Recommended Practice for Pipeline SCADA Displays

API RECOMMENDED PRACTICE 1165
FIRST EDITION, JANUARY 2007

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AMERICAN PETROLEUM INSTITUTE

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Pipeline Segment

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Recommended Practice for Pipeline SCADA Displays

1 Scope

1.1 PURPOSE

This Recommended Practice (RP) focuses on the design and implementation of displays used for the display, monitoring, and control of information on pipeline Supervisory Control and Data Acquisition Systems (SCADA). The primary purpose is to document industry practices that provide guidance to a pipeline company or operator who want to select a new SCADA system, or update or expand an existing SCADA system.

This RP assists pipeline companies and SCADA system developers in identifying items that are considered best practices when developing human machine interfaces (HMI). Design elements that are discussed include, but are not limited to, hardware, navigation, colors, fonts, symbols, data entry, and control / selection techniques.

1.2 SCOPE LIMITATIONS

This RP was created by an API Cybernetics Subcommittee task force, based on industry practices used on liquid pipeline SCADA systems. Most participants operate crude, product, chemical, and natural gas pipeline systems.

It is recognized that each pipeline company has unique operating philosophies and SCADA systems; therefore, not all elements of this recommended practice may be applicable.

For example:

- Some pipeline control centers are a combination of several different SCADA systems.
- Some of these SCADA systems may not have the developer tools necessary to implement the recommended practices.
- Some operators may have existing display techniques that bridge over into unique operating philosophies.

This RP is not all-inclusive. It is intended to cover best practices and provide examples for display techniques only, not dictate operational control philosophy or overall SCADA system functionality. The reader should have a good working knowledge of pipeline operations and display techniques, and may have to refer to other publications for background or additional information.

This RP compliments but does not replace other procedures and effective display techniques or industry standards that are used for software development and implementation. Regulatory and individual company standards are not addressed in this publication.

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3 Definitions

3.1 API: American Petroleum Institute. The primary trade association of the oil and natural gas industry, API represents more than 400 members involved in all aspects of the oil and natural gas industry. The association draws on the experience and expertise of members and staff to support a strong and viable oil and natural gas industry.

3.2 API Cybernetics Subcommittee: The API Cybernetics Subcommittee monitors the field of science concerned with processes of communication and control to provide education and recommended practices to the pipeline industry for monitoring and operating pipelines from a remote location.

3.3 Button Bars: Button Bars are used to place fixed links between a series of displays or to provide links to submenus.

3.4 client server architecture: In client server architecture, the computing load is distributed among the many clients (individual computers) in a network, drawing information from central servers of the information. The opposite of client server architecture is the situation where a central powerful computer does all the processing, feeding the results to dumb terminals which do little more than communicate requests and feed back the results processed centrally.

3.5 control center: Physical location where controllers monitor and control the pipeline systems. A control center typically consists of one or more controller consoles which are manned 24 hours a day, 365 days a year.

3.6 controllers: Personnel who are responsible for monitoring and controlling the pipeline system.

3.7 dialog box: An interactive message box. A temporary window on the screen that contains a set of choices whenever the executing program needs to collect information from the user.

3.8 display(s): The visual presentation of text and objects on a monitor.

3.9 Gestalt Principles of Perception: Gestalt is a psychology term which means "unified whole." It refers to theories of visual perception developed by German psychologists in the 1920s. These theories attempt to describe how people tend to organize visual elements into groups or unified wholes when certain principles are applied.

3.10 hidden text: Information that is not visible (in background) to the Controller until a specific event occurs, at which time the text becomes visible (in foreground).

3.11 hot spot: An area, symbol, or text on a display, that when selected, provides navigation to some predefined display, execution of some command, opening of a new window, etc. Synonymous with navigation buttons, poke points, poke boxes, etc.

3.12 Human Factors Engineering (HFE): The science of designing systems that are safe, comfortable, effective, and usable. The goal is to design systems so end users can avoid frustration, make few mistakes, and experience an increase in productivity.

3.13 Human Machine Interface (HMI): A computer workstation normally associated with a graphics workstation that allows interaction between people and end devices.

3.14 invalid: An indication of a point state that is undefined, out of range, or otherwise unknown.

3.15 Liquid Crystal Display (LCD): A display which utilizes two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light.

3.16 monitor: The term monitor refers to the hardware used to present SCADA displays to the controller.

3.17 navigation button: An image of a button on a computer screen which simulates being "pushed" when clicked by the mouse.

3.18 offscan: A term used to describe a point that has been deactivated from the active polling sequence (not scanned or refreshed by SCADA system).

3.19 operator: A term used for a company that monitors and controls a pipeline system.

3.20 poke point: The control that is placed on top of an object that causes an action to occur when clicked.

3.21 pop-up: A sub display, that temporarily overlays the viewing area, used to provide additional details related to the current display.

3.22 remote: A field device, such as a Remote Terminal Unit (RTU), Programmable Logic Controller (PLC) or Flow Computer, that communicates data and field information to and from the SCADA host.

3.23 SCADA Controllable: A device or point that is controllable from the control center through the SCADA system.

3.24 should: The term "should" is used in this standard to indicate practices which are commonly used or accepted, but for which operators may determine that alternative practices are equally or more effective.

3.25 Supervisory Control and Data Acquisition (SCADA): A system which is a combination of computer hardware and software used to send commands and acquire data for the purpose of monitoring and controlling.

3.26 static: A term used to describe a point or object that does not change state.

3.27 tag: 1. A text string attached to a database point that indicates some relevant detail about the point.
2. A type of data attribute associated with a database point.

4 Human Factors Engineering Considerations in Display Design

Display design refers to the way information is arranged and presented on a monitor. It can vary extensively, depending on the function being performed by the display. Therefore, display design requirements may be unique for each display, depending on the display's primary function.

Displays should be designed to provide optimum transfer of information to the user. Information should be presented simply and consistently, in a well-organized manner, and in expected locations. Generally speaking, displays should have an orderly and clutter-free appearance, a simple way to navigate through the system, and obvious indications of interrelationships.

Display design should be guided by the following Gestalt principles, a psychology term which refers to theories of visual perception:

- Proximity—The human perception system tries to organize objects into groups if they are near each other in space.
- Similarity—Objects are perceived as a group or set if they visually share common properties, such as size, color, orientation in space, or brightness.
- Closure—The human visual perception system tries to complete figures and establish meaningful wholes. Incomplete objects or symbols can then be perceived as complete or whole.
- Balance—Humans prefer stability in the perceived visual environment. The presentation of materials at right angles and in vertical or horizontal groupings is easier to look at than curved or angled visual images.

In addition, display design should incorporate the general principles of Human Factors Engineering (HFE) discussed in the next sections.

4.1 SHORT-TERM MEMORY

An overriding principle in display design is the limitation of the human short-term memory (STM). STM is the place in the human information processing system where all conscious processing of information occurs. Studies have shown that short-term memory can process seven, plus or minus two blocks of information. A block of information is any meaningful cluster of data (e.g. a word, or a phrase, a number). This information must be processed, or transferred to long-term memory before new information can be added to short-term memory. If the first set of information is not transferred, it will be forgotten as new information displaces it in short-term memory.

The STM limitation does not mean that only seven, plus or minus two, points or symbols should be on a display. The STM limitation cannot be erased, but techniques of representation should be used to allow the controller to treat numerous points as one block. For example, demarcating related groups, putting a box around them, use of closure by putting values inside figures, all facilitate processing of those elements as a block. The general principle is that related information should be grouped together, but large groups of information should be broken up into subgroups. Related information is determined by what tasks are required to be performed by the user and by the users' perceptions of the information requirements. Relative spacing of items in a display, rather than using an equally spaced array also helps the grouping process. Enumerating or presenting information in numeric, alphabetic, or chronological order also helps an individual mentally associate groups of information. STM also has implications on the number of displays to be created. If a controller has to compare information on two different displays, then STM requirements are higher than if the same information were on a single display. STM limitations pose strong arguments for a minimal number of displays with well-grouped data.

4.2 SIGNAL-TO-NOISE RATIO

Talking with someone in a crowded room is often difficult since the words are difficult to distinguish as the background noise increases in intensity and the pitch of the surrounding conversations is similar to one's own. The signal (the words) is being masked by a noise similar in intensity and characteristics (the surrounding conversations). Similarly, as more items are added to the display, it becomes increasingly difficult to locate the signal or target on the display. Anything that is not a signal is noise and will make location of the signal more difficult. When designing a display each element on the display should be examined with respect to how it impacts controller behavior. The adage that "it can't hurt" for low use items is wrong; it hurts because it makes it more difficult to find the important items.

Displays should not have elements without purpose. Display design principles indicate that as much useful information as possible should be put on each display, but useless items should not be included.

4.3 EYE SCAN PATTERN

The locations where objects are placed on a display, as well as their size, determine their relative importance to the viewer. Larger objects and objects placed on the top and the center of the display tend to have more importance than others. Studies have shown that the initial eye scan pattern of the monitor tends to concentrate on certain areas of the display (see Figure 1). The information that is important to the controller and needs to be picked up on the initial scan of the display should be located in the upper left and lower right of the display. This does not mean that data placed elsewhere on the display will be missed by the controller. After the initial eye scan, the controller will look at the entire display.

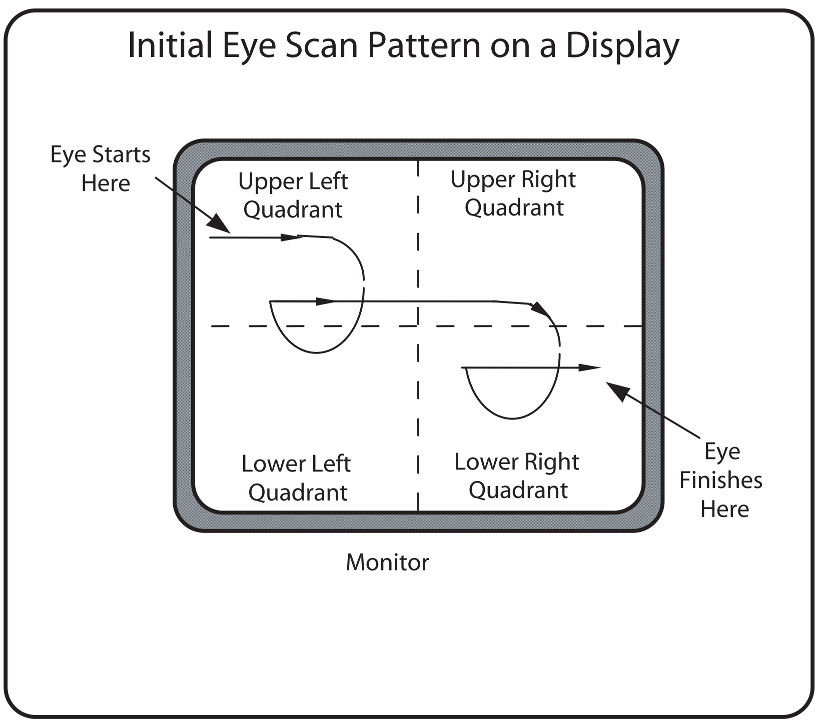


Figure 1—Initial Eye Scan Pattern on a Display

4.4 CONSISTENCY

Consistency is essential to display design, especially if controllers are managing multiple monitors. Documenting operator interface standards early in the design phase ensures consistency. This includes placement, shape, color, and presentation of both static and dynamic objects. Consistency facilitates rapid controller response since it helps the controller know where to look for pertinent data and how it will appear.

The presentation of text should vary as little as possible. Changes to lettering size, font, color, capitalization, shading, or underscoring to get attention are confusing, unnecessary, and make displays difficult to read.

On-screen language should be as close to natural dialogue as possible. Avoid local jargon unless it is industry specific and contributes to quick understanding with all users of the system.

