E-Journal of Advanced Maintenance Vol.5-2 (2013) 132-137
Japan Society of Maintenology

Safety Measures for the Main Control Board Replacement Project at Ikata Units 1 & 2

Nozomu HASHIMOTO[1*] and Kenji TADA[1]

[1] *SHIKOKU ELECTRIC POWER CO., INC., 2-5, Marunouchi, Kagawa, 760-8573, Japan*

ABSTRACT

When Units 1 and 2 of the Ikata Power Station underwent replacement of their main control boards, control cabinets, and associated equipment, it was necessary to remove all the control boards, cabinets, and cables from the control building including from the main control room. This meant the loss of operation and monitoring functions in the main control room and functions of control cabinets. To maintain the operation and monitoring functions required under plant shutdown conditions, temporary operation and monitoring equipment (i.e., temporary main control board) was installed in the temporary main control room. The advance preparations included a trial switching from the permanent to the temporary main control board to identify and address potential problems in advance. When the replacement work was underway, a work schedule sheet posted in the temporary and the permanent control rooms was used to prevent human errors caused by operators' recognition errors. Monitoring and control signals were switched from the old boards to the temporary boards and from the temporary boards to the new boards at appropriate timings to ensure plant safety during the replacement operation.

KEYWORDS

Safety, Reliability, replacement operation, temporary boards, operation and monitoring functions

ARTICLE INFORMATION

Article history:
Received 15 November 2012
Accepted 20 August 2013

1. Introduction

The main control boards, control cabinets, and associated equipment were replaced and totally digitalized at Units 1 and 2 of the Ikata Power Station (hereafter referred to as the "CBR (Control Board Replacement project"). This was a comprehensive digital upgrade of nuclear I & C systems at an existing plant, the first-of-its kind in the world. The CBR project was carried out at both units during their refueling outages, which took place simultaneously for the first time in our company's history. It was successfully completed in August 2009, as scheduled.

2. Overview of the CBR project

Ikata Units 1 and 2 started commercial operation in September 1977 and in March 1982, respectively. Driving factors for the CBR project include: procurement of replacement parts and components is becoming more difficult with supply discontinuation of analogue instrumentation; digital control systems are now most widely used; partial replacement of equipment can be very costly because of complexity associated with connecting systems. Thus, the decision was made to replace the entire I & C systems, including the main control boards which were located in one main control room, safety protection systems, reactor control systems, and cabling between different devices, with integrated digital systems incorporating state-of-the art technologies. The overall architecture of the equipment included in the project scope is shown in Fig. 1.

Based on the results of a comprehensive review on the reliability of the replacement work, the operability of power supply systems, and the economic efficiency, the project was carried out at Units 1 and 2 in parallel with each other by shutting them down almost at the same time. The control

*Corresponding author, E-mail: hashimoto14978@yonden.co.jp

boards, control cabinets, and cables were all removed from the control building including from the main control room before the new boards, cabinets and cables were installed. The loss of operation and monitoring functions in the main control room and those of control cabinets was compensated for by installing temporary operation and monitoring equipment (hereafter referred to as the "temporary main board") in the temporary main control room, to ensure plant safety during the CBR project. The sectional view of a control building before and after replacement is shown in Fig. 2, and CBR construction process is shown in Fig. 3.

