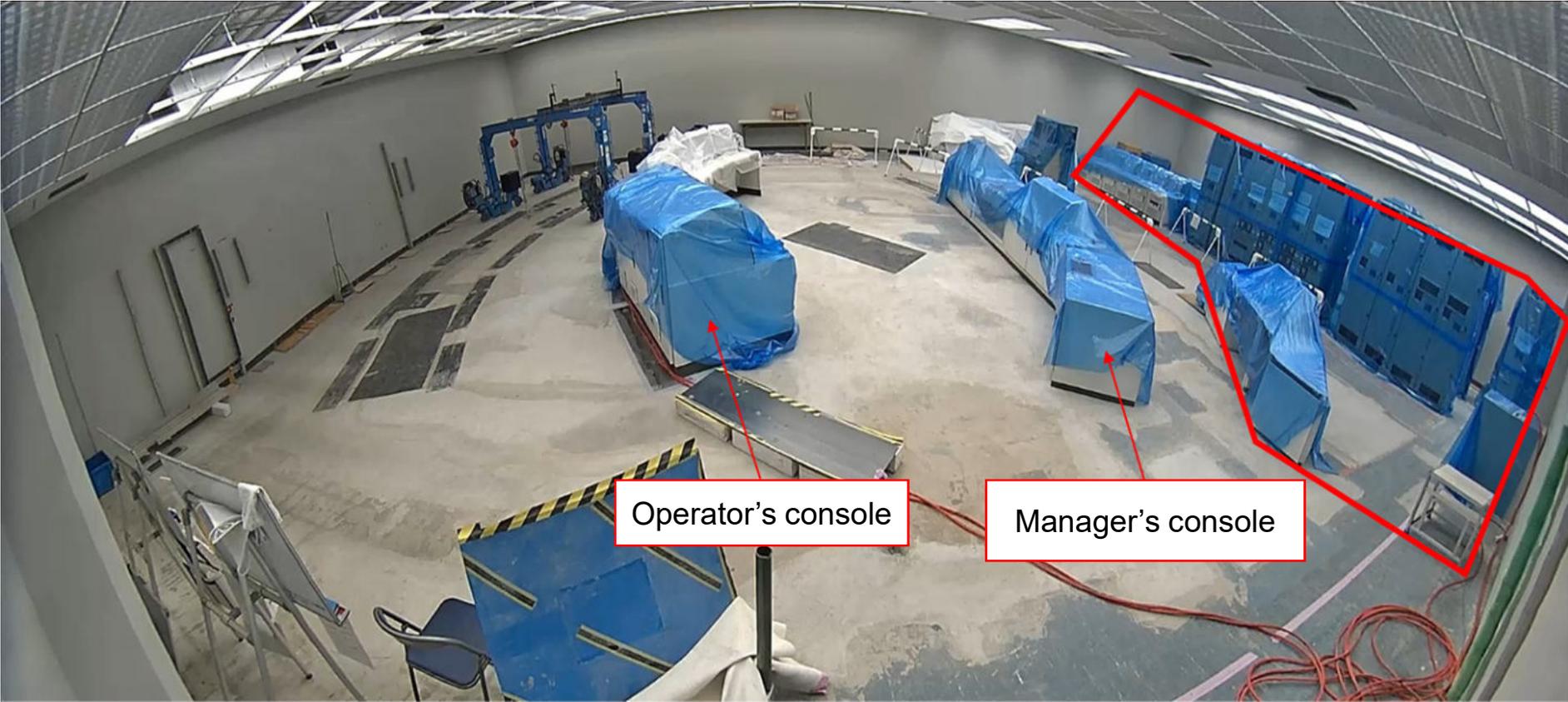
Operator's console

Manager's console

Status of replacement work(before and after replacement)

Install the digital main control panels

(9/13)