4.5 CODING

Coding is the assignment of meaning to an arbitrary visual cue. Examples of information coding include color-coding of normal/abnormal conditions or shape-coding of device symbols such as pumps, valves, and meters.

Coding allows more information to be conveyed in a smaller space. For example, if red is used exclusively for warning of emergencies, the alarm text or symbol could change color to red rather than write the word "emergency" next to the alarm text or symbol. Another benefit of coding is that it helps bypass some of the STM limitations. Color is processed prior to conscious processing, allowing information to be transferred even if the STM system is overloaded.

It is important to develop a coding scheme before you begin building displays. The total list of attributes for which codes need to be developed should be set forth before deciding on coding options. This applies to the four major methods of coding:

1. Layout and Position (See Section 6).
2. Color (See Section 8.2).
3. Shape (See Section 8.3).
4. Alpha-numeric or Text (See Section 8.5).

Exercise caution not to overuse coding, as it can then lose its effectiveness. The following traits should be kept in mind:

- Detectable—The controller should be able to detect the stimulus. Blink rates beyond human thresholds for detection do not make good codes.
- Discernible—The controller should be able to differentiate the code from the background or other codes. Use of alternating colors, where blue-yellow-blue means one thing and yellow-blue-yellow means something else, would not be a good coding technique.
- Compatible—The code should have natural associations where possible, such as associating red/green with stop/go and danger/safe.
- Meaningful—If the code does not have an impact on controller behavior, there shouldn't be a code. Coding for aesthetics of information, or because things are different is not a reason to use a code.
- Consistent—The code should be used the same way throughout the system and whenever appropriate. This is the best way to develop the stimulus response that is at the heart of coding. Developers should not alter the coding characteristics in the middle of the display system.
- Multidimensional—Multiple coding techniques should be employed when possible. An example of this is a stop sign; it employs several coding techniques: color (red), shape (octagonal), alphanumeric ("stop"), and position (right side of road).

5 Display Hardware

5.1 GENERAL CONSIDERATIONS

Modern SCADA systems typically use local network connected computers and workstations for the primary human-machine interface sub-system. This technology has been proven to be cost effective, scalable, and easily upgraded as needs change.

5.2 DISPLAY DEVICES

5.2.1 Display Device Types

Information is presented to the controllers on a video monitor using cathode ray tube (CRT), liquid crystal display (LCD), projection or plasma technology. Large monitors with the capability of displaying high-resolution images are common practice.

5.2.2 Number of Monitors per Controller Console

Controller consoles and workstations are typically equipped with multiple monitors all of the same technology. The exact number should be chosen based on expected controller workload, the number of displays to be viewed concurrently, and how much information can be clearly presented on each monitor. The ability of the display sub-system software to show multiple displays on the same monitor may also influence the size and quantity of monitors. Controller consoles with multiple monitors are typically positioned horizontally in front of or around the controller. Stacking of two or more rows of horizontally oriented monitors is also a common arrangement.

5.2.3 External or Remote Display Devices

Some control rooms or operating environments may lend themselves to having display devices other than the monitors at the controller's workstations. These devices may range from large display projection systems to laptop or handheld personal computers. Remote presentation of data should be as identical as is possible to what is displayed in the main control center.

Display projection systems can provide a means where a large audience can all see the same data at the same time. Projection systems in control rooms are typically overhead projectors that present the image on a wall mounted monitor and are driven by one of the controller console computers. Large-screen rear-projection systems are also used in a similar fashion.

A handheld terminal is defined as a mobile PC, PDA (Personal Data Assistant), Pocket PC, tablet PC, or laptop PC. These devices use application software to interface with a SCADA process control system via wireless networking technology.

Safety, integrity, and security are the primary concerns with any remote or handheld SCADA device interface, especially when allowing remote access using wireless technology. More details on SCADA security can be found in API 1164 *Pipeline SCADA Security.*

5.3 DISPLAY RESPONSE

Display sub-system response is a function of both hardware performance and software design. In modern SCADA systems that use client server architecture, both the host (server) and HMI computer (client) can affect the initial display call-up time and data refresh rate. Once installed, display response times should be periodically reviewed.

Display call-up time is the amount of time required from the moment a display is requested until it is fully displayed. Reasonable display call-up times should be expected in any SCADA system design. Display call-up times of one second or less are typical while the SCADA system is under a normal processing load.

Display refresh rates are intervals of time specified for data to update on a display. Display refresh by updating all data fields displayed versus updating individual fields as they change is a software design issue; either scheme should provide changed data to be visible in a reasonable time. Data refresh rates may be selectable with respect to the type of data (status, analogs, accumulators, etc.) being updated and the speed of data acquisition from the remote field devices. Often it is desirable to refresh the data on a display as quickly as possible after it has been received and processed by the SCADA host computer.

5.4 CONTROLLER INPUT DEVICES

A Controller input device (peripheral) is any component that attaches to a main computer. Examples of input devices used for entering information into a computer include keyboard, mouse and track ball, touch-sensitive screen, control-grip and joystick, graphics tablet, and voice recognition device.

The standard computer keyboard and mouse or trackball are the most widely used input devices on SCADA systems. Keyboards are used to enter instructions and data via keys. There are many variations on the layout and labeling of keys. Extra numeric keys may be added, as may special-purpose function keys, whose effects can be defined by programs in the computer. A mouse or track ball is a hand-guided device that controls the movement of the cursor or pointer on a monitor. A typical mouse or track ball contains at least two buttons with multiple functions.

A dedicated input device per monitor is not typically used in larger control centers. Console workstations typically have a keyboard and mouse or trackball which are used to perform input on multiple monitors.

6 Display Layout and Organization

6.1 GENERAL CONSIDERATIONS

For display design, the developer should first decide what and how to display the information. Deciding what information to display depends on the purpose of the display and the tasks it will support. An important step in this decision is the review of the display by the controllers who will be using the display. Displays that model the real world process and structure are easier for the controller to recognize and react to normal and abnormal situations. However, duplicating every component of the field piping and equipment (i.e., drain piping, locally operated equipment, etc.) may create clutter on the display. Graphics should be made as simple as possible while still representing what is actually occurring in the field.

Pipeline information can be displayed in either a graphical or tabular format. Generally, graphical displays work well when physical pipeline configuration details are important. Tabular displays are best used for text or numeric summaries, such as event logs, alarm summaries, ticket details, proving reports, or displays used to total numbers from various locations that are not necessarily geographically near one another.

On a graphical or tabular display, the flow of the pipeline and information is commonly from left to right, top to bottom. Geographical orientation (North—top of screen, South—bottom of screen) is not commonly used on tabular or graphical displays. However, overview type graphics (e.g., a pipeline overlay on a topographic map) typically display the flow of information geographically. Bidirectional station displays could be managed by the addition of dynamic directional indicators.

6.2 DISPLAY HIERARCHY

SCADA systems typically consist of multiple levels or types of operational displays, where each level presents additional detail. This hierarchical structure helps to minimize the number of displays a controller is required to work with and to group information in a logical manner that is easy to locate. An example of an organized four level system is outlined in Table 1.

Table 1—Four Level Display Hierarchy

Level	Display Type	Features
1	Pipeline Overview Display or Map	This display is a qualitative overview of all the pipelines operated, assuming more than one pipeline is being monitored by the same Controller Console. The overview, which is typically a pipeline systems map, is usually the highest level in the hierarchy and illustrates the basic geographic layout of all pipelines. This display could be designed with navigation buttons for access to individual pipeline overview displays. Operation of controllable field devices is normally not allowed from this display.
2	Operational Overview Displays or Primary Displays	This graphical or tabular display presents a single pipeline system. This display could be designed with navigation buttons for access to individual station displays. Operation of controllable field devices is sometimes allowed from this display.
3	Station Displays or Secondary Displays	This display graphically presents a single station and location or group of locations. Greater attention to detail in station piping and field devices is present. This display illustrates detailed functionality for a specific station, including equipment status and analog data. This display could be designed with navigation buttons for access to detail displays. Operation of controllable field devices is typically allowed from this display.
4	Detail Displays	This display presents greater equipment detail and additional operational or point information, etc. Examples could include control displays and informational displays. Control displays are typically pop-up type parent/child in nature and contain in-depth information for a specific data point including ranges, alarm limits, remote name, current value, etc. Informational displays include summaries for database information, event logs, trends, etc.

6.3 WINDOW MANAGEMENT ISSUES

Window management issues are an important consideration in the design of the HMI. Issues to be considered when creating the display layouts include the maximum number of open windows, window sizing, window locations, whether a new window replaces an existing one, and how windows are closed, minimized or resized.

6.3.1 Number of Open Windows

One widely used technique to consider in the management of open windows is to limit the maximum number of open windows per monitor, regardless of the type of display. Only associated pop-up control windows, layers, and overlays would be allowed to open for a given parent window and remain open until closed or the parent window is closed. Child windows would be configured for movement on top of the parent window. Secondary windows would be permitted to overlay the main window; however, they should be designed with a close button which would return the controller to the main window.

Benefits of the above technique include limiting memory consumption, simplifying the controller interface with the computer system, and maintaining a link between open main windows and other associated windows. However, this technique may limit controller flexibility, and may force the use of multiple monitors to achieve an appropriate level of visible windows.

A second technique of managing the number of open windows is to place no limit on the maximum number of windows. Benefits of this technique include increasing the controller's ability to manage the interface with the computer system, providing almost unlimited use of monitor space and computer functionality. Limitations of this technique include creating the possibility of overloading the computer's resources making the system unstable, increasing the possibility of the controller losing the location of an important window when it is overlaid by other windows, and breaking any link between the current visible window and other associated windows.

6.3.2 Sizing

Window size may be fixed or variable, depending on the amount of data displayed and controller preference. However, attention should be given to data that may be truncated if a window is resized smaller than the initial rendering. For example, alarm name, time stamp and alarm message should always be visible without scrolling. Window scaling may be used in this scenario to prevent clipping or truncating data.

6.3.3 Location

Window locations should be consistent for similar display types. For example, initial rendering of pop-up type windows should always be in the same area of the main window. They should be designed to minimize interference with parent display data where possible and configured for movement on top of the parent display.

6.3.4 Layering

New windows can be designed to either replace or layer on top of others when rendered. However, navigation to a main map or menu should always be accessible to the controller in the event they need to start from scratch. Alarm windows should never be minimized and should remain 'on top' of the stack if layering is utilized.

6.3.5 Windows Spanning Multiple Monitors

SCADA system display capabilities differ based on operating system, software and hardware types selected. Some SCADA HMIs function with multiple monitors configured as one workspace, and others function independently. Either method is acceptable. A benefit of the one workspace method is the ability to see more detail on a complex display by stretching the window across multiple monitors, however, portability to single monitor HMIs is compromised.

6.3.6 Screen Savers

Screen savers are not recommended for use on controller workstations that are active 24 × 7 and in a secure location. Screen savers with passwords should be used on any SCADA workstations in an unsecured location.

7 Display Navigation

7.1 GENERAL CONSIDERATIONS

Navigation design is critical to the successful use of the SCADA system by the controller. Significant planning is required based on the capability of the software and operating requirements of the pipeline system. Input should be obtained from SCADA developers and controllers. An initial step in this process might include vendor supplied training on the capability of their software and available navigation techniques. Windowing, layering, and menu capabilities should be fully understood prior to the design process.

7.2 NAVIGATION TECHNIQUES

Navigation techniques are the various ways a controller can interact with the SCADA displays. One key element in designing navigation schemes is to provide multiple methods of accessing any display. Examples of navigation techniques include, but are not limited to, menus, button bars, hot spots, and navigation buttons. Sometimes the mouse buttons are used to perform different functions based on the navigation techniques used. Keyboard keys can be used in a similar manner.