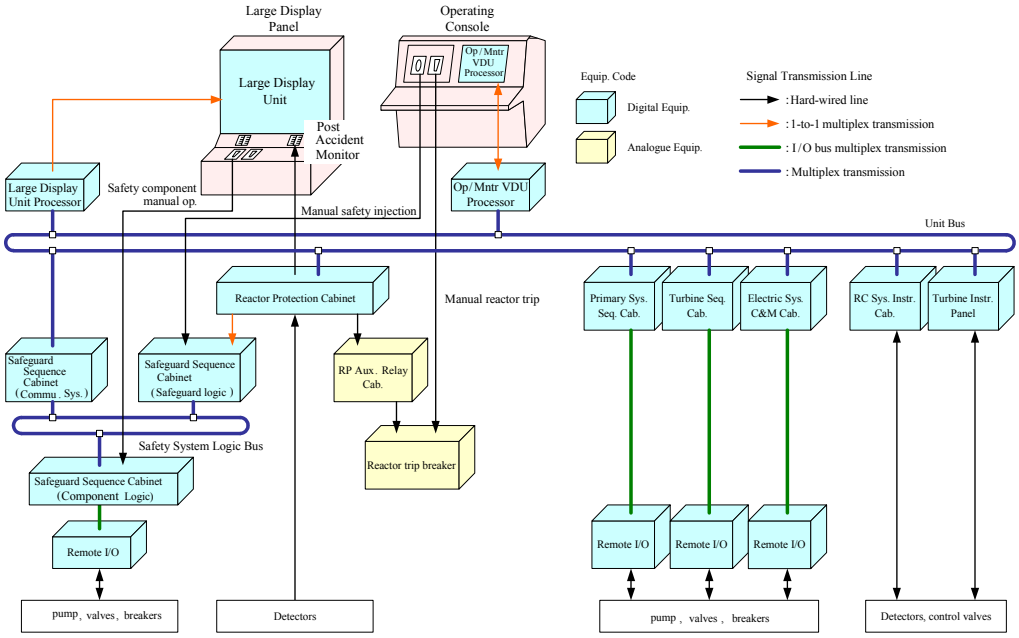

Fig. 1 Overall architecture of the equipment within the project scope

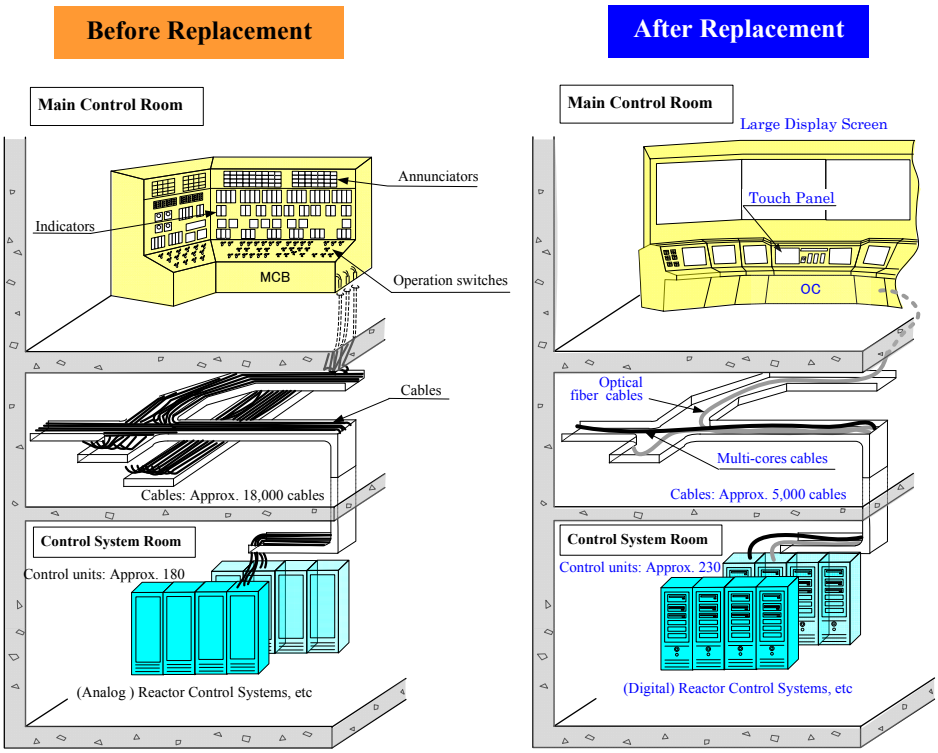

Fig. 2 Sectional view after/before replacement

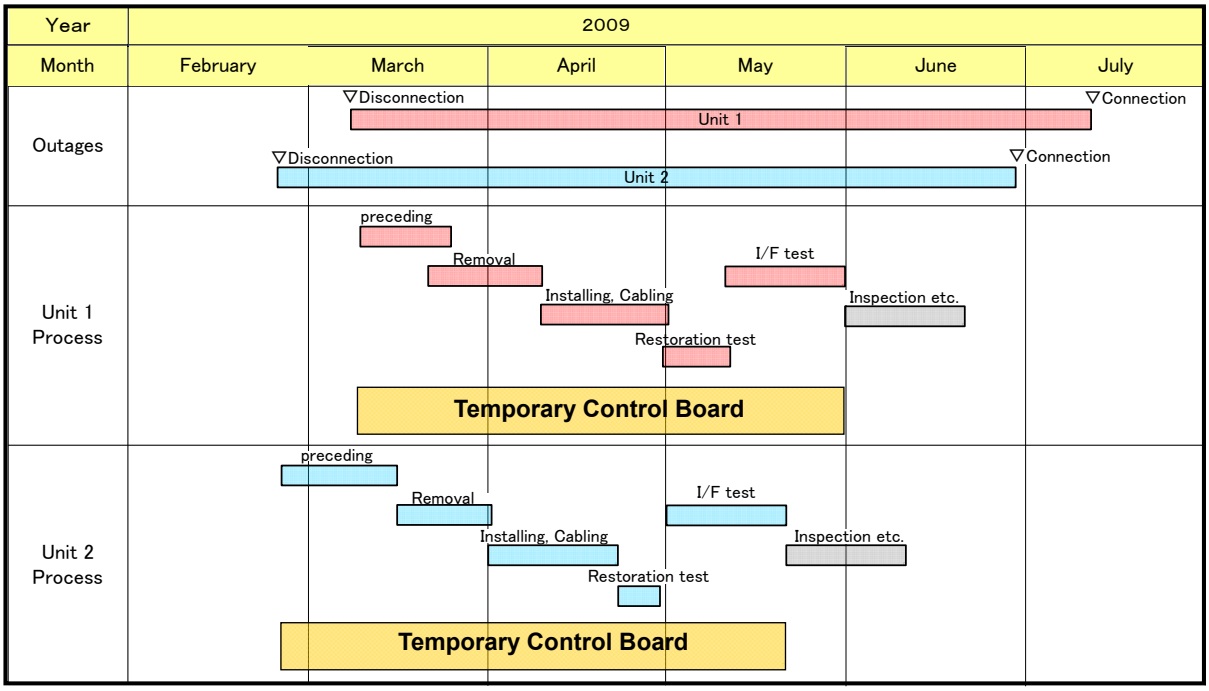

Fig. 3 CBR construction process

3. Concerns and measures associating with the replacement work

The CBR project was a major-scale replacement work replacing main control facilities in two units simultaneously. If there was an unexpected complication, we would have had to go through the time-consuming process of cause investigation, drafting and actual execution of measures, throwing off the entire replacement work schedule, and possibly refueling outage schedule as well. The plan was to monitor operations of systems as necessary during the refueling outage, from the temporary control board until the main control board was removed and replaced. However, signal switching had to be conducted one by one between the temporary control board and main control board according to functional requirement timings of target facilities in the midst of the unpredictable refueling outage processes as well as countless other processes taking place simultaneously.

Moreover, operators had to monitor the operation by grasping the signal switching status between main control boards and temporary control boards exactly.

Due to the reasons above, we had concerns over delayed replacement work resulting in reevaluation of work processes and the refueling outage schedule, as well as complexity of work processes affecting safety assurance of the plant by causing operation errors and misinterpretations.

To this end, we tried to enhance reliability of the replacement work by extracting and taking measures against problems in complications involving facilities and switching operation through cable identification and advance confirmation of the temporary control board, as well as full combination tests at the factory prior to the replacement work during the refueling outage.

Also, we conducted measures with regard to progress management and status display for equipment operation switches in order to prevent operation errors and misinterpretations for the temporary control board during the replacement work.

4. Advance preparations

4.1. Cable identification

The equipment (e.g., field components) which fell outside the upgrade scope was to remain in continuous use, including the cables. All the existing cables for these components had to be cut off immediately before entering the control building for connection to the upgrade equipment. For this

purpose, efforts began in 2003 to identify, and attach cable indices to these cables at the cut-off points. These efforts continued during three refueling outages for each of the two units. This was an extremely difficult task, because there were as many as 18,000 cables, some cables were left abandoned for the removal equipment in the field, and drawings were no longer available for Non-class equipment. Fortunately, however, all the cables were able to be identified and the database was completed before the replacement operation started. Cable identification processes are illustrated in Fig. 4. We attached the identification tags on the new installed cables, and update all the drawings for the future maintenance.

