

High-Performance Control Room Operator Display Services



Improve operations by enhancing the user's ability to better understand process conditions, identify impending anomalies and mitigate the effects of an abnormal event.

Plant operators frequently face significant on-the-job challenges associated with a lack of situational awareness. A key contributing factor is the operators' ability to recognize, understand and quickly respond to abnormal situations. Poor situation awareness can often lead to loss of production, revenue, machinery life, and in serious instances, human life. Operators need the appropriate tools and working environment that reduces the potential for mistakes and enables quick resolution to issues.

High-performance control room services provided by Emerson mitigate the risks associated with a lack of situational awareness. Deploying the services helps to eliminate or alleviate preventable conditions such as unmanageable alarms and inefficient action. Results of the program optimize the overall operator experience through the use of cohesive documentation, simplified alarming and graphics and improved control room ergonomics. Implementing high-performance control room services provides several benefits:

- Focused control within normal ranges
- Increased awareness of process changes
- Improved management of abnormal situations
- Avoidance of event escalation
- Reduced operator fatigue and stress
- Collaboration between plant personnel
- Reduced control room traffic and distractions
- Easy identification of critical performance indicators
- Proactive operations
- Increased facility safety, reliability and production

Although benefits are optimized by implementing all facets of a high-performance control room, at times this may not be feasible. One service that can be executed individually and provide immediate positive returns is the human machine interface, specifically the operator graphics. Implementing the guidelines and conventions of high-performance graphics can provide the following benefits:

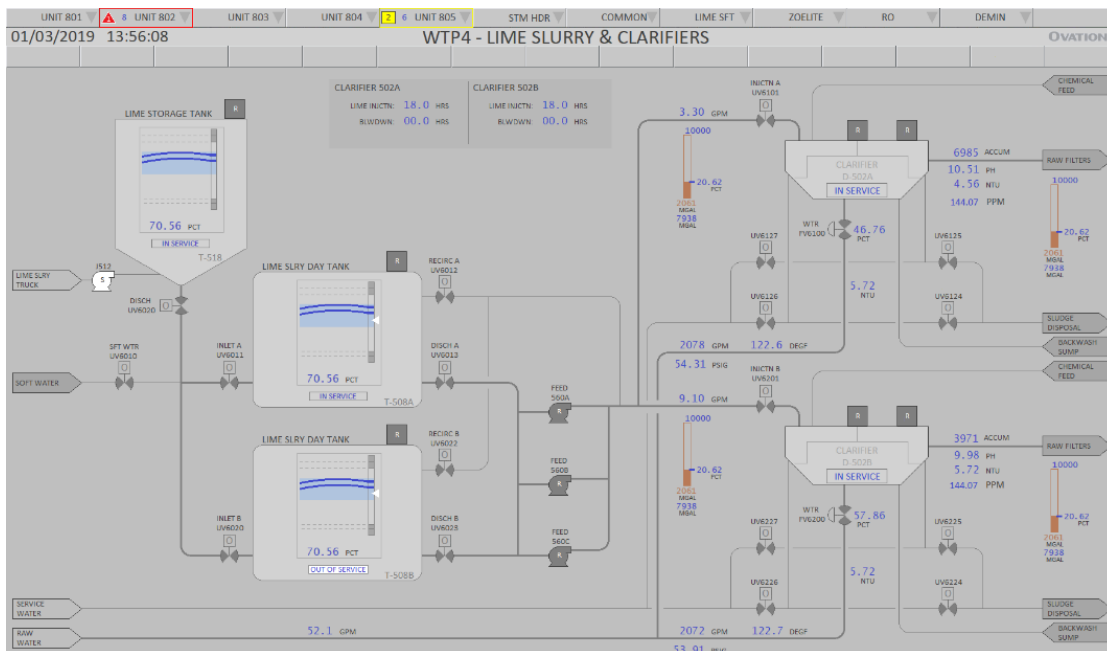
- Advances the recognition and understanding of abnormal conditions
- Empowers operations with task appropriate information
- Mitigates risk and decreases response time
- Reduces operator confusion, stress and fatigue
- Presents at-a-glance overview displays

Philosophy

Any activities to advance operator interface improvements begin with the discovery and documentation of a graphic philosophy following the guidelines of ANSI/ISA 101.01, ANSI/ISA 18.2, EEMUA 191, IEC 62682 and EEMUA 201. Emerson initiates high-performance graphic efforts with a multi-day consultative workshop to educate and share ideas with plant personnel. Results of the workshop are used to develop a custom graphic philosophy.