The controller should be able to access necessary displays with a minimum number of key strokes or mouse clicks, and should be allowed to navigate through displays using a single input device. For example, when navigating through hierarchical displays, a single action (e.g., mouse click) could permit the user to navigate to another display level. A single action could also permit the user to toggle between the last two displays.

7.2.1 Menus

Menus are one method used to navigate to various displays. Menus should be consistent in terminology and order structure. They should be designed and sorted in a logical order to minimize scanning and search time. Menu sorting by frequency of use, related display types, and geographic areas are typical examples.

The number of menu options will influence the number of menu levels required. If more than one level is required, grouping should be logical to the controller. If many levels are necessary, a help field or preview that looks ahead to options at the next level could be beneficial.

Menus are typically used to navigate between pipeline systems, between pipeline stations, and between SCADA applications. Types of menus might include pull downs, pop ups, button bars, and dedicated display menus.

Pull-down menus, also called “drop-down menus” or “pop-down menus,” are the most common type of menu used with a graphical user interface (GUI). A menu title is displayed that, when selected by clicking it, causes the menu to drop down from that position and be displayed. Items are selected by highlighting the line in the menu and either clicking it or letting go of the mouse button.

Pop-up menus are typically menus that are activated by pressing or clicking on a selected option in a dialog box. When the menu option is clicked, the rest of the menu pops-up.

Button Bars can be used to place fixed links between a series of displays or to provide links to submenus.

7.2.2 Hot Spots and Navigation Buttons

Hot spots and navigation buttons refer to an area, symbol, or text on a display, that when selected, provides navigation to some pre-defined display. Hot spots may or may not have a visible indication that it provides navigation; however, operators should be instructed as to the use of this method. A navigation button is an image of a button on a computer screen which simulates being “pushed” when clicked by the mouse and provides navigation to some pre-defined display.

For example, on long pipelines with multiple stations, the individual station displays could be fitted with navigation buttons to access both previous and next station displays so the controller can navigate from one end of the pipeline to the other, one station at a time. Hot spots could be used on a pipeline system overview map to navigate to individual station displays using the station name as the hot spot.

7.2.3 Mouse and Keyboard

Using the mouse to place the cursor over hot spots and buttons is the most common navigation technique. Although the number of mouse buttons is limited, additional navigation may be possible dependent on the functionality associated with the mouse button. For example, left clicking the mouse might call up a specific station display, while right clicking the mouse might navigate to the display associated with the most recent alarm.

Historically, dedicated keyboard keys were used to navigate displays. However, keyboard sequences are not intuitive, and can be confusing. Therefore, keyboard navigation alone is not commonly used.

7.3 ZOOM, PAN, AND OVERLAYS

Consideration should be given to the density of information and/or number of symbols on a graphic display to allow a controller to easily see what is going on. When display density gets too high, the use of zoom, pan, layering and overlay techniques can be considered for certain types of displays such as maps and trends. These techniques allow a controller to choose a level of detail based on their needs. Zoom and pan features are typically assigned to a mouse button, while layers and overlays are called by buttons. Trend displays are a typical example of the benefit of zooming because of the quantity of data available. Zooming allows the controller to reduce the number of trended points, which enhances the ability to interpret the trend.

8 Object Characteristics

8.1 GENERAL CONSIDERATIONS

On SCADA displays, objects are defined as any type of symbol or text that relays information to the controller. Each object has attributes or characteristics such as color, size, shape, fill, etc., that are used to enhance or fortify the meaning to the controller. The careful design and planning of a good set of displays should incorporate an appropriate mix of these different types of objects.

There should be a distinct difference between controllable and non-controllable objects. This may be done with color, borders, fonts, highlights, symbols, etc.

8.2 COLOR

The use of color is an effective way of increasing a controller's information gathering and processing capabilities and can dramatically improve search and identification tasks, when applied correctly. Color is highly effective for highlighting related data that is distributed throughout a display.

The following are some guidelines to consider when choosing color.

8.2.1 Number of Colors

The number of colors used should be kept to the minimum needed to provide sufficient information. Research has indicated that the number of colors used on SCADA displays should not exceed eleven. Exceptions can be made for special applications (i.e., batch tracking screens, commodity labeling, etc.).

The benefits of color are best realized if color is used discriminately. Excessive use can hinder effective control room operation. The same qualities which make color useful can result in unintended confusion or distraction if over used or inconsistently applied. As colors are used more frequently and as the number of different colors increases, the attention-getting value of each color diminishes.

8.2.2 Color Selection

One of the primary principles to be considered in selecting colors is to assure that each color is recognized as different from the other. Optimal contrast and differentiation occurs when using the three additive primary colors (red, green, blue), three additive secondary colors (yellow, cyan, magenta) and white, as illustrated in Figure 2 below. Low contrast color combinations such as yellow on white, yellow on green, and cyan on green should be avoided. Colors selected should contrast well with each other and the background on which they appear. This contrast is most apparent using a light foreground on a dark background.

The ambient lighting in the area in which the color is used may influence the apparent color of the object on the display. Colors selected should be evaluated under all illumination conditions.

Dynamic and high priority information should use colors that capture the controller's attention, compared to the colors used for static and other information. Consider using less intense colors, such as gray, for identification of objects that are in the background of the display. Similarly, flashing colors should be reserved for events requiring controller attention such as unacknowledged alarms. Flashing colors for static operating conditions is not recommended, as this can draw attention away from other operating information.

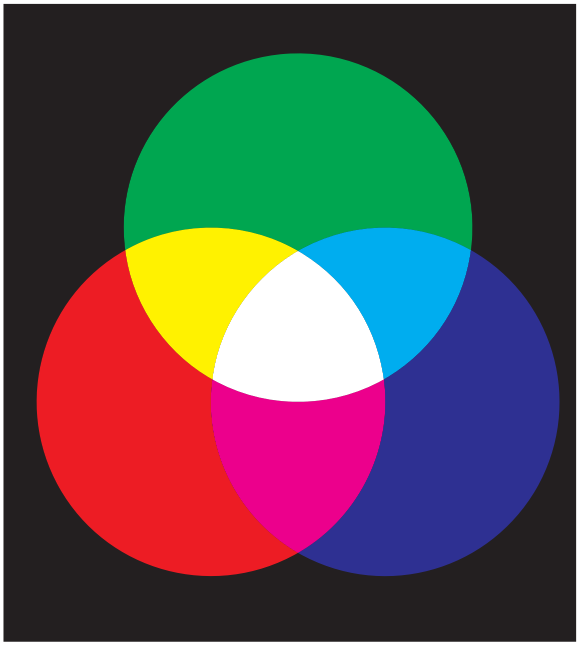


Figure 2—Color Wheel

8.2.3 Meaning of Colors

Learning the meaning of a color can be facilitated by keeping the color simple and by taking advantage of common usage in everyday life. Complex or poorly designed coloring schemes distract from, rather than enhance, controller performance.

Some colors have a predefined meaning in our society. A traffic light is a good example—red indicates stop, unsafe and danger; yellow indicates hazard, caution potentially unsafe; and green indicates go, safe, OK to proceed.

When a particular color has multiple meanings it loses both its attention-getting quality and may lead to confusion or controller error, especially under stress. Therefore, selected colors should be consistent across all types of displays.

8.2.4 Redundancy

Color is only one indication used to relay information. Pertinent information should also be available from some other cue in addition to color such as a symbol or piece of text. An accepted practice is to use a combination of colors, symbols and text coding. For example, a text string may be used next to a pump symbol to indicate a pump's status in addition to the color of the pump.

8.3 SYMBOLS AND SHAPES

The use of symbols aid comprehension and detection more than plain text. Creating a standard, consistent set of symbols is essential to efficient and understandable display design. Standard symbol libraries should be used in the development of all displays, across all systems.

Symbols should be used to represent equipment components and product flow. They should have obvious meanings and be designed to resemble the objects, processes, or operations they represent. Consistent symbol size should be used across all displays and images chosen should be identifiable from the maximum viewing distance and under minimal ambient lighting conditions.

Symbols are typically drawn as solid forms. Symbols should be as simple as possible to reduce distortion. Consideration can be given to the use of fill and patterns to demonstrate additional detail. An example would be the use of symbol fill (linear or area) proportional to the data value, such as a tank volume shown by proportional area fill of a tank symbol.

Appendix A1 contains examples of the more commonly used pipeline symbols.

8.4 ANIMATION

Animation for SCADA displays refers to the dynamic changes in size, shape, orientation and movement of an object tied to variables in the SCADA system, such as analog and status values.

The use of animation is often restricted since it can be distracting to the controller. Simple animation, however, can be effectively used in certain situations. Examples include variable size bars for analog readings of tank levels and batch tracking.

8.5 TEXT

Two relevant factors to consider for text legibility and comprehension are textual format and content. Content includes what should be displayed while format describes the best manner in which text should be presented.

8.5.1 Format

Careful selection of font type, size, and spacing aid in clearly displaying information on a graphical display. Font selection is primarily dictated by the available display system technology and whether it is a pixel or vector based environment. Other factors to be considered when formatting text include the following: the distance of the screen from the controller, the size of the monitor, the resolution of the display, and the spacing between characters and lines of text. Additionally, text should be of consistent case (either uppercase, lowercase, proper case). Formatting techniques should be applied consistently throughout all displays.

Simple sans serif font families like Arial, Helvetica, or Verdana, with straight lines and clear definition offer more clarity than highly stylized fonts like Times New Roman. Scripted and special effected fonts styles (italicized or bolded) are generally avoided.

Figure 3—Example Fonts

The selected font should be scaleable without deterioration in the quality of the displayed characters. The chosen font should also have easily distinguishable ‘similar’ characters such as o & 0, 9 & q, X & K, S & 5, etc.

Consideration should be given to spacing around and within the text to ensure it can be easily read by the controllers. For example, fixed text spacing may be desirable for tabular displays, while variable spaced text may be more appropriate for other displays. When large quantities of text are displayed in a tabular arrangement, the selected font is usually monotype or non-proportional like Courier New, where every character or symbol occupies the exact same width such that numbers and text align. In addition, the font weight should be heavy enough to stand out from the background; however if the font is too bold, adjacent characters may appear to run together.

8.5.2 Content

The formatting techniques described above apply to any type of text shown on a display. This includes numeric values for dynamic data and character strings which display dynamic states. Static labels are used to identify symbols or dynamic values. Messages are lengthier statements used to provide information or feedback to the controller. Abbreviations are used to display common terms in a shortened form.

8.5.2.1 Labels

Labels should convey the basic information necessary for the identification, activation or manipulation of an item. Labels may be text, numeric, alphanumeric or a combination. Some examples of labels include display labels (e.g., display title), symbol labels (e.g., pump name), and data field labels (e.g., BBLS).

Labels should be comprehensive, legible, and offer ease of readability. Consider using simple words or abbreviations that are intuitive and convey verbal meaning in the most concise, direct manner. Avoid using similar label names to describe different functions.

When a label is used to identify a symbol or text, it is typically placed in close proximity to the object. The placement of the label should be consistent with respect to the symbol or text it is labeling, and should have enough separation to be easily discriminated from surrounding fields. For example, the label for all valves would be in the same location relative to the valve symbol.

In tabular displays of data, each individual row or column (e.g., data group, field, or message) should contain a distinct, unique and descriptive label. For repeating data fields, the label could be centered either to the left of the data fields for rows or above the data fields for columns to facilitate grouping of the data fields.

8.5.2.2 Messages

A message may be a prompt, a diagnostic message or an information or status message. Consider placing items of importance either at the beginning or end of the message. Items of lesser importance could be placed in the middle of the message.

Messages should be directly factual and informative and stated in the affirmative and active voice. They should be constructed using short, meaningful and common words, and be kept as simple as possible. Ideally, messages require no transformation, computing, interpolation, or reference searching.