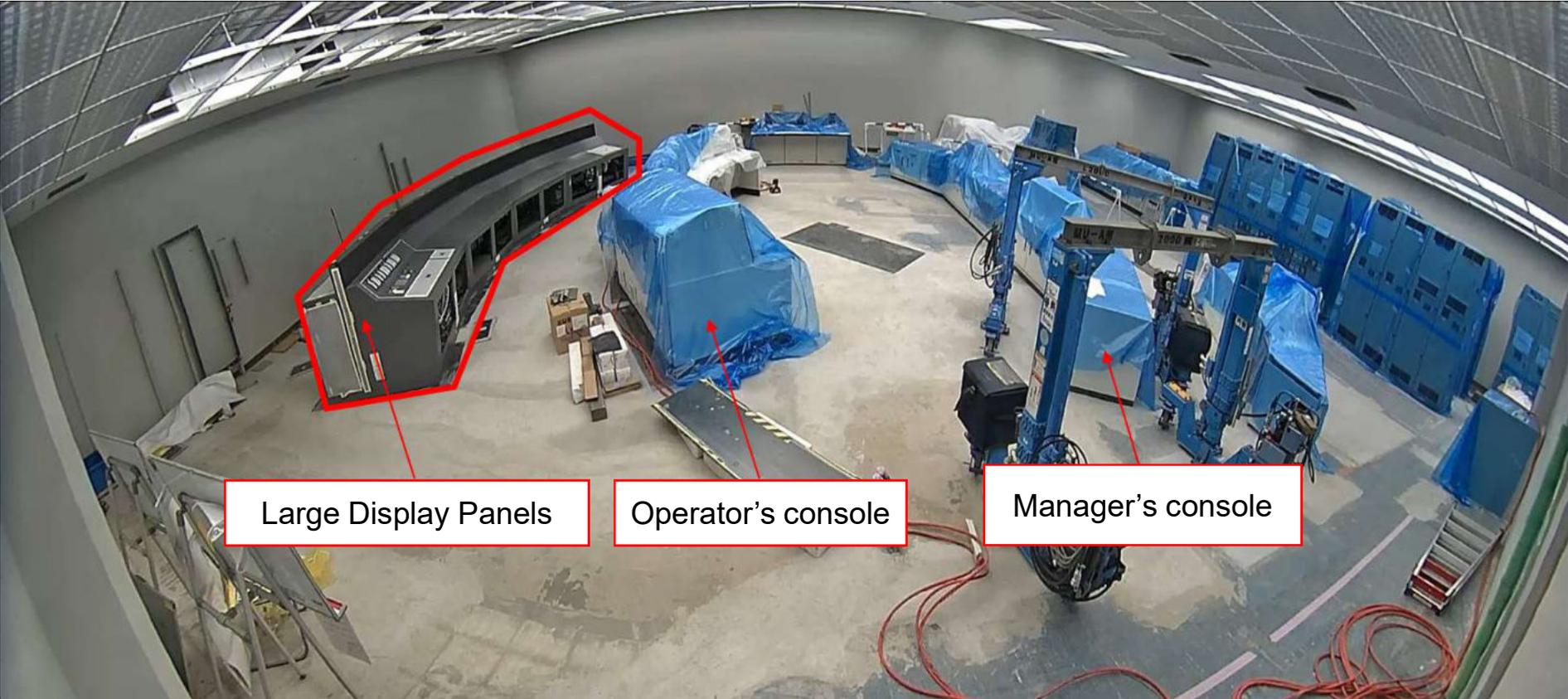
Operator's console

Manager's console

Status of replacement work(before and after replacement)

Install the digital main control panels

(10/13)



Large Display Panels

Operator's console

Manager's console

Status of replacement work(before and after replacement)

Install the digital main control panels

(11/13)



