The control room on an offshore oil platform can quickly become a scene of frenzied activity in an emergency: Alarms scream, warning lights blaze and screens flash. Operators are inundated with information. Decisions have to be made, and made quickly. Which situation is the most critical? What has to be done first?

Cool, calm and collected

No cause for alarm on the Grane oil rig

Ragnar Aarlien, Charlotte Skourup

The Grane offshore platform, operated and owned by Hydro

A scene like the one above is hardly likely on Hydro's Grane platform in the North Sea. Why? Because the platform, expected to become one of the top oil producers in the Norwegian offshore sector when it reaches peak production, has advanced ABB technology installed on it to make sure operators know exactly what to do in emergencies. That is especially important for a platform of this size and complexity (Grane has units for accommodation, drilling and processing).

For the Grane project ABB in Norway developed a safety and automation system (SAS), a process information management system (PIMS) and electrical tagged equipment (ETE) as part of the ABB Industrial^{IT} portfolio. The SAS ranks emergencies, shuts off alarms for all but the most critical situations, and uses lights and symbols sparingly, to clearly direct the operators' efforts.

The first production well came onstream at 06:59 am on 23 September 2003. Eventually, 12 pre-drilled wells will be linked up to the platform. Oil production from the field will be gradually increased until it reaches the planned level of just over 210,000 barrels per day.

Indispensable human operators

Offshore platforms like Grane are huge, both in size and in value. Their value has two components – the enormous structure and infrastructure on the one hand and the oil they produce on the other.

Every improvement in productivity translates into an increase in revenues. Oil and gas companies therefore invest heavily in optimizing their platforms' technical equipment, especially in upgrading the process control systems, simulators, safety systems and PIMS.

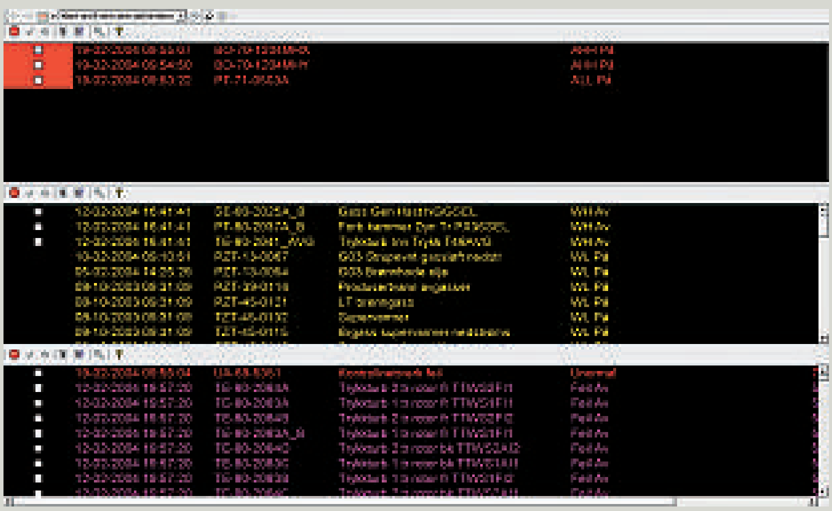
Only a small part of this equipment is completely automated. Human operators therefore play a decisive and indispensable role in the overall system operations. Operators are responsible for making key decisions, such as how the flow of oil from the wells should be optimized, where preventive maintenance is required, or when stops should be scheduled. Importantly, operators learn by doing, acquiring individual process skills and knowledge along the way.

The industry typically focuses on optimization of the control system, but only rarely considers the operators as being part of the overall control chain. This is because it is much easier to measure technical improvements than it is to gauge human performance, especially improvements in decision-making. One area for which the operators are entirely responsible, and which still cannot be automated and performed by computers, is alarm handling.

How operators handle alarms

Alarms are generated whenever a parameter in the process exceeds its predefined limit(s) for acceptable deviations. Typical sources are process measurements or simulations with mathematical models of the process. The primary function of an alarm is to warn the operator about an abnormal situation [1]. Alarm reports usually list the alarms chronologically, with their name, criticality, time and date. Sometimes a

> The new safety and automation system ranks emergencies, shuts off all but the most critical alarms, and uses lights and symbols sparingly.