8.5.2.3 Abbreviations

The appropriate use of abbreviations allows the developer to display content clearly and concisely across all displays. The abbreviations should be consistent in form—short, meaningful, distinct, and not include punctuation. Only standard and common abbreviations familiar to the controller should be used.

Standardized list of abbreviations and acronyms could be created and available for online user reference. This list would include abbreviations that are to be used in point descriptors, graphic text descriptors, and engineering units. One to three character abbreviations may be used to eliminate display clutter.

9 Object Dynamics

9.1 GENERAL CONSIDERATIONS

Object dynamics refers to changes in an object's characteristics associated with changes in the database point(s) tied to that object. In general, these database point changes can consist of changes in value/state and changes in data attributes related to the point. Object characteristics that can be altered to reflect different values/states and data attributes include color, shape, texture, area, line fill, and text. It is common industry practice to use color and text as the primary object characteristics to display object dynamics. However, other characteristics could be considered, such as line fill to display the level in a tank.

9.2 DATA VALUES

Every database point has a state or value. Some points, like statuses, have two or more discrete states while others, like analogs, accumulators and tanks, have a numerical value. It is important that the current state or value, or at least the last known state or value, of a database point is displayed and is recognizable by the controller. For points that use multiple object characteristics to indicate states or values, at least one of the characteristics should persist when the data attributes are applied.

9.2.1 Discrete State Database Points

Consideration should be given to using more than one object characteristic to display a discrete data state. One presentation technique for data states combines a character or combination of characters with a colored symbol. For example, an open valve has a green valve symbol with the green text "OPN" on a black background next to the symbol.

The information in Appendix A1 shows examples of color and text object characteristic changes for pump and valve states. The red and green states are based on a user's familiarity with a stoplight. This color scheme can be applied to most pipeline devices that have discrete states. The example also includes text abbreviations in parenthesis. Application of these discrete states should be consistently applied on all displays.

It is acceptable to indicate the flow state in a pipe symbol with color. For example, under no flow conditions, the pipe symbol might be red. When flow was detected, the pipe symbol might be green.

Text objects typically display dynamic effects in one of two ways: hidden text and visible text. For hidden text, the alarm message is visible while the normal state is displayed with the foreground color equal to the background color effectively making the point hidden. If the point is normal, but has abnormal data attributes, the normal state becomes visible. Since most devices are not typically in an alarm state the hidden text type helps minimize clutter on a display.

The visible text object type typically uses different colors for each point state. It is normal for the text contents to change based on the point state. For example, a fire alarm may say "FIRE ALARM" when in alarm and "FIRE CLEAR" when clear. An example of this is included in Appendix A2.

9.2.2 Numeric Database Points

It is common practice to display numeric values with foreground colors based on the state of the database point. An example of this is demonstrated in Appendix A5-4.

9.3 DATA ATTRIBUTES

Each database point within a SCADA system has many possible data attributes above and beyond its actual value. A data attribute refers to a quality or characteristic of the point. It is important that a controller can easily see both the data value and the data attributes on a display, especially those data attributes that would indicate that the points value/state is unreliable.

9.3.1 Data States

The list of available data states is generally specific to the SCADA system in use. The following states are not an all inclusive list. In some cases, the terminology is different between SCADA systems.

A database point can have one or many of the data attributes listed at the same time. All database points can have data attributes whether the data originates in a field device or internally in the SCADA system.

9.3.1.1 On-scan / Off-scan

A remote can either be on-scan or off-scan. When on-scan, the data from the remote is being updated on a periodic basis. When off-scan, the remote is no longer being polled or processed by the SCADA system so data from the remote is not being updated.

9.3.1.2 Manual Override / Real-time

Each database point can be placed into a manual override condition. In this mode, the specific database point does not update to reflect its actual field value, and can be manually adjusted by the controller. This is typically used when an instrument fails. The real-time value is erroneous and could therefore cause confusion or miscalculations. In real-time mode, the database point updates as the field value changes.

9.3.1.3 Alarm / Normal

Status, analog, meter and tank database points generally have the ability to generate alarms based on certain states and user entered parameters. For analog, meter and tank points, these alarm states could include high-high low, low-low, rate-of-change and deviation. For status points, one or more states can be defined as an alarm state. Some systems have the ability to differentiate alarms by severity. When this is done, a visual indication of the alarm severity associated with the point may be used as well.

9.3.1.4 Communication Failure / Communication Normal

When communication is lost to a remote, the SCADA system is no longer receiving updated data from the remote.

9.3.1.5 Alarm Inhibit / Alarm Enabled

A database point can be alarm inhibited to prevent alarms from being generated, while updated data for the point is still processed.

9.3.1.6 Unacknowledged / Acknowledged

When an alarm is generated for a point, the point can be in either an unacknowledged or acknowledged state.

9.3.1.7 Informational Tag / No Tag

A user can enter an informational tag on a database point to describe some relevant detail about the point (e.g., reserved, unavailable, not commandable, warning message). This attribute indicates that a tag exists.

9.3.2 Data Attribute Hierarchy and Display Techniques

A consistent approach to displaying data attributes is important. All displays should use the same technique for each data attribute where feasible. Display of every data attribute for every point is not practical. Therefore, consideration should be given to creating a hierarchy of data attributes such that the controller would see only the most important attributes.

Some of the data attributes that could be addressed with symbol and text displays, along with a suggested order of precedence are off-scan, manual, communication failure and alarm inhibit. For example, a point that is off-scan and in manual would only display the data attribute for off-scan.

It can be useful to have displays available for documentation and training purposes that show examples of data attribute hierarchies and display techniques. A controller can reference these displays if they are uncertain of a specific display technique.

As with objects, it is a common practice to use more than one technique to display a data attribute, such as combining a character with a color scheme. For example, a point in manual override might have a black "M" on a yellow background next to the point while a point that is off-scan might have a white "O" on a blue background next to the point. Text strings can also be used to indicate data attributes. Additional examples are shown in Appendix A1.

10 Control and Selection Techniques

10.1 OBJECT SELECTION

The term "poke point," as used in this document, is the control that is placed on top of an object that causes an action to occur when clicked. The selection area for poke points should be of sufficient size such that objects or buttons can be accurately selected. A poke point that is too small can lead to frustration when trying to select an object. Overlapping of poke points is also not a good idea since it can lead to unpredictable results.

Consideration should be given to differentiating which objects are controllable and which are not. Some techniques that have been used in the industry include making the object label one color if it is controllable and another color if it is not, changing the mouse pointer's shape when positioned over the object, or applying a border to the object. The examples in Appendix A1-2 and A1-3 use white object labels for non-controllable devices, and cyan object labels for controllable devices.

Often times, selecting a poke point for an object is navigation to another display. This display is usually a pop-up type display that identifies the commands available for the device associated with the object. It is also important to identify and verify the correct device has been selected.

Typically, a device can be operated from many displays. For example, a pump may be started from a piping display, an overview display or a hydraulic gradient display. Consider the status of other related devices to determine if the primary device should be controllable from a display that does not contain those related devices.

10.2 COMMAND EXECUTION

Control of pipeline devices should require two or more actions before a command is sent to the field device. This prevents a misplaced mouse click from operating a field device. A common technique is select-before-operate where a device is selected from a display and then another mouse click is required in another location to operate the device. For example, a valve may be selected first and then an open button is selected to issue an open command to the valve.

It is also common practice to require two mouse clicks on a control pop-up display to execute a command. For example, after a valve has been selected, the control pop-up may require an open or close button to be selected and then an execute button to be selected.

Some commands may require data entry. An example is an analog setpoint. As with other commands, two or more actions should be required before the setpoint is sent to the field. A common technique is to select the analog value, enter the new value through a pop-up, and then select the execute button.

Appropriate feedback should be provided to indicate success or failure of a controller command. Command failure could be indicated by an alarm message, the device symbol blinking in a unique color, or text next to the device symbol. Command success could be indicated by the device symbol and state text changing to the new state.

10.3 ERROR MANAGEMENT

Display design techniques should include error management. The most effective error management is an interface design which minimizes invalid entries. Errors may occur, and the functional interface should include provision for managing errors and mistakes related to functional tasks performed by the user. The interface should allow easy correction and recovery while protecting the application from catastrophic user errors.

Error messages are alphanumeric messages that should be displayed when an incorrect value is entered or a bad selection is made. For example, a controller may enter a discharge setpoint value that is outside of the valid operating range. An error message could identify the value as out of range and prompt for a new setpoint. Ideally, the error message would display the valid input range.

The display design should also support informational and warning messages. These messages are typically generated based on a command being executed. For example, sending a command may generate a warning message that the command violates an operating procedure. This warning message could allow the controller an opportunity to cancel the command prior to its issuance to the field device or to proceed with command execution.

11 Administration

11.1 CONSISTENCY WITHIN A COMPANY

This document acknowledges that each pipeline company may have a different approach to implementing SCADA systems and, therefore, not all elements of this recommended practice may be applicable. An important consideration is to insure that the operator interface provides as much consistency as possible in both functionality and appearance.

11.2 DOCUMENTATION

Because SCADA operator interfaces can be extensive and detailed, it is important that the company's operator interface standards be documented. The documentation should be periodically reviewed for accuracy and updated as required.

11.3 CONSISTENCY BETWEEN CONTROL CENTERS AND REMOTE LOCATIONS

To avoid confusion and enhance communications between control center personnel and field personnel, displays, control panels, and other indicators used in both locations should be consistent. This could include, but not be limited to, colors, symbols, text and labels. Naming conventions including equipment tags, station names, and other identifiers between the control center and remote locations should be standardized.

11.4 MOC (MANAGEMENT OF CHANGE)

All display changes should follow a Management of Change (MOC) process. OPS Advisory Bulletin ADB-03-09 highlights some of the concerns with improper control of SCADA system changes.

11.4.1 Maintenance and Testing

Documented procedures should exist and be followed for modifying SCADA displays.

It is good practice for owners and operators of pipeline systems to periodically review their SCADA displays for accuracy.

Companies should consider using off-line, backup, or development workstations/servers to help ensure that impending display changes are tested before moving the changes into production.

11.4.2 Release Management

Once a display has been tested and verified, the display can be installed into the production system. Consideration should be given to archiving previous versions of SCADA system displays. Installation on the production system should be coordinated with the pipeline controllers and be as non-intrusive as possible. When new display functionality is added to the system, appropriate notification and training of controllers should occur.

12 Sample Displays

The contents of Appendix A provide samples of various types of displays that could be considered when designing SCADA interfaces. The sample symbol sets and displays take into consideration information provided throughout this document and provides display examples based on the techniques accepted by the liquids pipeline industry. The types of displays used are a function of the intended use of the SCADA system, the complexity of the pipeline operation, and company operating philosophy.