The graphic philosophy encompasses all primary aspects of operator interfaces within the control room from physical control room elements to navigating through distributed control system graphics. The philosophy defines the requirements that guide the design of each operator interface point regardless of the contractor or vendor. High-performance control room philosophy topics include:

- Purpose and use of high-performance control room philosophy
- Lifecycle management
- Responsibilities
- Control room design
- General alarm management rationalization
- Operator display design process
- Operator display layout
- Operator display navigation
- Operator display style conventions
- Monitor and assessment
- Management of change



Consultative Workshop

Emerson conducts a multi-day consultative workshop hosted by a cross-functional team of subject matter experts, each with decades of experience in control systems engineering, technical troubleshooting, project management, alarm management and operator interface design.

The workshop is typically conducted on-site with all key stakeholders including the automation system owner, site superintendent, operations manager, maintenance manager, operators, technicians, plant engineers or any other plant staff who may have a vested interest in high-performance control room graphics. Alternative arrangements can be made for facilities with limited resource availability.

The primary objective of the workshop is to educate and train participants on high-performance graphic principles, guidelines and best practices. This effort fosters operator buy-in and an awareness on why such a change to the operator interfaces is needed; what background, research, analysis and studies have been conducted to support the proposed change and how this service is implemented.

An important workshop task is creating a storyboard that outlines the top-level overview graphics that operators will use 85% of the time while process conditions are stable and normal. The storyboard process brings participants together as a team – with initial coaching, consulting and illustrating presented by Emerson subject matter experts and evolving into participants identifying key process variables, display techniques to optimize information flow, sizing and interface layout. This unique approach by Emerson promotes acceptance by operators and technicians.

As part of the workshop, Emerson experts perform a task assessment by observing operators in their control environment and noting various operator actions including how they navigate through graphics, access control and troubleshooting details and use current graphic conventions.

Implementation Strategies

The service includes creation of a customized high-performance graphic implementation strategy to meet various customer needs. Emerson develops the plan based on schedule, budget, availability of personnel and any other customer restrictions. The graphics strategy can be paired with an alarm management strategy.

The most common implementation strategies are:

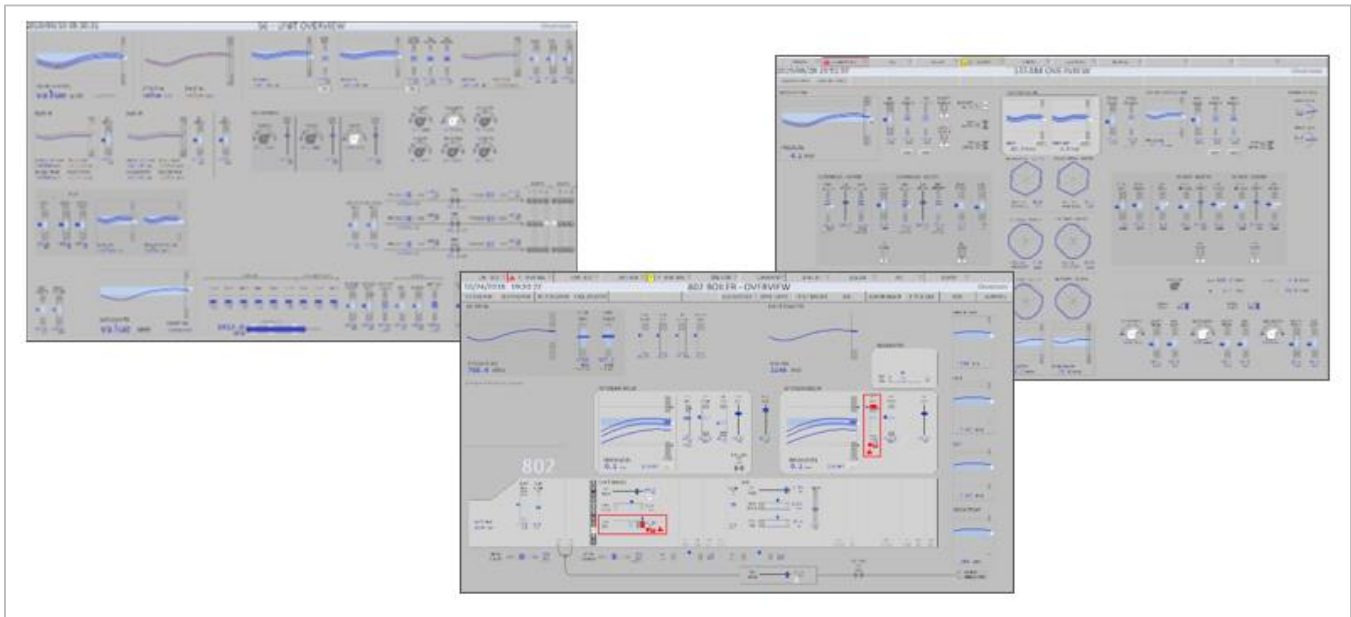
- At-a-glance overviews
- Full high-performance graphic deployment
- One-to-one conversion