Large Display Panels

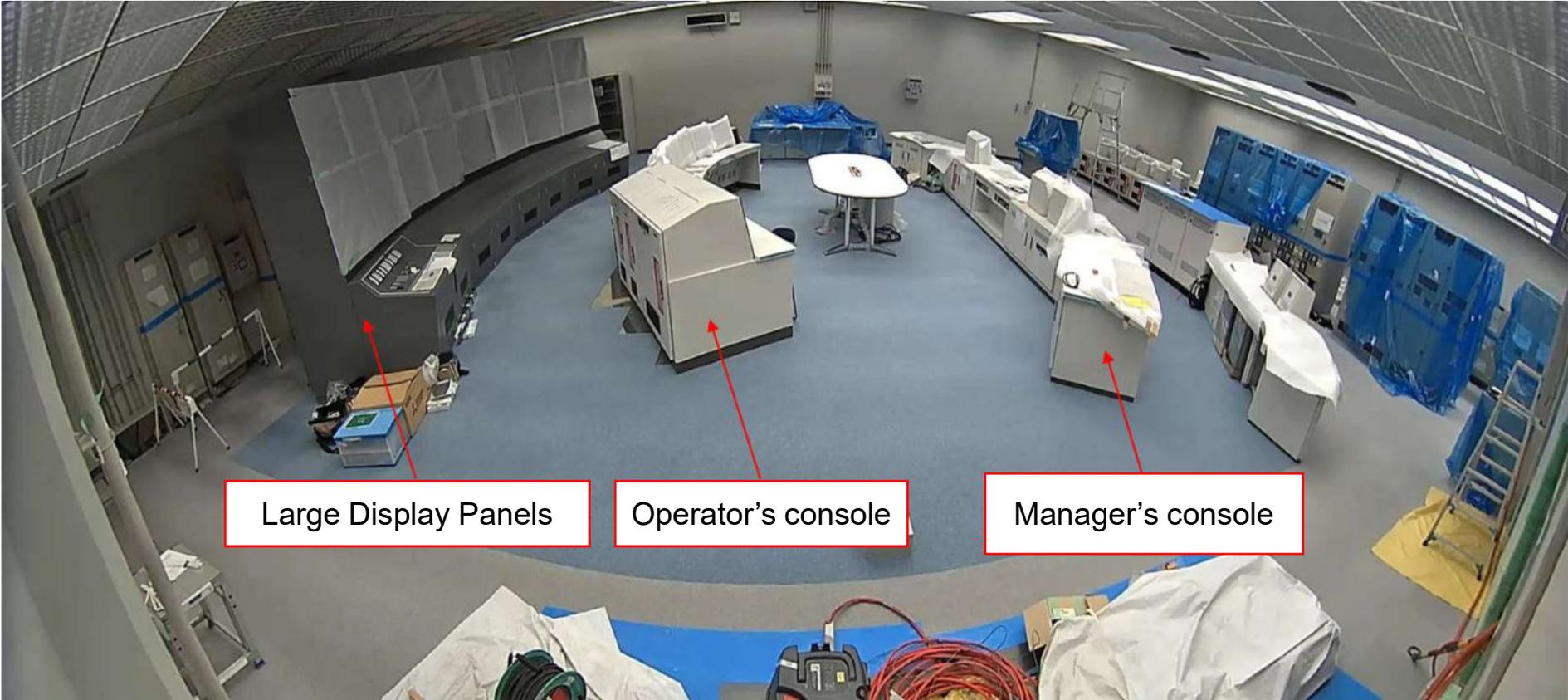
Operator's console

Manager's console

Status of replacement work(before and after replacement)

Install the digital main control panels

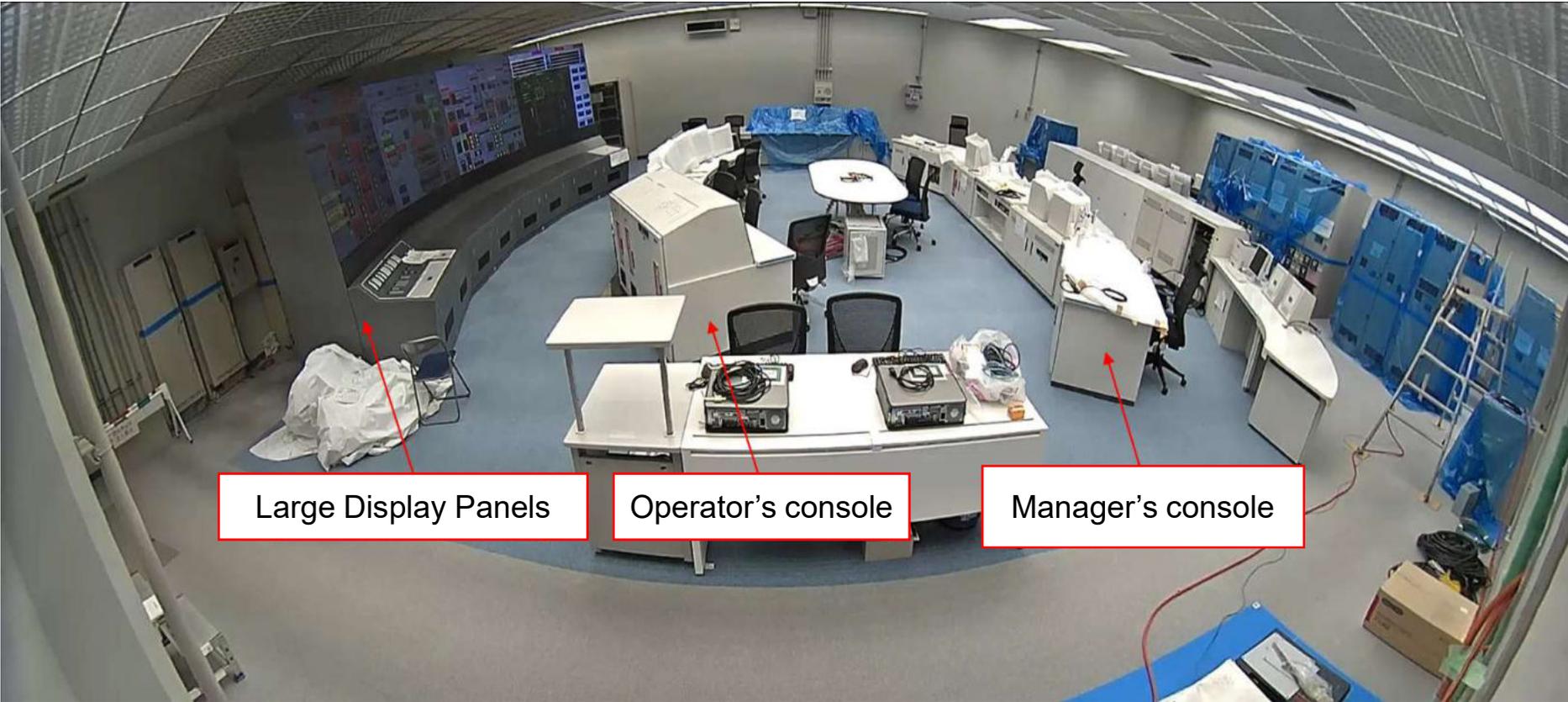
(12/13)



Status of replacement work(before and after replacement)

Trial Operation (After laying cables)

(13/13)



Large Display Panels

Operator's console

Manager's console

Thank you.

The Kansai Electric Power Co.,Inc.