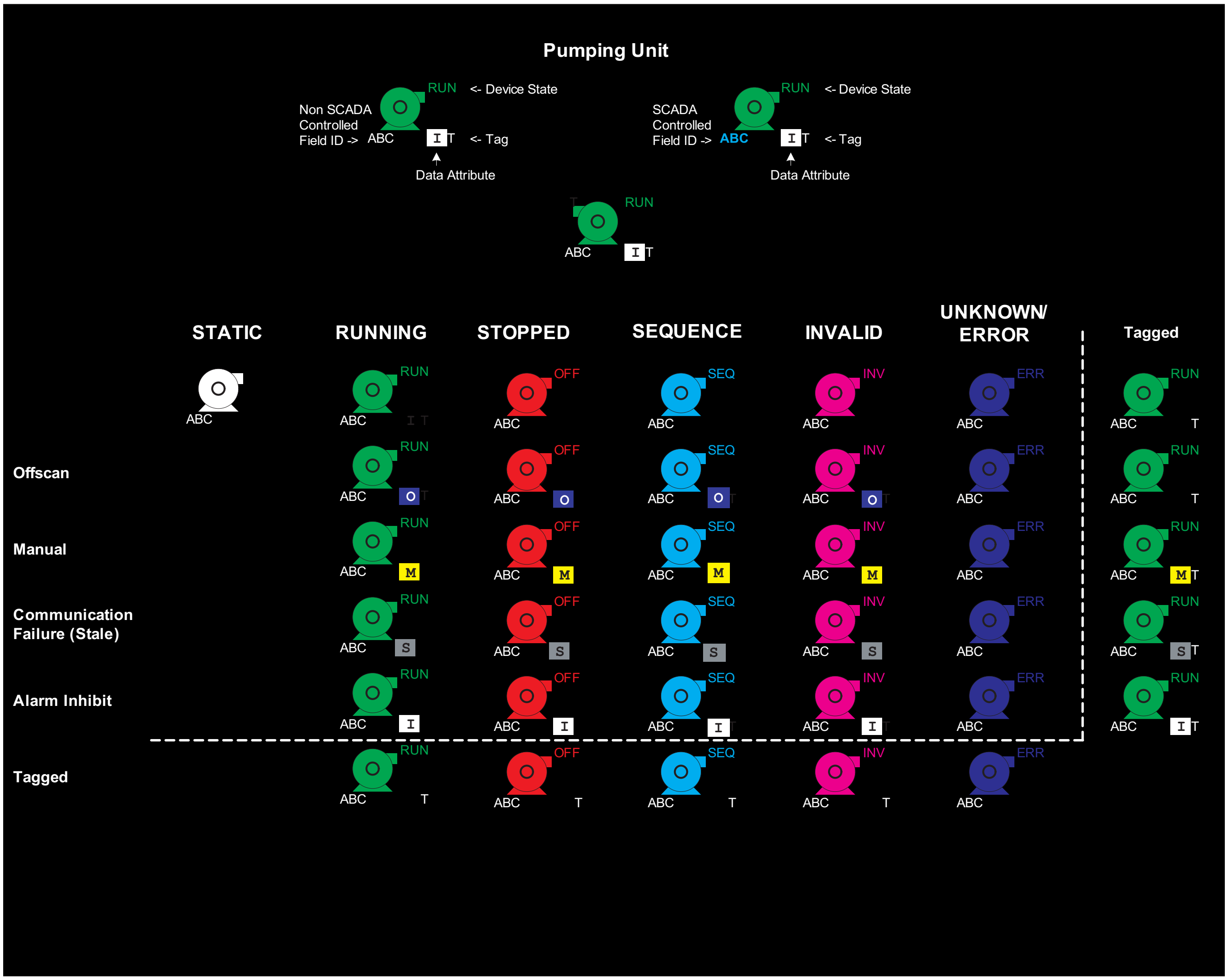
APPENDIX A—EXAMPLES

APPENDIX A1—EXAMPLE SYMBOL DYNAMICS

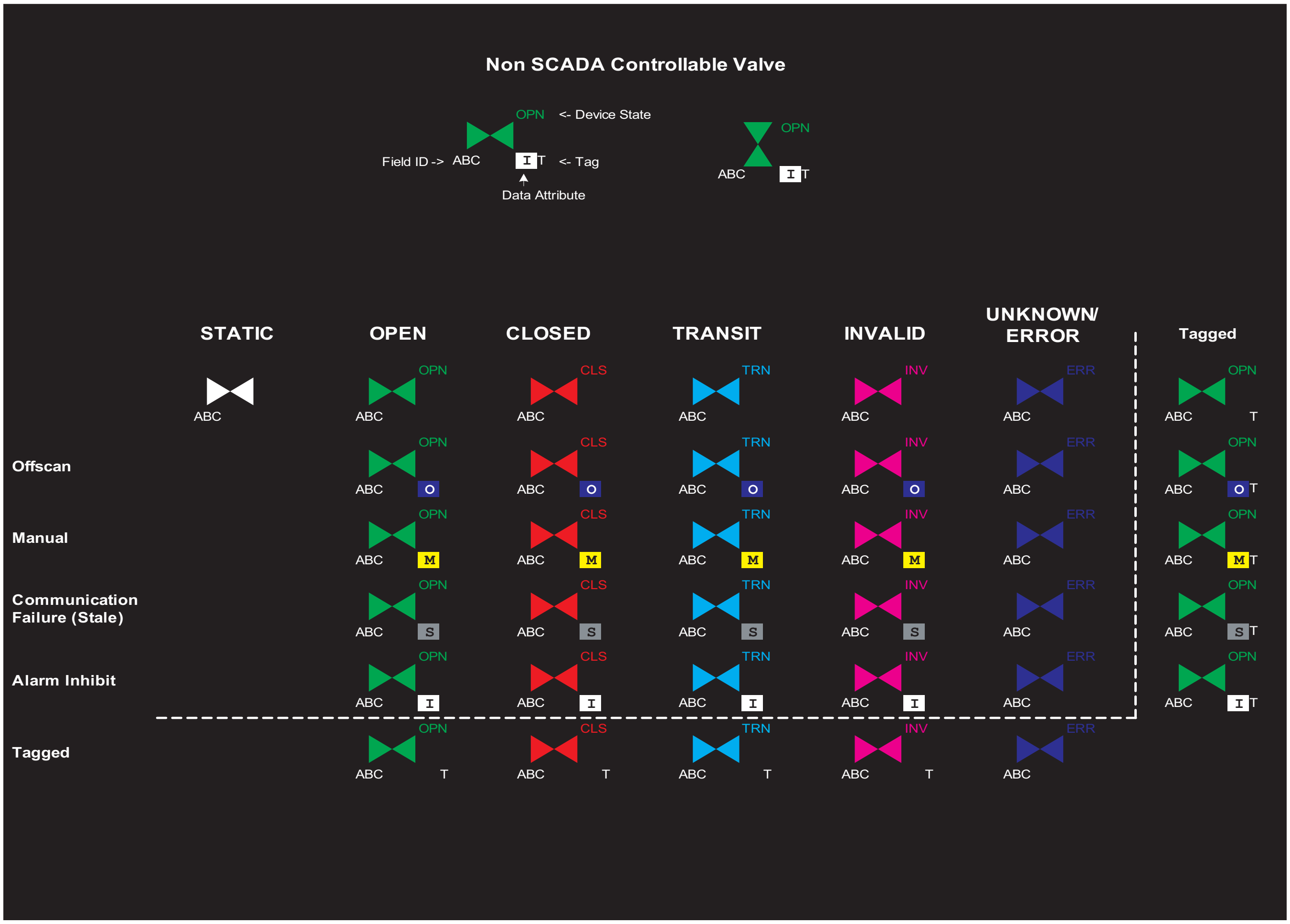
Examples of object dynamics for typical states and data attributes for the main symbols and text typically used in SCADA displays are below. Similar logic could be applied to any other symbols and text required.

For symbol recommendations, each page shows the symbol in all valid orientations at the top of the page. It also suggests the location of the text state, the location of data attributes and the device label. The grid below then illustrates the device in typical valid states and typical data attribute combinations. In this example, multiple data attributes follow the documented data attribute hierarchy with the exception of the tag attributes.