A well-defined, documented graphic philosophy that identifies standard definitions, conventions, guidelines and governing values specific to the facility is required for successful implementation.

At-a-Glance Overviews

A significant challenge that hinders control room situation awareness throughout the automation industry is the lack of quality overview graphics. This challenge is intensified when operators use more than six monitors mounted on a console to view process conditions, with alarms displayed on the largest monitor available.

Designing robust, at-a-glance overviews provides the operator with a collection of graphics specific for steady-state or normal operations. In most facilities, operators access overview graphics 85% of the time, with the remaining 15% spent accessing control and/or P&ID type graphics. Overview graphics take advantage of the latest display tools and techniques to convert raw data into useable information, enhancing the operators' ability to recognize a pending abnormal condition prior to an alarm event. The operator can then take corrective action faster rather than waiting for an alarm event to annunciate.



Full Deployment

Full deployment of high-performance graphic concepts, conventions and guidelines helps to optimize operator performance. This implementation strategy reduces the time and effort required for an operator to resolve an abnormal condition once it has been recognized, to follow startup and shutdown procedures or to efficiently troubleshoot a problem. Replacing traditional control system graphics with high-performance graphics enhances the display of important data by using an optimized color pallet and consistent shapes and symbols.

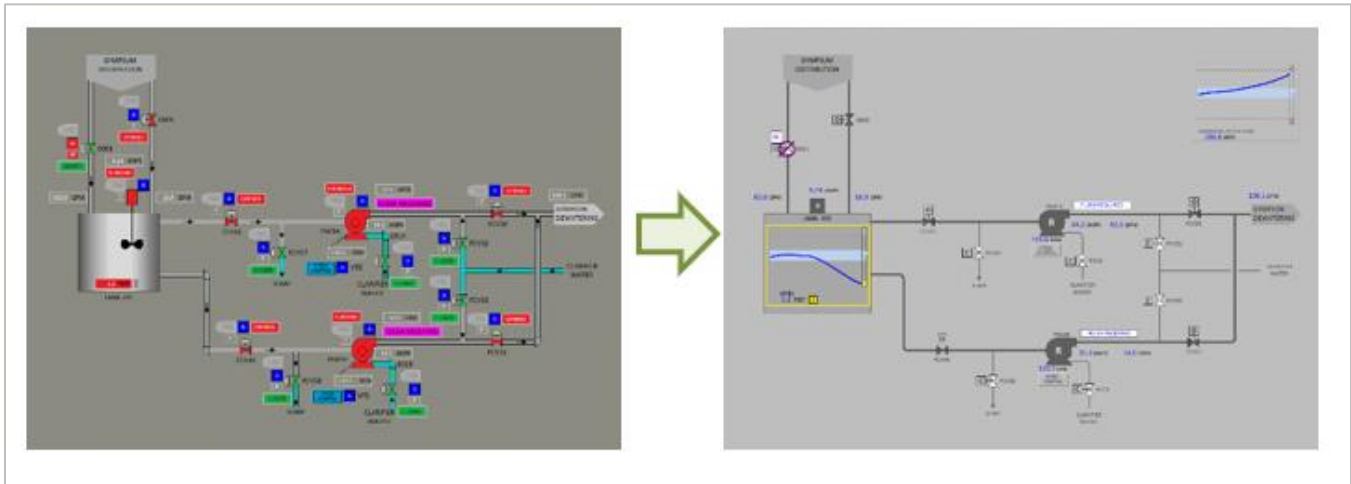
Feedback received by operators on issues associated with the use of traditional control system graphics includes:

- It takes too many actions to get to a graphic
- It takes too many actions to get to a control faceplate or window
- There is inconsistent use of shapes, symbols and colors
- There is an absence of alarm information on graphics
- It is too cumbersome to memorize all the alarm limits or ranges

As part of this strategy, Emerson uses the task assessment results to redesign system graphics with a focus on transforming data into actionable information, simplifying content presentation to enhance perception and integrating alarm management to emphasize abnormal conditions. Typically, this effort reduces the quantity of graphics by up to 40% from traditional graphics.