Typical alarm list, showing the alarm names, degree of criticality, time and date

Operator stations and one of the large screens in the Grane control room

lengthier description is added. A typical alarm list, with priorities 1, 2 and 3, is shown on page 46.

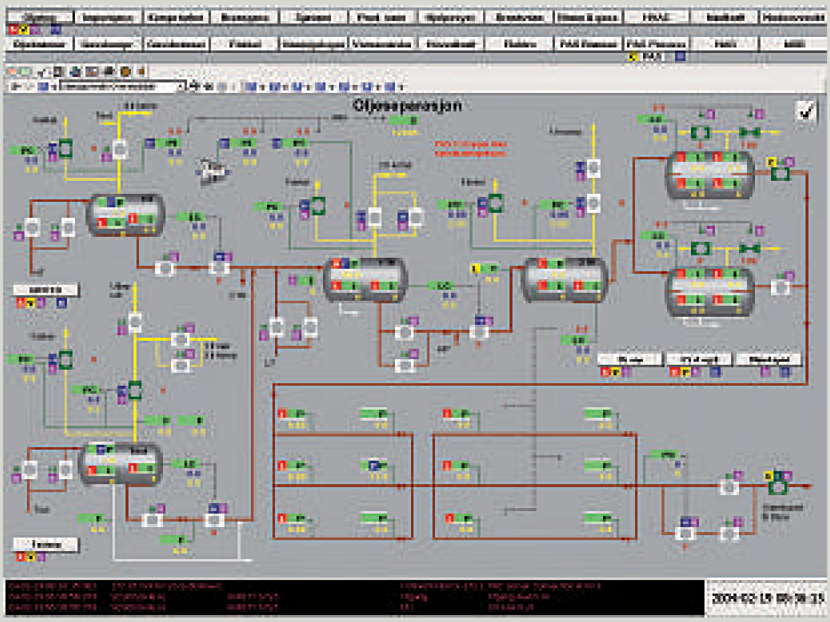
The procedure for alarm handling begins with an operator taking responsibility for a specific incoming alarm by acknowledging it. This same operator is then responsible for taking the alarm off the list after the cause of the problem has been removed.

In normal everyday situations alarm handling is straightforward. It is in critical situations that it becomes a risk factor. A continuous stream of alarms appears on the operator's screen, pushing earlier alarms off and out of view. The operator therefore only sees the most recent alarms, which may be follow-ups of previous, more critical alarms. Situations like this can overwhelm even the most experienced operator. This was, in fact, how the Three-Mile Island accident in the USA began [2]. It took more than 12 hours for the nuclear plant's crew and the engineers to concur in effective corrective action.

The stress and information overload – visual as well as audible – that can be caused by a flood of incoming alarms in an emergency has the potential to become a hazard in itself. This makes the design of the human-machine interfaces all the more important. What is needed to ensure safe operation is a combination of the latest ergonomics know-how, dealing with factors like human information processing, and advanced control technology [1].

Human strengths

As already implied, the overall control/alarm chain consists of computer systems *and* operators. These two key elements have different, but complementary, strengths. The computer's main strengths are storing and searching large amounts of data and information, as well as repeating memorized tasks and multi-tasks. The human strengths lie in another area – judging situations, making decisions, solving problems, reasoning and acting intuitively. Pattern recognition, such as identifying a critical situation among a group of alarms, is therefore a human strength, and one which strongly depends on skill and experience.



Operator station screen. The fixed display at the top has 'dynamic' buttons linked directly to detailed overviews of the process sections.

This, then, is one of the main tasks of the control room operator. It is his responsibility to interpret the alarms and take whatever action is necessary to eliminate the critical situation. Often, however, a situation will involve more than one alarm, so to be able to interpret it accurately the operator needs to be continuously aware of what is happening in the process.

Situations of the kind described call for skilled operators who understand the process and are able to filter and prioritize the alarms. However, there is still always the risk of information overload.