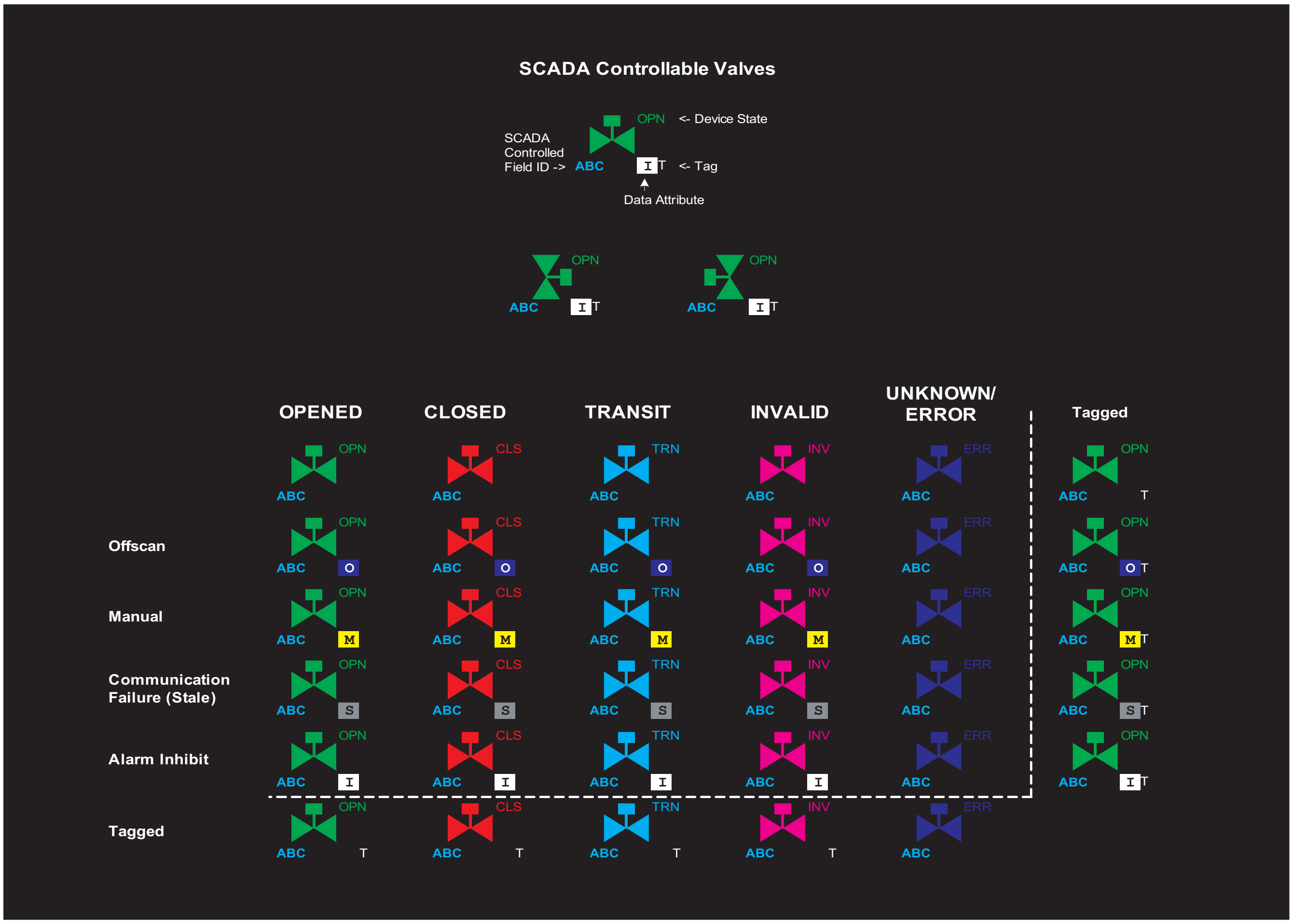
Appendix A1-1: Pumping Units



Appendix A1-2: Non SCADA Controllable Valves

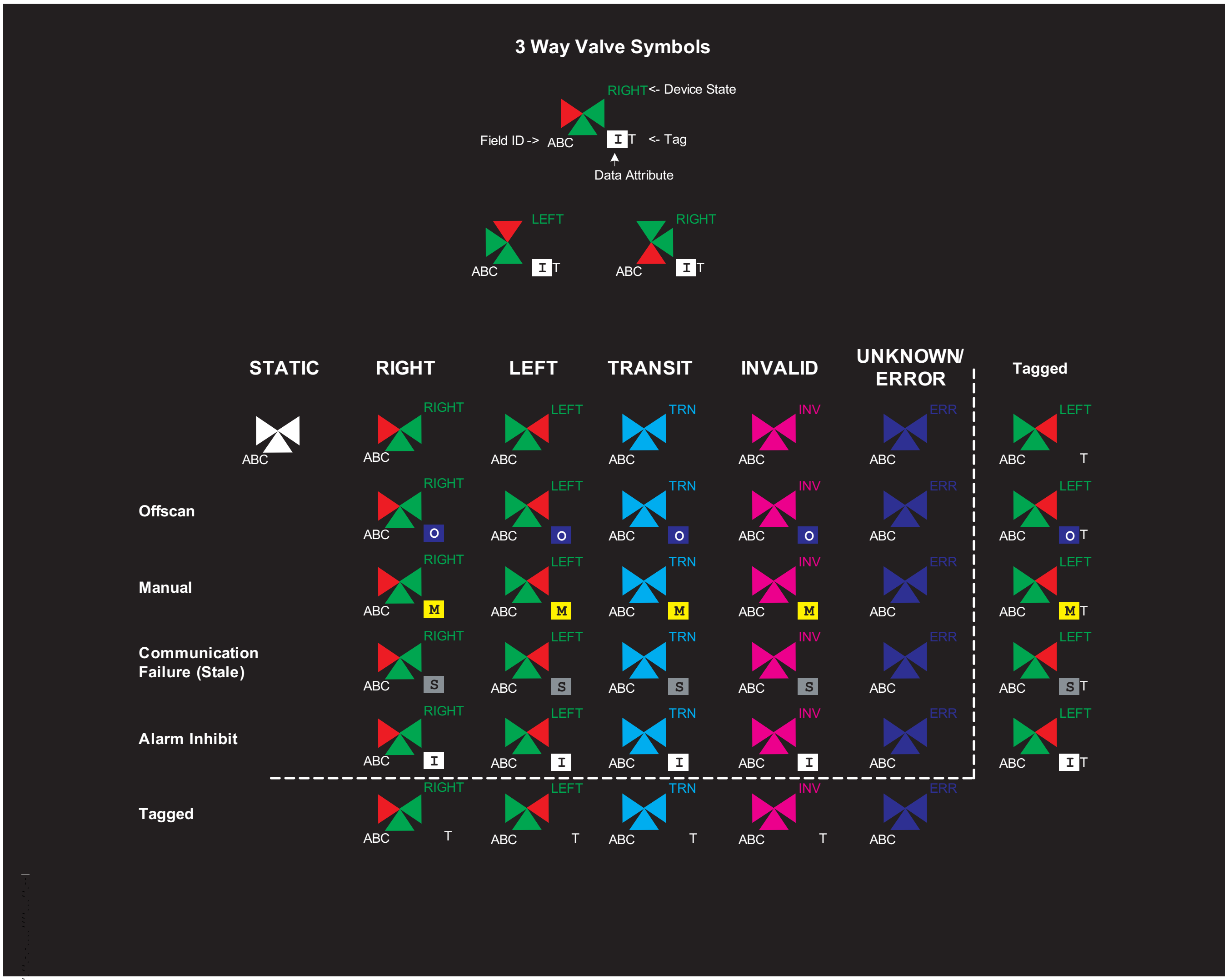


Appendix A1-3: SCADA Controllable Valves

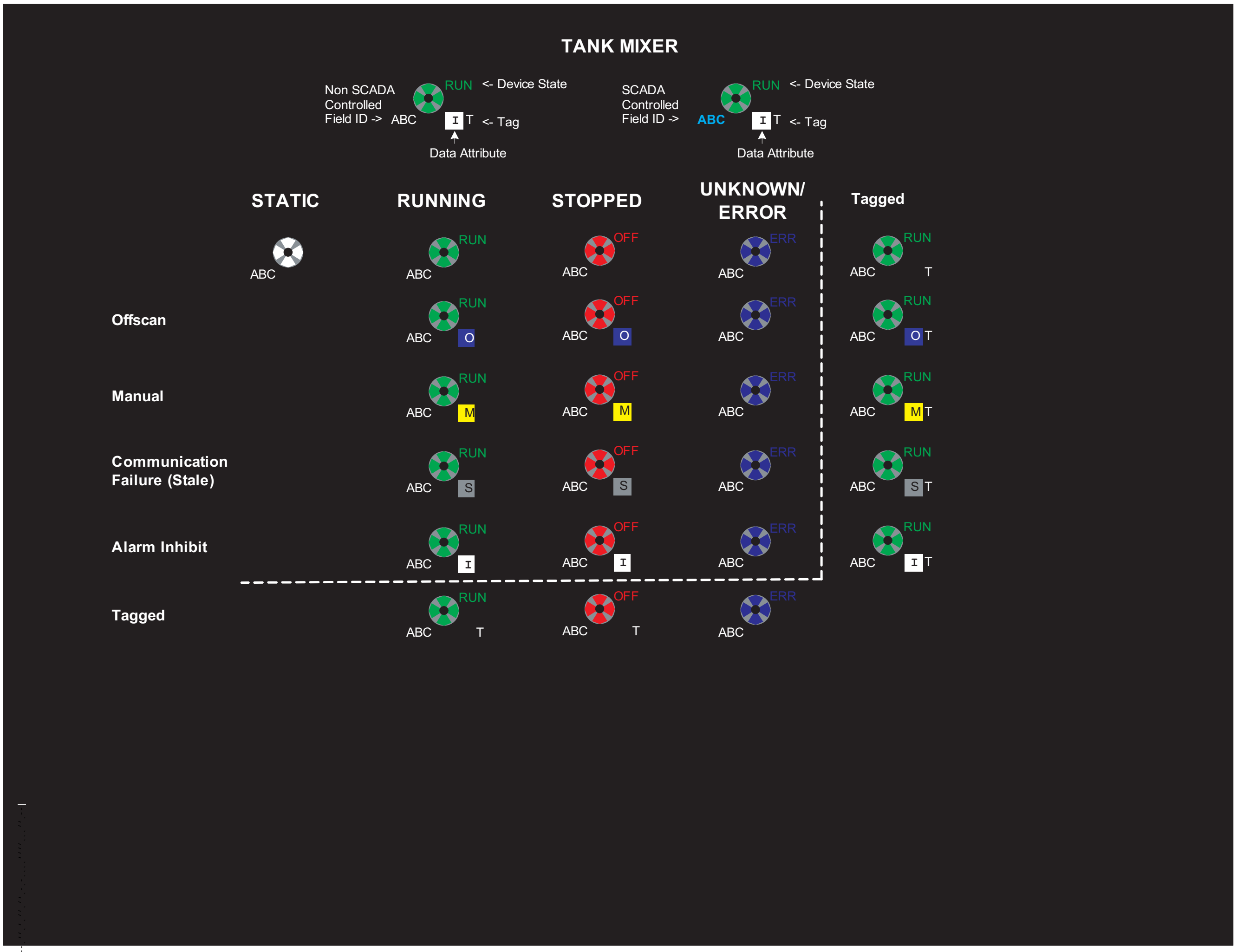


Appendix A1-4: 4 Way Valves

Appendix A1-5: 3 Way Valves



Appendix A1-6: Tank Mixers



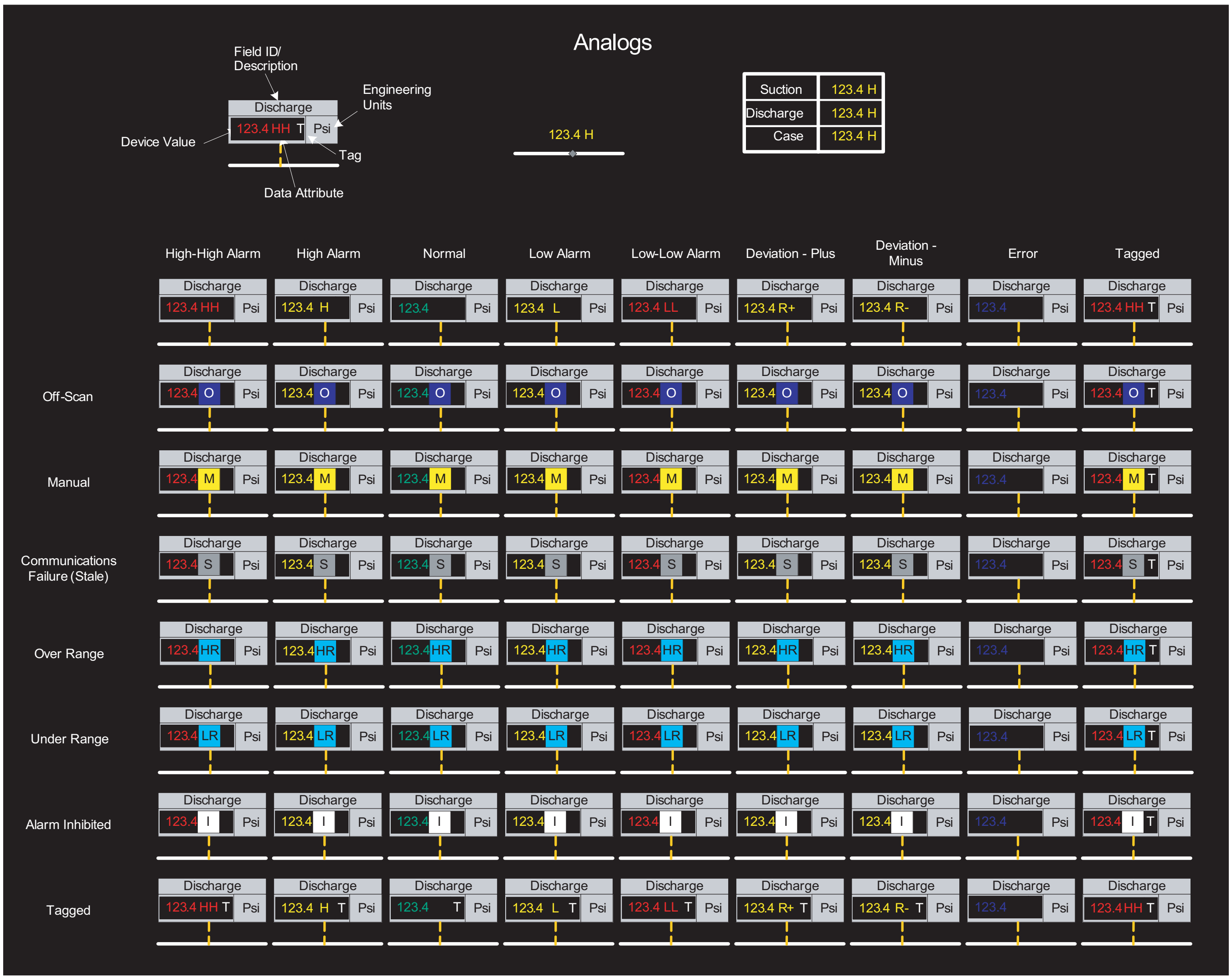
Appendix A2—Discrete State Points

In this example, for hidden text the alarm state foreground is shown in red text on a black background while the normal state is shown as black text on a black background effectively making the point hidden, assuming no abnormal data attributes exist. If the point is normal but has abnormal data attributes, the normal state is visible and is displayed in green text on a black background. Since most devices are not typically in an alarm state the hidden text type helps minimize clutter on a display. The actual alarm / normal text would reflect the specific device such as pressure relief or high tank. The text does not typically change when the value changes.

In this example, the visible text object type follows the red/green pattern for symbols where the red state is the more dangerous state. It is common for the text contents to change based on the point state. For example, a discrete point may display "LOCAL" in red text on a black background when in alarm and "AUTO" in green text on a black background when clear.