One-to-One Conversion

As an alternative to a full changeover of all control system graphics, customers can select individual graphics to be converted from using traditional to a high-performance display elements. This strategy can be implemented to ease schedule demands and meet budget constraints, while providing a gradual transition for the way operators view important plant information. One-to-one conversions maintain the content and layout of existing traditional graphics, but presents the information using high-performance graphic standards for colors, shapes and symbols.



Service Details and Components

High-performance control room services consisted of three key facets – control room design and hardware, alarm management and operator display graphics.

Control Room Design and Hardware

Physical control room elements should follow the guidelines outlined in the high-performance control room philosophy documentation, which include:

- **Position consoles and furniture**
 - Create a specific operations task area or ‘operations bubble’ to reduce traffic
 - Enhance observation of the large screen display from areas within the control room the operator often uses such as a kitchen or library
 - Accommodate communication and collaboration between operators
 - Neutralize contrast ratios with the material, lighting and windows beyond the operator’s point of view
- **Leverage lighting**
 - Create a specific operations task area to reduce traffic
 - Create a comfortable operating environment
 - Reduce screen glare

- **Manage acoustics**
 - Use sound absorbing ceiling tiles to absorb noise
 - Use acoustic wall paneling to absorb noise
 - Use wall and floor materials to minimize reflection
 - Use directional speakers to concentrate alerts and minimize noise pollution
- **Minimize traffic**
 - Partition non-operation work areas and workstations to reduce distractions and minimize clutter
 - Provide independent work areas and workstations for technicians, engineers and non-operations personnel to prevent sharing with operators
 - Assign a specific collaboration area where operators can be consulted by maintenance and technicians
 - Locate materials such as lockout/tagout boxes and locks to facilitate plant procedures while maintaining operational awareness
 - Locate logbooks, manuals and procedures to simplify access
- **Utilize large screen displays**
 - Position the displays at a suitable distance, height and viewing angles for glare, eye/neck strain and visibility
 - Position the displays so they can be viewed by operators in different stations/areas of the control room such as the collaboration area and library
 - Size the displays accordingly to properly display all key performance indicators and high priority alarms, enabling the operator to quickly diagnose the entire process
- **Design operator consoles**
 - Provide the operator sufficient space for workstation input devices (such as a keyboard and mouse), telephone, radio and paperwork
 - Provide sufficient distance between the primary monitors and the operator
 - Position monitors at suitable distances, heights and viewing angles for glare, eye/neck strain, and visibility
 - Account for console adjacencies such as hard-trip panels and business workstations such that the operator can always view the large screen display
 - Provide only enough primary monitors to support operator functions – no more than six monitors during normal conditions and no more than four monitors during abnormal situations including start-up and shut-down

Alarm Management

Key to successful implementation of a high-performance control room is the development of a strategy to manage alarms. Deploying the guidelines provided in the alarm management philosophy document, such as the guidelines listed below, will contribute towards a proactive, instead of reactive, operations culture.

- Alarms focus on providing/improving situation awareness
- An alarm maintenance program or system should be employed for maintaining alarms
 - Maintain alarm thresholds, deadbands, delays, cutout
 - Maintain instrumentation quality alarms – repair instrumentation
 - Periodic review of alarm priorities
 - Maintain alarm response procedures

- An alarm has an associated operator action – if no action is required it should not be an alarm
- Events/alerts are introduced to hold the place of no-action-required alarms
- Upon alarm indication, the operator knows which action is required
- All alarms are prioritized based upon the philosophy, EEMUA KIP range, or work-load analysis
- Alarm characteristics should be consistent between all user interfaces – large screen display, primary monitors, alarm screen, etc.
- Alarms are identified by operator control functions, segregated control rooms and/or by plant area designations
- Alarms are minimized by strategic analysis of conditional alarming, alarm deadbands and delays, derived alarm cutouts
- The alarm list contains fewer than 10 alarms
- No standing alarms exist

Operator Displays

Control system graphics that comply with high-performance governing documentation can include the following:

- The graphics use predominantly grayscale color pallet – alarm colors are not used for any other purpose (red, yellow, magenta, cyan)
- High salient colors are employed only to highlight alarms and abnormal conditions
- Line width and type depict differentiation in process types
- Subtle colors can be used to sparingly to represent complex or detailed processes
- Equipment status feedback follows the convention of ‘continuity of flow’ – the process line is dark, energized equipment is also dark to show a continuity of color; de-energized equipment is light to interrupt the continuity of color and thus the process flow
- Style is based upon a representation of the process data – not particularly the appearance of physical layout of processes or equipment
- Overly complex or intricate configurations are minimized to improve clarity and maintenance
- Trending of process variables is maximized to show historical data
- Analog representation is leveraged overall numerical data to translate data into information
- Reliance on human memory is minimized by incorporating alarm thresholds into analog representations and trends
- Triple-redundant information representation is used for critical process points such as alarms
- Process details are subdued to reduce the overall harshness of static information
- Process animations and dynamic process lines are eliminated
- 3D representation of tanks, process vessels and equipment are avoided
- Display hierarchy introduces drill-down details
 - **Level 1: Plant monitoring**
 - Priority 1 alarms
 - All key indicators to show the health of the system in one scan
 - No navigation away
 - No control interface
 - Shown on large screen display

- **Level 2: System monitoring and control**
 - Priority 1 and 2 alarms
 - Navigation to other level 2 and 3 displays
 - Quick access to control interfaces utilized during normal run time conditions
- **Level 3: P&ID control and troubleshoot**
 - All alarms
 - Navigation to level 2 and other level 3 displays
 - Access to all control interfaces
 - Used primarily for start-up, shut-down and abnormal conditions
- **Level 4: Diagnostics**
 - Trends
 - Point information
 - Permissives

High-Performance Control Room Services Background Information

The high-performance control room program developed by Emerson responds to the emerging needs of customers to incorporate human performance factors into the operational environment to help:

- Mitigate risk of facility interruptions, equipment damage, personal injury and/or death
- Reduce operator stress and fatigue
- Preserve personnel expertise and knowledge
- Develop, document and maintain procedures and practices
- Monitor operational, technical, and environmental KPI's
- Strengthen inter-reliance among plant operations and maintenance
- Develop enhanced alarming and visualization strategies
- Instill lifecycle management practices

Emerging Trends

Over 80% of process facility abnormal conditions are attributed to operator error – or the lack of the operator to recognize, understand and/or forecast responses to upset conditions. These abnormal situations have resulted in an estimated loss of \$20 billion/year ranging from equipment damage, loss production, decrease equipment life, additional maintenance, equipment replacement, loss of process materials/fuel, fees and fines and higher insurance rates/premiums. Accident study details show at times that the operator was inundated by alarms, the operator could not differentiate an abnormal condition to other display information, the operator could not translate encrypted alarm messages, previous shift operators did not communicate equipment malfunctions, inaccurate situation response, the operator was not able to accurately interpret the situation and obsolete operation procedures.

The high-performance control room program brings human performance elements into the control room to lessen the percentage, and risk, that an abnormal situation is credited as operator error, let alone occurs at all.

- The operator atmosphere is overhauled to minimize operator fatigue, stress, and confusion – providing not only an efficient and productive atmosphere, but also creating a work environment that will attract the next generation operator
- Operators and staff undergo instruction specific to understanding and identifying situation awareness allowing self-exploration as to why it is imperative for changes to be made, how the changes will impact their environment, activity and procedures – creating buy-in, trust, motivation, understanding and generate participation towards design
- Existing experience and knowledge is captured and managed – from documentation, operators, technicians – to minimize reliance on human memory, transform data into information, reduce complexity and to pass that information forward to others
- Clarity and understanding by the operator is of foremost importance in alarming and operator graphical displays – perceive the process conditions, understand the conditions, predict the future conditions – reduce response times, minimize process interruptions and have consistent response to abnormal conditions
- Additional access by operators to help guides and procedures which are accurate, up-to-date, and managed is emphasized – minimizing reliance on human memory, create consistent and repeatable responses/actions and create trust in materials

Incorporating human performance elements throughout the process, power, and water industry control rooms has shown proven success. The improvement ratings in one particular instance are shown below.

Task	With “Traditional” HMI	With High-Performance HMI	Improvement
Detecting abnormal situation before alarm	10% of the time	48% of the time	5X increase
Success rate in handling abnormal situation	70%	96%	37% over base case
Time to complete abnormal situation tasks	18.1 min	10.6 min	41% reduction

Considerations

Awareness of human performance issues is growing considerably in both the power and water markets during the last ten years.