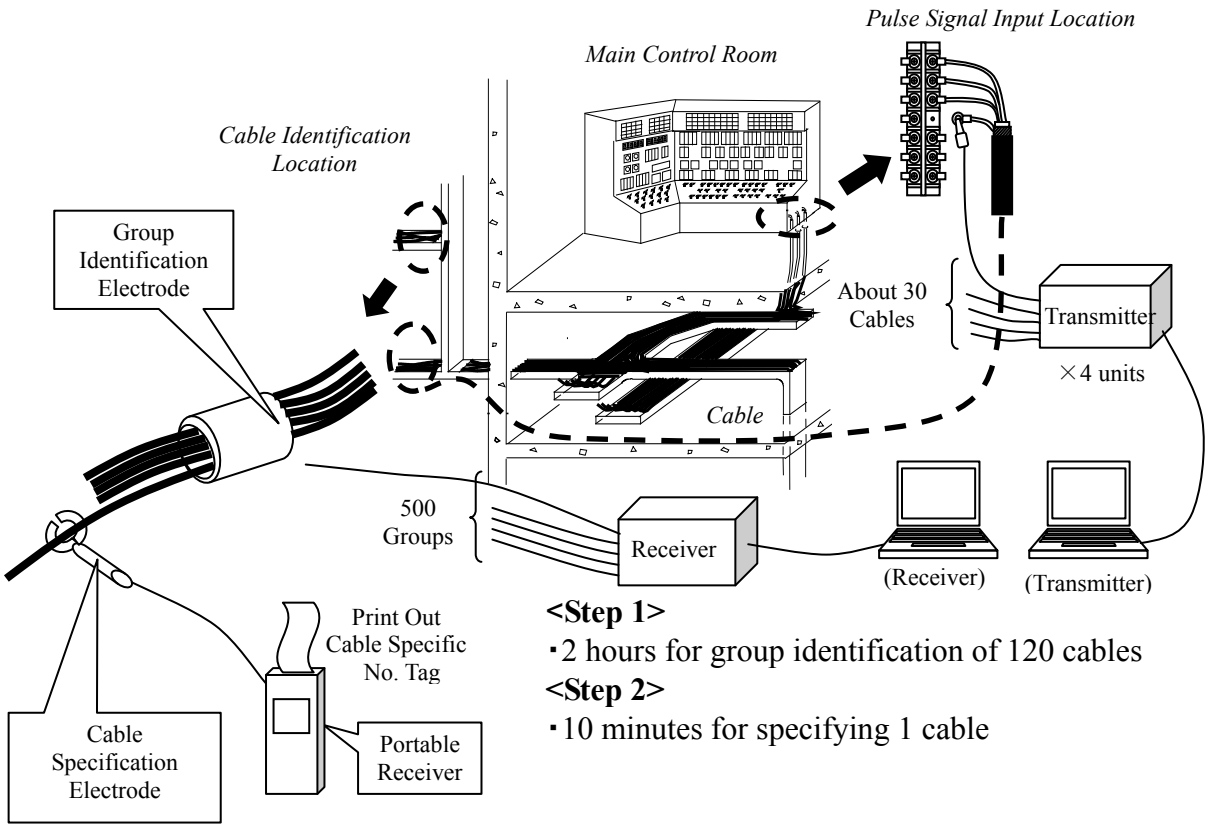

Fig. 4 Cable identification processes

4.2. Preceding work

A temporary main control board (hereafter referred to as "temporary board") was installed during a refueling outage preceding the CBR outage. Therefore, it was configured to receive power supplies from two systems taking work during the blackouts caused by the refueling outage into consideration. It was to be used for operation and monitoring of power supply systems, HVAC (Heating, Ventilating, and Air Conditioning) systems within the radiation-controlled areas and other systems which would be needed during the CBR operation. The relevant components were connected to this temporary board to check and confirm that they functioned as intended and then were re-connected to the existing main control board. This helped to reduce time for switching to the temporary board and prevented connection problems from being detected after the CBR operation started.

4.3. Advance interface verification

In order to prevent connection failures after the CBR operation started on site, interfaces between non-upgrade items and upgrade equipment were reviewed and evaluated. Some breakers and solenoid valves were subjected to combination testing in a vendor's shop.

5. Measures for the replacement work

Since timings of disabling target system facilities during the refueling outage vary, signal cables had to be switched in sequence accordingly. In order to prevent operation errors we performed a functional check each time for every cable upon receiving permission from operators before and after the switch, since target cables were different everyday.