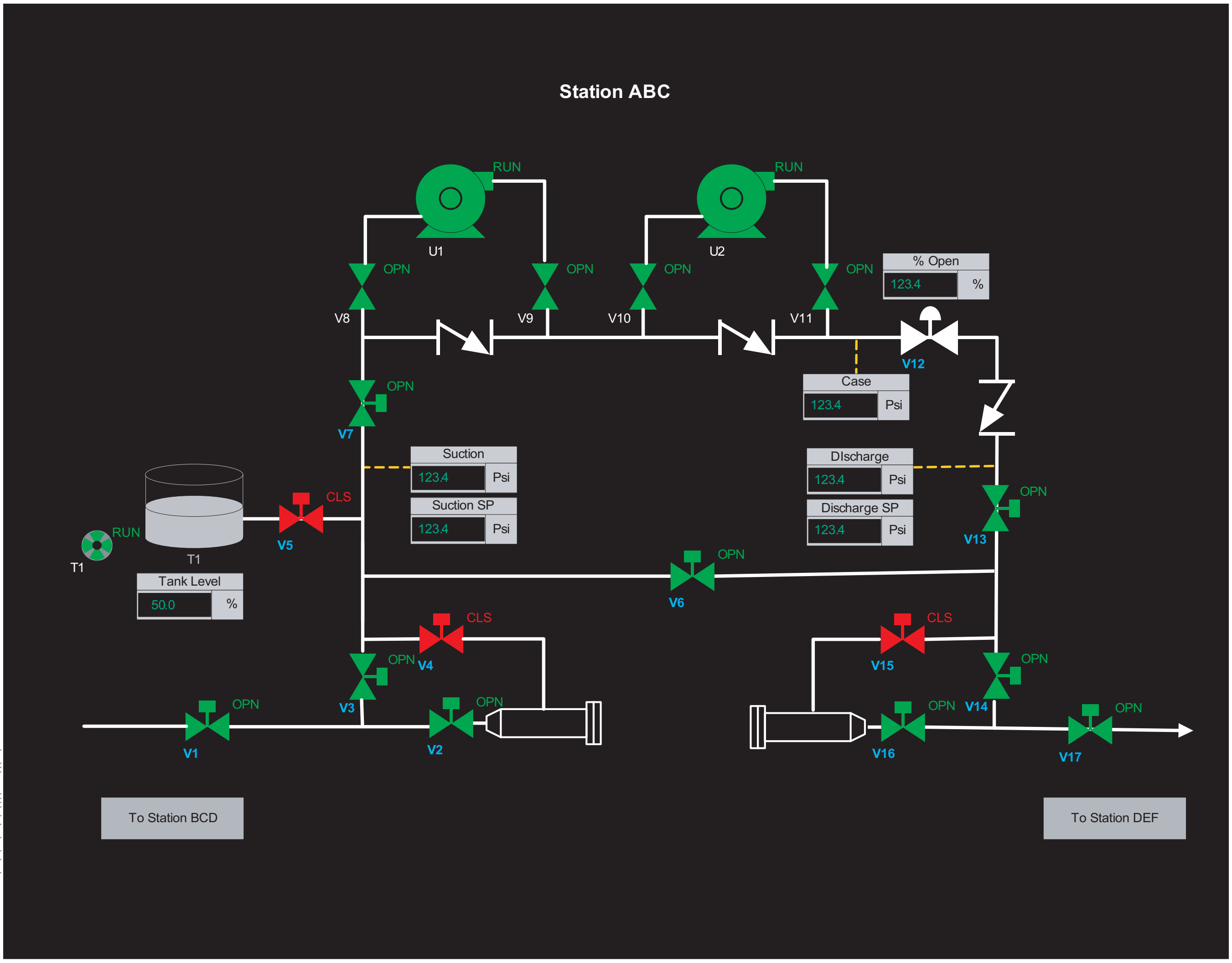
Appendix A3—Numeric Points

This analog point display example can be applied to any numeric value database type (i.e., analogs, accumulators, tanks, etc.). The top of this page shows examples of a few techniques that can be used to display analog data. It also demonstrates possible color and text options to be used for various data attribute combinations.



Appendix A4—Sample Station Display

This example piping display combines static and dynamic symbols and text with piping, navigation buttons and numeric data from the previous example symbols. This display is intended to provide an illustration of the individual objects and how they may tie together.



Appendix A5—Sample Summary Displays

Summary displays could be an effective way to show information about multiple data points. Data points are displayed as rows with the columns being the relevant information for the data type. Typical summary displays include database, alarm, event and communications. On initial display, the summary may have a default filter for the data. Typically, various filters are provided based on the type of summary display. Some filter examples include filtering on date, pipeline system, remote, or point name.

Display hierarchy design may provide detailed displays that are navigated to by selecting a row in the summary. In some cases, multiple detailed displays are provided and the navigation is based on which column of the specific row is selected. Filtering and sorting capabilities may be provided to allow evaluation of a subset of data or to aid in identifying specific points. Paging or scrolling capability is also typically provided since summary displays may exceed one page.

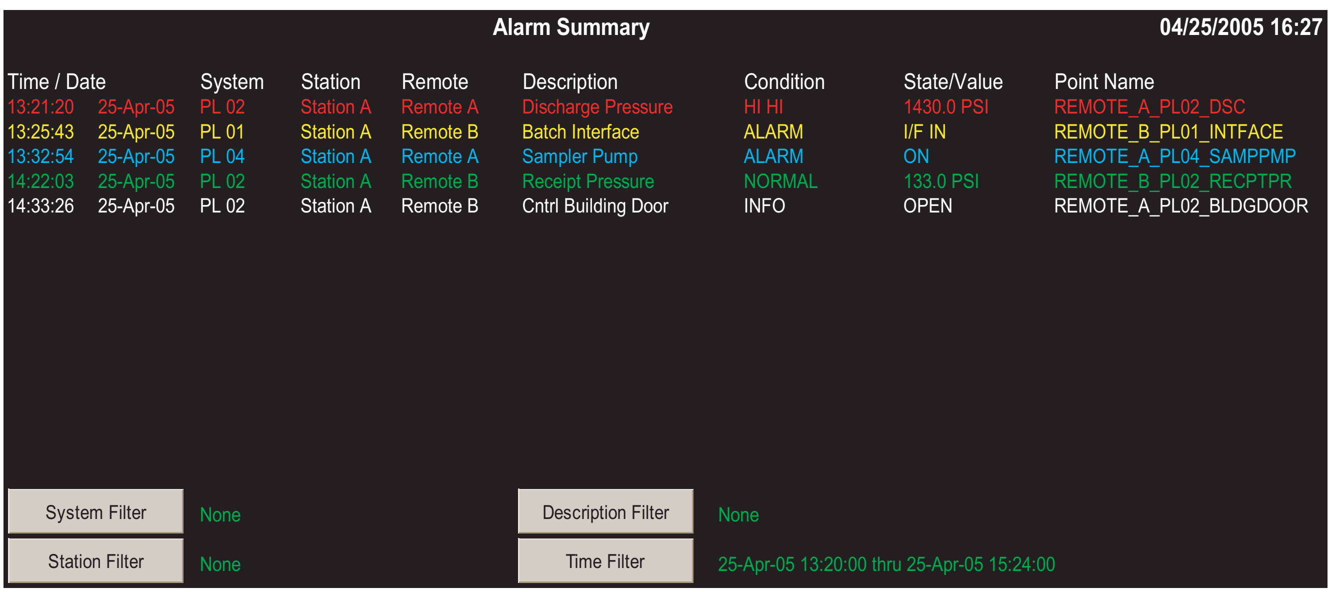
Appendix A5-1: Alarm Summary Displays

Alarms are indicators of abnormal or unexpected conditions in the system for which the controller is notified through the alarm management system. Alarm examples include un-commanded device changes, high and low limit violations, abnormal communication status, and return to normal alarms. Alarms can be segregated into different levels of severity. Each level should have a unique look and sound. An example of a multi-level alarm severity structure could be Critical or High-High (Red), Medium (Yellow), Low (Cyan), Informational (White), and Normal (Green). Unacknowledged and acknowledged alarms should be presented differently. Typically, unacknowledged alarms flash and acknowledged alarms do not.

In the Alarm Summary example, each alarm message contains an event time stamp, the name for the point in alarm, text which explains the alarm, and the severity of the alarm. Alarm selection may provide immediate access to a more detailed corresponding station display where associated data can be analyzed.

Different variations of tabular alarm displays can also be provided. For example, an unacknowledged alarm summary might display the newest unacknowledged alarms, ordered by severity. A system alarm summary might display all outstanding alarms ordered by severity. A chronological alarm summary might display all outstanding alarms, displayed in chronological order independent of severity.

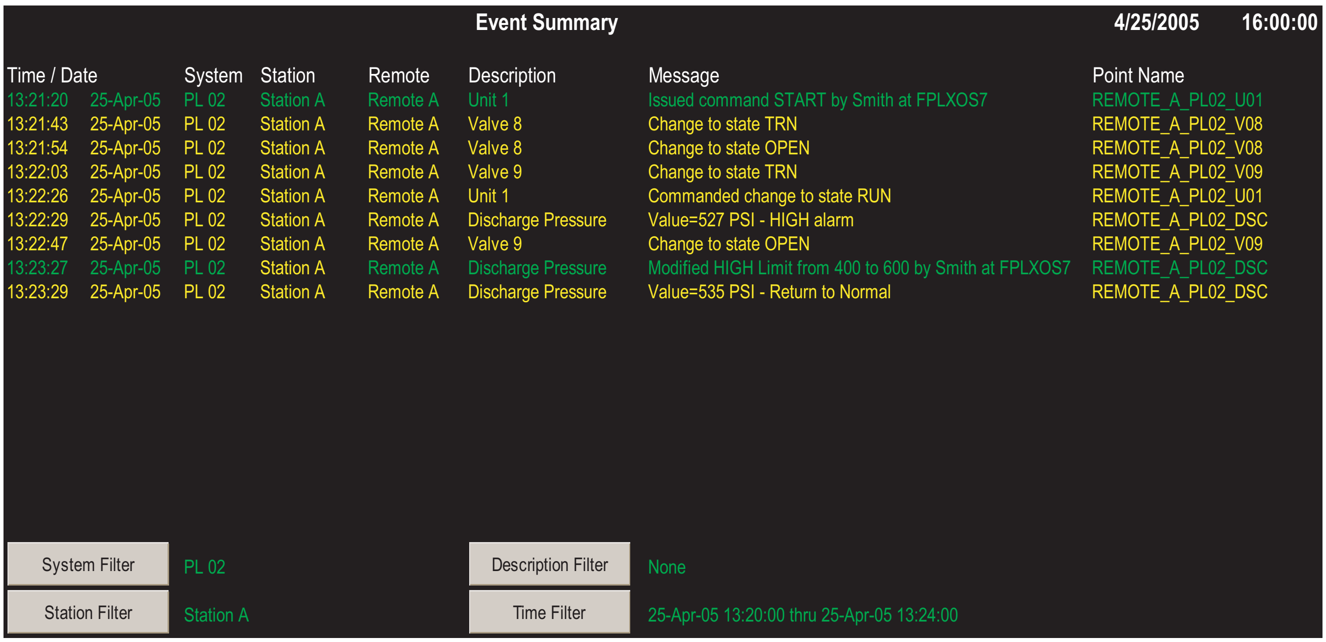
Filtering and sorting may be provided on timestamp, pipeline system, remote, point name, point description, and message text. Filtering is typically not provided on the unacknowledged alarm display to minimize the risk of missing an alarm.



Appendix A5-2: Event Summary Displays

SCADA systems typically capture all alarms, commands and system messages as events. The controller may access these events to review activities that have occurred. This access is usually provided through an event summary display where each event is a row on the display.

