The control room is where operators perform plant operations using control systems every day, and a safe, comfortable, and functional environment helps operators to run the plant more efficiently. The control room must therefore be designed accordingly. Yokogawa has been designing control rooms for various industries for over 30 years. Taking an example of the layout for operator consoles in a consolidated control room, this paper looks at Yokogawa’s Control Room Design service.

INTRODUCTION

When considering improving the efficiency of plant operation, major focus is put on process units, control systems and production or operation management. However, it is also important to prepare a comfortable and safe environment for operators, who are trying to operate the plant more efficiently every day using control systems.

Yokogawa has designed more than 500 control rooms for various industries for over 30 years. Yokogawa also participated in the ISO technical committee in drawing up the ISO 11064 “Ergonomic design of control centers” (ISO: International Organization for Standardization), one of the international standards for designing control rooms. This paper provides an outline of the Control Room Design service which Yokogawa offers based on its experience, which is one of the VigilantPlant Services launched to help improve operations throughout the plant lifecycle, as a partner of customers.

WHAT IS CONTROL ROOM DESIGN?

Different from general offices, it is important to design control rooms on the basis of the human-centered design approach as shown in Figure 1 by balancing comfort and functionality including the following aspects.

- Plant operation tasks and organization for operation (normal situations and emergencies)
- Design standards for control rooms (ISO 11064, industry standards including customer’s standards)
- Study items based on ergonomics (layout, lighting, coloring, sound, operator console design, large screen, and selection of furniture and materials)

Yokogawa set the process from design to installation and construction of a control room as follows referring to ISO 11064.

1) Conceptual Design
2) Basic design
3) Detailed design
4) Installation and construction

Conceptual design is particularly important. This is where the design policy and the customer’s requests are confirmed and issues in the subsequent processes (basic design, detailed design, installation and construction) will be identified prior to the basic design and detailed design. It is also important for improving the efficiency of the entire designing works.

OUTLINES AND PROCEDURE OF CONTROL ROOM DESIGN

Yokogawa’s Control Room Design service is designed for the conceptual design phase of the entire control room design process. The service may include the basic design phase or the detailed design phase upon the customer’s request.

This service is provided following a standardized
Control Room Design for Efficient Plant Operation

...procedure based on the DMAIC process of Six Sigma (Define, Measure, Analyze, Improve and Control). Table 1 shows the procedure of the service.

<table>
<thead>
<tr>
<th>Step</th>
<th>Task items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>• Set the goal considering comfort, safety, functionality and innovation.</td>
</tr>
<tr>
<td>Measure</td>
<td>• Gathering information using questionnaires on plants, buildings, systems, operation and standards.</td>
</tr>
<tr>
<td></td>
<td>• Conducting a field survey of the existing control rooms, including the interior layouts, travel routes, operator console layouts, Human Machine Interface (HMI), panels, furniture, etc.</td>
</tr>
<tr>
<td>Analyze</td>
<td>• Analyzing the customer’s needs based on acquired information.</td>
</tr>
<tr>
<td>Improve</td>
<td>• Revision of the conceptual design including the room layout and its basis.</td>
</tr>
<tr>
<td>Control</td>
<td>• Submitting a final report and giving a presentation about it.</td>
</tr>
<tr>
<td></td>
<td>• Advising on the subsequent phases (basic design, detailed design, installation and construction).</td>
</tr>
</tbody>
</table>

**EXAMPLE OF CONTROL ROOM DESIGN SERVICE**

In this section, an example of an oil refinery is described to explain the study items, procedure and outputs of the service.

**Background of the Service**

This refinery is fully equipped with utility facilities and receiving & shipping facilities, in addition to the process units such as atmospheric distillation unit, vacuum distillation unit, fluid catalytic cracking unit, catalytic reforming unit, hydrosulfurization unit and asphalt production unit. Currently, the plant is operated at nine major control rooms near individual units.

The refinery has decided to construct a new unit and, at the same time, to consolidate the control rooms as part of its modernization project. They have chosen the option of centralized control of the entire refinery from one location, rather than constructing a dedicated control room for the new unit near it as before. Since the units in the refinery are interconnected to each other from upstream to downstream, the shift supervisors and the operators of the related units work closely together while maintaining good communication. A consolidated control room, where all the shift supervisors and board operators work together, provides the most suitable environment for ensuring efficient and safe plant operation for such complex units. It helps grasp the overall state of the refinery including better communication for operational changes and plant optimization.

