HUMAN-MACHINE INTERFACE (HMI) IN INDUSTRIAL PLANT OPERATIONS

Poorly designed human machine interfaces (HMI) in the power industry hinder an operator’s ability to rapidly recognize emerging abnormal situations, often leading to upset conditions and unplanned shutdowns.

With the advent of the distributed control system (DCS) in the mid-1970s, the operator’s scope of responsibility increased considerably – more instruments and significantly higher number of alarms. In the rush to take advantage of the new microprocessor-based DCS, automation suppliers, engineering firms, and operating companies overlooked the basic needs of the operator for clear and concise visibility to real-time information. In most control system upgrade projects, the operator interfaces were an afterthought and little attention was given to the ergonomic design and the usability of the displays.

Today, operator graphics at most plants are overloaded with information, are cluttered with inconsistent use of colors, and lack proper pattern recognition. The power industry has identified improving the design of operator interfaces along with optimizing the alarm systems as critical safety and plant reliability opportunities.

High Performance HMI Background
The human-machine interface (HMI) is the collection of screens, graphic displays, keyboards, switches, and other technologies used by the plant operator to monitor and interact with the control system, typically DCS or Supervisory Control and Data Acquisition (SCADA). The design of the HMI plays a critical role in determining the operator’s ability to proactively manage the operation, particularly during abnormal situations.

For several reasons, the current design and capability of most HMIs are far from optimal for running complex operations. Most of these consist of schematic-style graphics accompanied by numbers. Such displays provide large amounts of raw data with very little or no context. Existing operator displays at most power plants provide inadequate situation awareness to the operator.

High Performance HMI for operator displays is based on human factors engineering and ergonomic design that significantly improve situation awareness. PAS has developed methodologies to incorporate best practices into display design, which greatly improve the effectiveness of traditional displays.

High Performance HMIs provide the following benefits:

- Improved operator situation awareness
- Standardized templates for units and their subsystems
- Reduced training and maintenance effort
- $50K+ in reduced engineering costs per unit
- Up to 75% reduction in the number of graphics required
Certain automation companies and many engineering and consulting firms promote High Performance HMI as grey-scale graphical representation of traditional displays. They overlook important factors such as chunking and grouping of information, pattern recognition, progressive exposure, and information drill down.

Below are key components that govern the basis of High Performance HMI design.

**High Performance HMI Components**

**Component 1: Appropriate use of color.** Bright colors are reserved for important items on screens such as abnormal situations or alarms. Why is this important? Imagine you are the console operator and are given 3 seconds to find the abnormal situation(s) on the following graphic.

![High Performance HMI graphic](image)

As the operator, you do not have the luxury of unlimited time. Time is always a critical factor in abnormal situations.

A display designed based on principles of High Performance HMIs immediately draw the attention of the operator to abnormal situations.
Below is a typical HP HMI display that enables immediate recognition of an abnormal situation by the operator.

![HP HMI display](image)

Component #2: HP HMIs contain information not just data. A number on a screen is raw data; if that number is given context then it becomes information.

As the console operator, your job is to decipher if the compressor below is operating within normal operating limits (notice grey scale tones have been implemented).

![Graphic representation](image)

With the grey scale graphic above, it is easy to decipher that there are no active alarms (i.e., no bright colors). However, it is still difficult to quickly decipher if a parameter is approaching an alarm limit.

The graphic below is a representation of the same numeric values in the display above, but the numbers are contextualized to alarm limits, as well as desirable operating ranges. This display makes it intuitive to see the current status of the compressor.
In the above graphic, you can easily single out that the analog bar in the middle (with the title “Dsch degF”) requires attention — the pointer is not in the grey alarm region at the top, refer to the graphic on the right. However, the temperature is not in the desirable operating range, the light blue band. With this type of depiction, proactive intervention can be taken.

As the console operator you would be able to take corrective action before receiving an alarm.

Component #3: Embed information in context within the HMI. Embedded information in context allows for corrective actions to be taken faster.

On the graphic below, notice the point “Oil degF” is in alarm. What steps should the operator take to resolve this alarm? If the operator is not familiar with the required actions, the steps to respond and resolve the alarm should be easily accessible.
In 2009, ISA 18.2, the alarm management standard was published. After this point, most companies have carried out projects to document and rationalize their operating alarms. Part of documentation process involves capturing information for every alarm such as:

- causes for the alarm,
- consequences of not responding to the alarm, and
- corrective actions to be taken.

This information should be readily available to the operator via a right-click action on the alarm icon to pull up the appropriate information in context, see picture below. Accessible information in context expedites the initiation of appropriate corrective actions.
Component #4: Graphics should be designed with an objective-based approach

Most graphics in industry today are based on Piping & Instrumentation Diagrams (P&IDs) that were transferred to the DCS and populated with process values. When DCS systems were first introduced to the market, guidelines were not provided on how to build effective displays. P&IDs are engineering tools intended to build plants and provide renderings of equipment layout; they are not intended for monitoring and control.

The High Performance HMI methodology, as referenced in The High Performance HMI Handbook, Hollifield, Habibi, et al., 2009, contains the process of Goal and Task Analysis. Screens designed with this methodology increase the operators’ visibility to their span of control. These displays improve operator situation awareness allowing for quicker responses to abnormal situations.

For further information on principles of High Performance HMI please refer to the High Performance HMI Handbook.
Opportunities in the Power Industry
Specifically in power generation, the challenges outlined in this document exist:
- inappropriate use of color
- values are shown with little or no context
- lack of access to supporting information
- traditional display development based on P&ID layout

Power generation facilities have processes that are well defined. Many power plants of the same type have similar equipment, if not identical layout. Due to the standardized design of units, power companies are looking at ways to reduce their overall burden to support projects, maintenance, and operations at generation facilities. A way this can be achieved is through standardized HMI design. HMIs can be taken from one unit and utilized in another with minimal modifications.

Standardizing HMIs across an entire fleet provides the following benefits:
- a reduction in unplanned outages due to abnormal situations
- a reduction in operating, engineering and maintenance costs
- a reduction in training costs for operations to move resources around or provide back-up coverage
- the utilization of central or regional engineering and maintenance functions to share resources between multiple facilities

Standardizing on High Performance HMIs enables proactive monitoring and control for optimized plant operations. The improved operation situation awareness results in increased plant safety, profitability, and reliability.

About PAS
PAS is a leading provider of automation software for process safety, cyber security, and asset reliability to the power and processing industries worldwide. PAS’ comprehensive solutions include Industrial Control System Cyber Security, Automation Asset Management, and Operations Management which includes Alarm Management, High Performance HMI, Boundary Management and Control Loop Performance Monitoring. PAS solutions are installed in over 1000 facilities worldwide including industry leaders in Oil & Gas, Refining & Petrochemicals, Power, Mining, and Chemicals. For more information, visit www.pas.com.

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