Preventing information overload

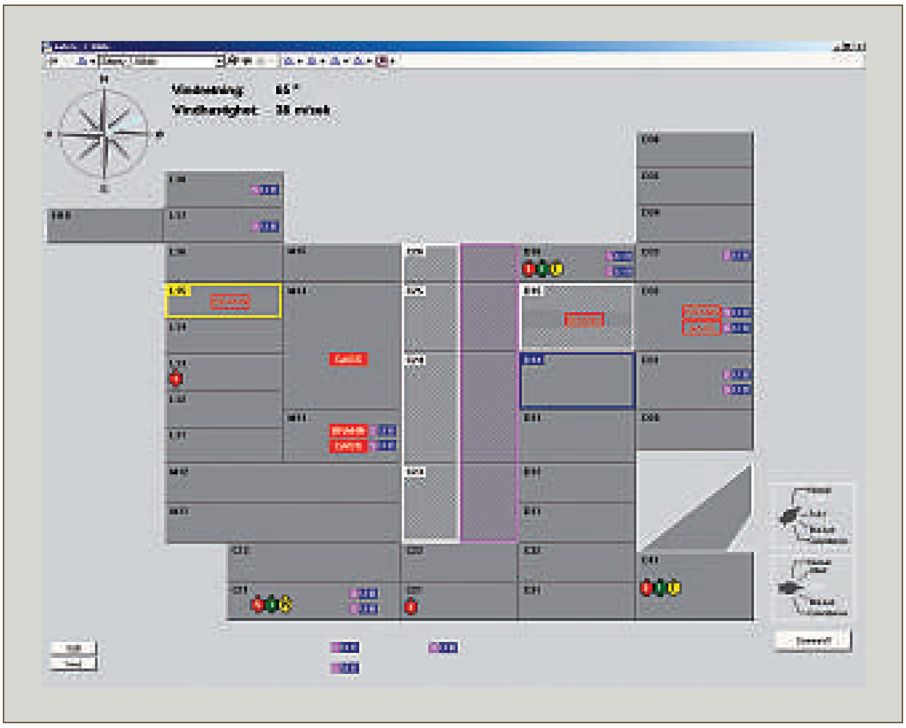
Looking at the control room, especially the SAS, on the Grane rig and comparing it with conventional control rooms, what stands out first is the extent to which it has been simplified. The designers' first priority was to provide the best possible working conditions for the control room operators. The philosophy behind the Industrial IT based SAS is to provide just enough information to allow the operators to quickly understand the current situation, and especially to avoid inundating them with unnecessary information.

Part of the success of the new control room is due to the involvement of the production supervisor in its design and development.

This and the design guidelines for the alarm system [1, 3] contributed to the 'clean' look of the control room, with four operator stations and three large screens in addition to one operator station for the information system and one operator station for Fire and Gas (F&G) testing. This 'large screen' solution is mainly intended to provide overview information, without interaction between the operator and the system. The main information sources are the flat screens at the operator desks. In addition, one of the large screens shows an overview of the emergency shutdown system (ESD). This large screen is normally deactivated until activated by an incoming alarm. The purpose of this is to avoid presenting irrelevant information to the operator that could distort his understanding of the current situation. The two other large screens provide either a process/utility overview or an F&G/process safety overview.

> Three priorities – safety-critical alarms, process-critical warning alarms and production-related trip alarms – were defined.

A fixed display at the top of the operators' screens has 'dynamic' buttons with direct links to detailed overviews of the different process sections. These not only allow users to view the status of the process sections, but also let them move quickly from one section to another. In normal situations, the buttons are blank. If an abnormal situation occurs, the button assigned to the process section involved has symbols added to indicate alarms, failures and other responses. The fixed display also indicates events that influence more than one process section,



Fire and gas (F&G) overview with alarms. Also seen here are the geographical sections for which work permits have been issued (red, green and yellow symbols).