To capture the full benefits of a consolidated control room, the refinery has decided to introduce Yokogawa’s Control Room Design service. They wished to improve the productivity of operators in the consolidated control room by an ergonomic design for better communication.

**Procedure of Conceptual Design**

The conceptual design of the consolidated control room was completed in two and a half months following the standardized procedure shown below.

- **Define**
  In a consolidated control room, more operators work at the same location and at the same time than in an individual control room. Therefore, we set the goal of the conceptual design to select a layout of the operator consoles considering plant configuration, work flows, organizations and operations not affected by acoustic noise, such as operators’ voices and alarm sounds from other operation sections.

- **Measure**
  A two-day field survey was conducted to grasp the current site situation, the project plan and requests.
  - Visiting the planned construction site of the consolidated control room and the existing control rooms
  - Gathering information such as the flow diagram of the existing units, their layout, the configuration diagram of the control system, the construction plan of the consolidated control room and its architectural drawings, the shift plan of the operators, a list of devices to be installed in the consolidated control room, and a future plan for new units
  - Interviews on the customer’s requests, current problems, plant operation tasks, etc.

- **Analyze**
  We analyzed the gathered information mainly for the locations of the operator consoles and created five cases of different layouts of the consolidated control room as shown in Figure 2.

  The five cases differ in grouping of operator consoles, orientation of placement of operators and locations of large screens, meeting areas, printers and visitors’ area. Cases 1 to 4 are for the planned consolidated control room and Case 5 for taking into account possible plans for future expansion of the control room. The process units assigned to the group of operator consoles are determined by analyzing work flows for enhancing coordinated operation among units for each case as shown in Figure 3.

  We compared and evaluated the five cases on the following points, compiled an interim report, and then explained it to the refinery.

  - Collaborative operation among groups and among units
  - Grasping the operation state of the entire refinery
  - Accessing the consolidated control room from outside
  - Influence of speaking and alarm sounds
  - Expandability for additional consoles
  - Usage of large screens and their quantity
• Balancing the numbers of control loops among groups

Using our knowledge and experience, we advised consolidating the number of devices such as consoles for engineering work and printers in the consolidated control room by system migration.

By comparing and examining the pros and cons of the five cases, we selected case 3 as the most suitable layout for the refinery. We conducted interviews regarding case 3 to confirm whether anything needed to be improved or examined further, and created a layout tailored to more detailed and specific requirements as shown in Figure 4, which was included in the final report.

Control

We submitted the final report to the refinery and advised items to be examined in the basic design and detailed design phases, and during consolidation of the control rooms.

The report not only shows the layout but also describes the design process to reach the final layout. It includes how requests for improvement were incorporated, why the design was selected, what discussions the proposal is based on and items to note when proceeding to the detailed design. The report also contains 3D graphics that show what the completed control room will look like. Figures 5, 6 and 7 show parts of the report.
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RESULTS

With this conceptual design for efficient operation, we selected a layout of the consolidated control room based on a careful examination of work flows including collaborative operation among units and travel routes of operators. It is important to share the designing process and intentions behind the design at the beginning of the design phase through such analysis and improvement. Combined with issues identified at this phase, transition and implementation in the following phases become much easier.

Accepting the conclusions of the conceptual design study, the refinery proceeded to the basic design, detailed design and installation and construction phases of the consolidated control room for efficient plant operation.

The refinery has been grateful for the results of our layout study and the quality of our final report and presentation.

CONCLUSION

The console and operator layout in the consolidated control room is arranged, in this example, focused on better communication in accordance with the process flow of the refinery units for achieving efficient plant operation. Although the service procedure of the Control Room Design is standardized, required study items and issues to be improved vary from control room to control room. Yokogawa will continue to provide the valuable Control Room Design service to create better operation environments for customers, based on a human-centered design approach.

REFERENCES

(1) ISO 11064, Ergonomic design of control centres, Part1: Principles for the design of control centres, 2000

* VigilantPlant Services is a registered trademark of Yokogawa Electric Corporation.