The publication of several books provided the general community knowledge and insight into the world of high-performance. Several organizations have furthered these publications through more defined and accredited studies and research. Technical resources may be familiar with industry and international standards concerning alarm management, situation awareness, and control room design. These include:

- ANSI/ISA 18.02: Alarm Management
- ANSI/ISA 101.01: Human Machine Interfaces
- IEC 62682: Alarm Management
- EEMUA 191: Alarm Systems
- EEMUA 201: Process Plant Operator Console
- ISO 11064: Ergonomics of Control Centers

The United States Department of Labor, Occupational Safety and Health Administration (OSHA), and varying facets of the insurance industry also act as driving forces, as they are often involved in accident analysis and report studies. An accident found to be related to the lack of human performance at a facility that has recently undergone a project where the operator interface should have been enhanced could face more scrutiny if human performance was ignored during the project.

Frequently Asked Questions

- **What are the differences between Ovation standard graphics provided as a base scope and Ovation high-performance graphics?**

While a gray area of uncertainty can exist between categorizing differences, high-performance graphics have a unique look, feel and functionality based upon adding a scientific approach to developing high-performance graphics and converting data into useable information. One must keep in mind, however, that high-performance graphics are founded on alarm management whereas traditional graphics are founded on P&IDs.

Ovation Standard Graphics	Ovation High-Performance Graphics
Process representation built strictly from P&ID showing all process pipes and detail	Process representation designed from how the process works, Operator input, operating procedures, alarm response and P&ID showing all information the operator needs, eliminating information not necessary and rationalizing representation
Pipe colors reflect an assigned process type	Pipe width and line type depict primary, secondary, tertiary process types per graphic. Case-by-case low salient colors can be leveraged when more than three process are depicted on the same graphic
Equipment feedback status colors reflect traditional electrical indications – red/green	Equipment feedback status indications reflect a continuity in flow yielding continuity in color
Process values are displayed in numerical format	Process values are analyzed for importance and relevance to be shown as numerical, analog bar or trend
3-dimensional elements are used for representation enhancements of tanks, vessels, and sometimes pipes	Saliency is minimized and contrast enhanced on relevant process information resulting in outline representation of tanks and vessels, and single line pipes
Alarm colors often overlap color indications used for equipment feedback status, pipes, labels, etc.	Alarm colors are not repeated for any other use
Device indications include independent elements for auto/manual, tagout, lockout, permissive, etc.	Device indications are minimized to reduce clutter and complexity by grouping indications as applicable – auto is invisible/manual is shown, tagout, lockout and permissive are grouped with details in the control faceplate
Animation and blinking is used to enhance the display of the process as features	Animation and blinking is strictly avoided to reduce complexity, confusion, and distractions resulting in attention tunneling
The typical coal fired Unit consists of 150 graphics	The typical coal fired Unit consists of 75 graphics

Ovation Standard Graphics	Ovation High-Performance Graphics
Graphics used to monitor the system show all information at all times per P&ID	Graphics used to monitor the system only show relevant information needed during normal running conditions – information needed for control is differentiated to a drill-down level for start-up, shut-down, troubleshooting – why display data 100% of the time when it is only needed 5% of the time

▪ **How is Grayscale different than high-performance?**

Grayscale is a common term which is used in conjunction with high-performance, however there are significant differences. First, grayscale is in the context of graphics and only graphics while high-performance is comprised of much more. In addition, in the realm of grayscale, no color is used except for alarming. In high-performance graphics, low salient colors can be used in a managed approach. Note that many customers speak ‘grayscale’, but they often mean ‘high-performance’ without recognizing the differences in buzz words.

▪ **We have a large infrastructure and cannot convert everything over to high-performance in one instance. What advice can be provided?**

High-performance can often be phased into a facility, segmenting the scope of work, and allowing acclimation one step at a time. The common approach is to start with alarm management and Level 1 overview displays. This activity can be done and installed giving the operator relief of alarms while presenting the primary overview. The next phase can continue with any additional alarm management followed by level 2 sub-system displays. The level 2 displays provide the next level of drill-down, or process detail from the level 1. The operators can utilize the level 2 displays during normal runtime modulation and control. The final stage will be to complete all remaining activity including level 3 displays. The level 3 displays provide equipment level displays for all control functions during start-up, shut-down and abnormal conditions. When it comes to control room furniture, this scope of work is best conducted during the second phase but can be delayed as needed. Other phased approaches are possible and can be addressed as needed.

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