

Design of General Operating Support System

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1. Introduction

General Operating Procedure (GOP) of Nuclear Power Plant (NPP) provides Main Control Room (MCR) operators with the procedures for start-up operation and shut-down operation. These GOPs are used in full range depending on the operation mode and generally consist of purpose, reference, precautions and limitation, procedures, attachments [1]. In particular, the GOPs used in startup and shutdown operation require the many tasks of MCR operators [2-3].

This paper suggests the conceptual design of General Operating Support System (GOSS) with consideration of characteristics in digital MCR of APR1400.

2. Configuration of GOSS

The computer based procedures are applied to the NPP from Shin-Kori 3&4 units. The Korea Hydro Nuclear Power (KHNP) Computerized Procedure System (CPS) consisting of server and clients automatically provides a procedure flow to the MCR operators according to the user's instruction evaluation [4]. The server of GOSS simultaneously receives the procedure flow from the server of CPS and sends the related operation support display to the MCR operators. And also this server receives the indication information and status data of plant and calculates the important equation such as shutdown margin using this information of plant. Figure 1 shows the configuration of GOSS among the GOSS server, plant and CPS server.

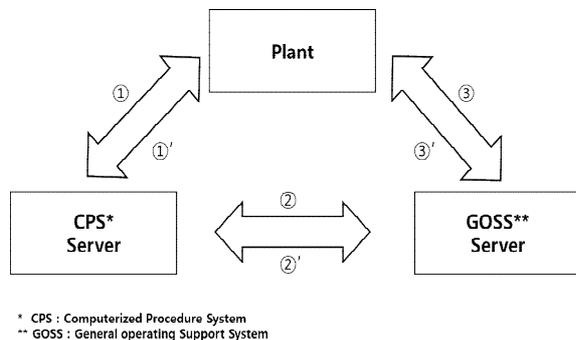


Fig. 1. Configuration of GOSS

Table I shows the typical sending and receiving data among the plant, CPS server and GOSS server.

Table I: Sending and Receiving data

| No. | Data |
|-----|--|
| ① | Information related to the instruction (Display, plant status, Heartbeat (HB) etc.) |
| ①' | Requested data, HB etc. |
| ② | Executing Procedure Identification(EPI) (GOP.30010002.1.2.1 etc.) |
| ②' | Information related to the EPI - Monitoring result of plant status - Monitoring result of limiting conditions for operation - Related technical base for logic condition and general operation etc. |
| ③ | Information related to the instruction (Plant status, Heartbeat (HB) etc.) |
| ③' | Requested data, HB etc. |

3. Main features of GOSS

This section describes user interface and main features of GOSS. GOSS can be executed simultaneously in conjunction with CPS or can be executed as a stand-alone machine. GOSS is divided into three main functions which are support displays, monitoring the conditions of plant and references (technical bases, other system procedures, etc.) for the related operation.

And the user interface has multiple panes which can be resizable by user's arrangement and the leftmost pane provides the buttons to call the main functions. Fig. 2 shows the typical user interface of GOSS.

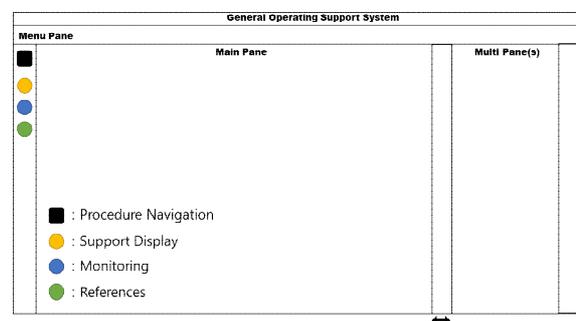


Fig. 2. Typical user interface of GOSS

3.1 Support displays

The plant status related to a step or an instruction is shown on the support displays. The display for

shutdown margin calculation is also provided. Fig. 3. The typical window of shutdown margin calculation.

| | Previous Status | | Current Status | |
|---------------|-----------------|-----------------|----------------|-----------------|
| | Time | Condition | Time | Condition |
| Time | 20:00:00 | 00:00 | 20:00:00 | 00:00 |
| Core | MWD/MTU | | | |
| Power | 0.000 % | (-) 0.000 %Δk/k | 0 % | |
| AVG. Time | 0.000 °C | | 0.000 °C | (+) 0.000 %Δk/k |
| Measured | 0.000 MW | | 0.000 MW | |
| Boron density | 0.000 MW | | 0.000 MW | (+) 0.000 %Δk/k |
| Position | BG-0.000 cm | (-) 0.000 %Δk/k | ARI-0.000 cm | (-) 0.000 %Δk/k |
| Xe Power | | | 0.000 % | (+) 0.000 %Δk/k |
| Sm power | | | 0.000 % | (+) 0.000 %Δk/k |
| 합계 | | (-) 0.000 %Δk/k | | (-) 0.000 %Δk/k |

Fig. 3. The typical display for shutdown margin calculation.

Support displays can calculate equations using user's input value and plant variable and calculated equations can be sent to other server or printed.

3.2 Monitoring the conditions of plant

GOSS monitors the specific conditions of plant which are created by the procedure writers such as Limiting Conditions for Operation (LCO) etc. The example is shown on Figure 4.

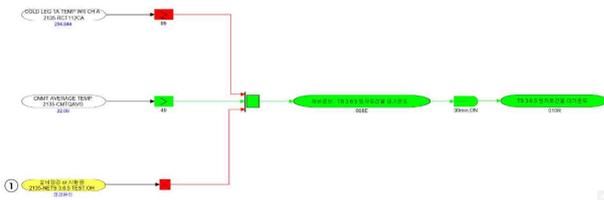


Fig. 4. Suggested arrangement of the console display of APR1400

If the condition result is satisfied, GOSS generates the alarm popup on its screen and sends the signal to the server of CPS. However, the confirmation can only be done on one of the systems. Figure 5 shows the suggested arrangement of the operator console display of APR1400.

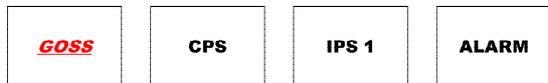


Fig. 5. Suggested arrangement of the console display of APR1400

3.3 Operating experience

Procedure is a kind of guide to operate the plant but it cannot be written in detail. The important procedure is included but all the information such as technical bases, operation experiences cannot be added. This information which enhances the situation awareness of the plant is provided.

4. Conclusions and further works

This paper describes the main features and user interface of GOSS. GOSS provides support display, monitoring function and references information for the general operation to operators. The support information can enhance the situation awareness of the plant and reduce the operators' workload.

GOSS is under development, and Verification and Validation (V&V) will be performed in the Shin-Kori 3&4 simulator after the development of prototype GOSS. The V&V result will be applied to final GOSS version.

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