Also, in order to enable operators on duty to grasp the status of every signal exactly, such as isolation of target signals, recovery status, controllability by the main control room and temporary control room during the switchover period, we posted the switch process schedule in both of the temporary and permanent control rooms. We also complemented operator's judgment through visualization of the latest signal conditions by marking progress of the replacement work on the schedule sheet.

While the temporary control room was in service, the operators were using the operational procedures including EOP, which had been set forth only for that outage period. Then, the operators started to use the new operational procedures for the new control boards, according to the progress of the replacement work.

In order to prevent operation errors, paper tags were attached to control hardware, and screen display was implemented for control software, so that operators could confirm control switch conditions before operation, such as whether the target control switch was operable or its function had passed over to the other control board. Fig. 5 shows an example of the temporary operation console screen. Four control devices are displayed with color-coded indications such as "unswitched to the temporary control board," "operations by the temporary control board terminated," "operation prohibited" and "being tested."

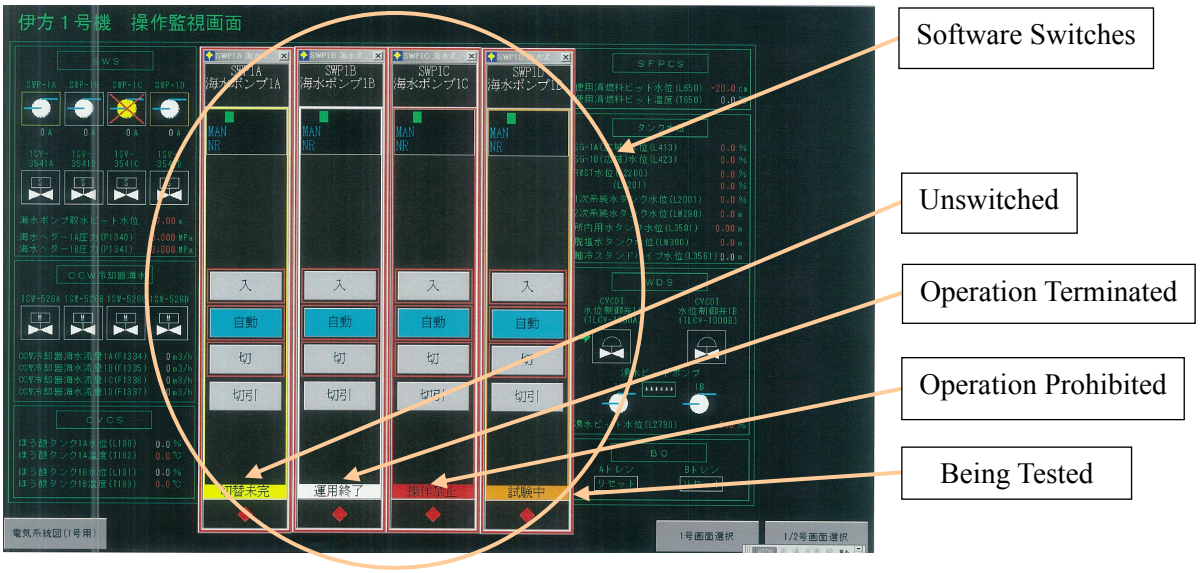

Fig. 5 Temporary operation console screen

6. Conclusion

We managed to prepare for replacement work on schedule by enhancing its reliability through the preceding work. We managed to prevent switching errors and operation errors through management of the switching process for each signal cable and visualization of switching status for working with the temporary control board during the replacement work. We managed to complete the replacement work during the refueling outage, while monitoring plant safety.

References

[1] "THE MAIN CONTROL BOARD UPGRADE PROJECT AT THE IKATA POWER STATION FOR UNITS 1 AND 2" , Seventh American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies NPIC&HMIT 2010, Las Vegas, Nevada, November 7-11, 2010

[2] "Modernization project of Ikata unit 1/2 main control room using full digital control board, " ICONE17 Proceedings of the17th International Conference on Nuclear Engineering, July 12-16,2009

[3] "The Main Control Board Replacement Project for Units 1 and 2," Maintenology 2010/Vol.8/No.4,Japan Society of Maintenology

[4] "Replacement Operation Schedule Management of Main Control Boards at Ikata Unit 1&2 Using Full Digital Control Systems", EJAM Vol.2, No.4, NT30