A unique project

For the Grane project, ABB and its partner, Kvaerner Engineering, took a new and unique approach to the engineering of the alarm system: project members from ABB ATPA Norway and Kvaerner were integrated in a joint engineering team that took responsibility for, among other things, preparation of the specification and the programming. This and important contributions by the end-user, Hydro, ensured a common understanding of the problems involved as well as a shared approach to problem solving.

such as aggregated alarms and shutdowns. One click takes the operator either to the process overview or direct to the detailed display where corrective action can be taken.

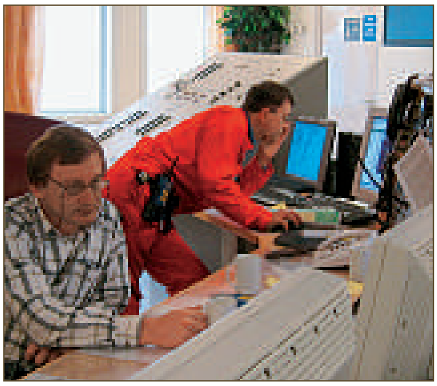
Getting the priorities right

Working closely with Hydro, ABB engineers both categorized and prioritized the alarms for the Grane platform. One of the first decisions to be made concerned the visual identification of the defined alarm categories. The following color codes were chosen:

Red: Action alarms
Yellow: Warning alarms + coincidence alarms
Magenta: Failure alarms and safety failure

Three alarm priorities were defined:
1st priority: safety-critical alarms initialized by the ESD or F&G. Other alarms in this category are safety failures and coincidence alarms.
2nd priority: process-critical warning alarms. These give the operator enough time to take action and prevent a production stoppage.
3rd priority: production-related trip alarms, production-related safety failure alarms, production-related coincidence alarms, plus non-production-related alarms.

Alarms with priorities 1 and 2 are shown on the large screens and accompanied by the same audible warning sound. For 3rd priority alarms there is a different warning sound. In the event of several alarms going off at the same time, the system ranks the alarms according to their priority, and the alarm with the highest priority dictates the



warning sound that is heard. A 2nd priority alarm will not be accompanied by a warning sound before all the 1st priority alarms have been cleared.

Which overview is shown on the large screen also depends on the actual alarm situation. The highest priority is given to the F&G/process safety overview, and this remains displayed until all of the 1st priority alarms are cleared. Afterwards, the process/utility overview automatically returns. The main purpose of this overview is to immediately inform operators of 2nd priority alarms (process warnings) and enable them to undertake corrective action before the situation can escalate and force a costly shutdown (a complete process shutdown can cost over US$ 5 million a day!).

The system also has functionality integrated in it that can take account of work permits. The F&G overview includes an overview of the geographical sections for which work permits have been issued. The operators thus have a clear picture of the location of field personnel and whether an F&G alarm could be related to maintenance or repair work.

Efficient project implementation

The Grane project benefited enormously from close cooperation between the main parties – Hydro, Kvaerner Engineering and ABB Norway – as well as the excellent team spirit in which the project was conducted (see panel). Ultimately, these factors were major contributors to the project's success. The measurable results speak for themselves: not only was the project completed under budget, but production started three weeks ahead of schedule.

The immediate benefits of the new control room technology are considerable: the number of audible alarms minimized; less noise in general; less information to consider; an awareness that displayed alarms are important and require attention; and visualization of information from various information systems integrated into the IIT platform.

What visitors to the Grane control room notice straight away is the peaceful, quiet atmosphere. In fact, they would hardly notice if, during their visit, a critical situation were to occur somewhere. The only signs would be a slight increase in activity, a few warning lights and some extra sounds – nothing like the dramatic scene described in the introduction.

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References

[1] Norwegian Petroleum Directorate: Principles for alarm system design, YA-711, Feb. 2001.
[2] **M. Rogovin, G. T. Frampton:** Three Mile Island: A report to the commissionaires and the public. Springfield, VA: National Technical Information Services, 1980.
[3] The Engineering Equipment and Materials Users Association (EEMUA): Alarm Systems – A Guide to Design, Management and Procurement. EEMUA publ no 191, 1999.