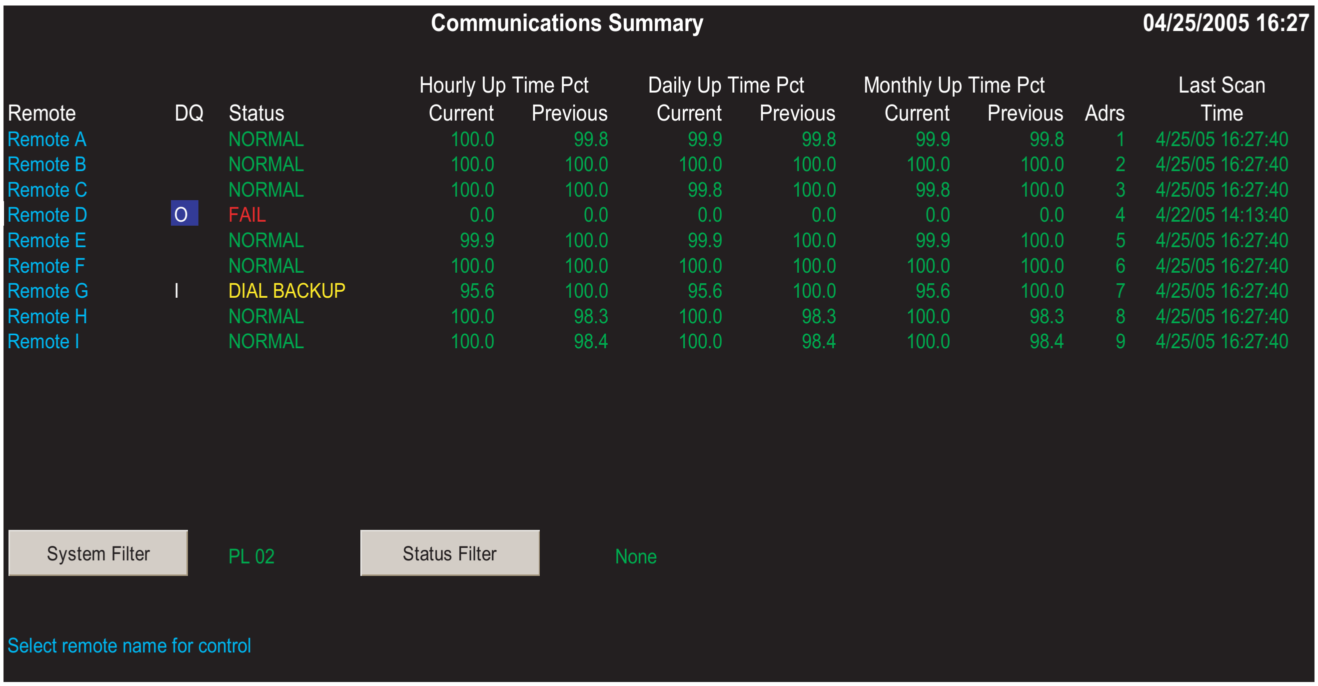
In this example, each event displayed contains an event time stamp, the point name and description for the point with which the event is associated, and the message text which explains the event. Other fields which might be displayed are the remote, pipeline system, and user id of the controller. A coloring scheme may also be used to distinguish between alarms, commands, and system events.



Appendix A5-3: Communications Summary Display

Communications summary displays are typically used to provide an overview of the current state of communications between the SCADA system and the field remote. Information regarding primary communications for each remote should be provided. Summaries also typically include statistics showing recent performance (e.g., hourly, daily and monthly uptime). Another communications summary display may show the status of all backup communications. Depending on the complexity, some systems combine the primary and backup communication information on one display.

In the example, each row represents one remote. Percentages for hourly, daily, and monthly up time are illustrated, along with the Remote address and the last scan time. The current status is also displayed, along with data quality attributes.



Appendix A5-4: Database Summary Displays

Database summary displays provide a tabular listing of all the records of the same database type. Database summary displays are usually provided for analog, status, accumulator and tank records, but can be configured for any other point type that provides value to a controller. The information displayed in these summary displays typically includes the point name, remote, description, current state or value and other pertinent information for each point type.

In this example, the point name, station, description, analog alarm limits, and current value are listed for each analog point. Of the various filter options available, this example is filtered by Point Name (PL02).

Analog Summary 4/25/2005 16:27:56

Point Name	Station	Description	High-High	High	Value	Low	Low-Low
REMOTE_A_PL02_DSC	Station A	Discharge Pressure	500.0	400.0	475.0 H	100.0	50.0
REMOTE_A_PL02_SUC	Station A	Suction Pressure	500.0	400.0	122.0	50.0	25.0
REMOTE_A_PL02_CAS	Station A	Case Pressure	600.0	500.0	490.0	100.0	50.0
REMOTE_A_PL02_TMP	Station A	Line Temperature	80.0	80.0	65.4	60.0	60.0
REMOTE_B_PL02_DSC	Station B	Discharge Pressure	500.0	400.0	385.0	100.0	50.0
REMOTE_B_PL02_SUC	Station B	Suction Pressure	500.0	400.0	20.0 LL	50.0	25.0
REMOTE_B_PL02_CAS	Station B	Case Pressure	600.0	500.0	725.0 HH	100.0	50.0
REMOTE_B_PL02_TMP	Station B	Line Temperature	80.0	80.0	65.4	60.0	60.0
	Station C	Discharge Pressure	500.0	400.0	369.0	100.0	50.0
REMOTE_C_PL02_SUC	Station C	Suction Pressure	500.0	400.0	76.0	50.0	25.0
REMOTE_C_PL02_CAS	Station C	Case Pressure	600.0	500.0	371.0 I	100.0	50.0
REMOTE_C_PL02_TMP	Station C	Line Temperature	80.0	80.0	65.1 O	60.0	60.0

Point Name Filter PL 02 Description Filter None

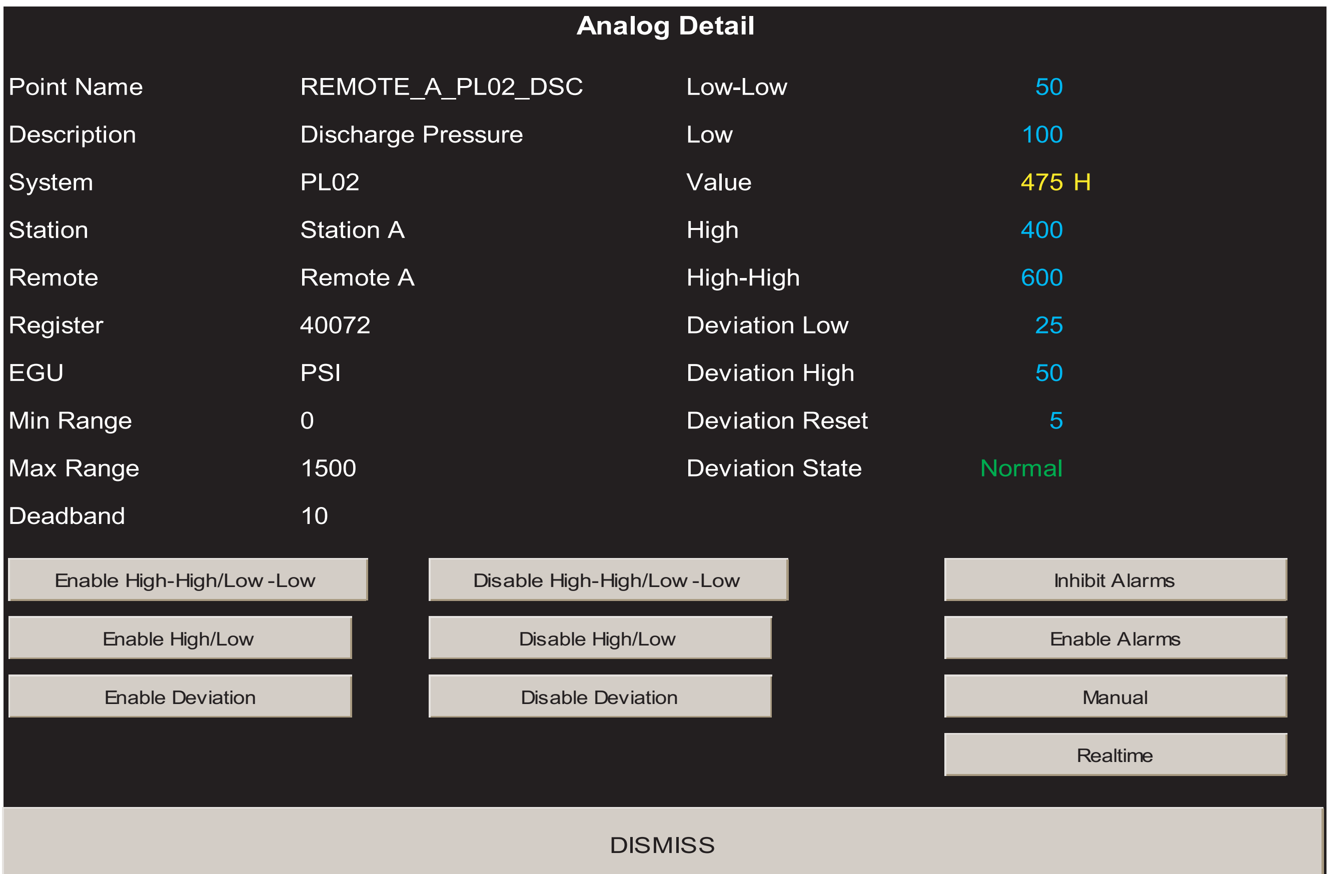
Station Filter None

Select point name for control

Appendix A6—Detailed Point Displays

Detailed point displays are normally accessed from a piping display or database summary display. These displays typically provide additional detail not provided on the summary display. Each display could be unique based on the database record type. In some cases, the display may only provide information while in others it may provide change or control capability. For example, analog high and low alarm limits may be entered via an analog detailed point display.

In this analog point example, detailed information is provided about the point. There are also poke buttons displayed to allow enabling and disabling specific alarm limits, or enabling and inhibiting all alarming associated with the point.



Appendix A7—Trend Displays

Trend displays are commonly used to provide a comparison of one or more SCADA points on a real-time or historical basis, which allows the controller to see trends in operations. Trends are routinely depicted graphically using lines and symbols. Typically, trend displays use the X-Axis to display time, and the Y-Axis to display data values.

Trend scaling should be appropriately labeled. The trend display format and naming conventions should be consistent between all locations. When multiple SCADA points can be trended on a single display, the plot of each point should be distinguishable by color and/or line type. Consideration should be given to using an unique color and/or line type to indicate data attributes of the SCADA point. An example is changing the color of the plot to indicate a communication failure.

Capabilities may include zoom and pan ability, the ability to change the start and end time of the point trended, the ability to change the minimum and maximum values of the Y-Axis, the ability to select and view previously defined trends and the ability to define new single and multiple point trend sets.

Appendix A8—Special Application Displays

SCADA systems typically provide customized displays that support special applications. Listed below are several types of commonly used displays:

- **Metering displays**—These provide the controller with a detailed look at a meter's calculations and scheduling information.
- **Meter Proving displays**—These provide the controller with a detailed look at a meter proving results, calculations and meter factors.
- **Computational Pipeline Monitoring (CPM) displays**—These are dependent on the type of CPM implemented. Three that are commonly used throughout the industry are Line Balance, Volume Balance, and Rate of Change. Typically, data provided on these displays include current alarm state and balance, calculation status, alarm status, and deviation values used to define limits for alarming.
- **Batch Tracking displays—**These show movement of batches through pipelines. Information that might be displayed for each batch include the product, batch ID, gravity, volume, mile post, number of barrels to the end of the section, and estimated time of arrival (ETA) to the end of the section.
- **Hydraulic Gradient displays**—These provide a graphical representation of the pressure profiles of the pipeline. Elevations, gauged pressures, maximum calculated operating pressures, and calculated line pressures are typical plotted values. The graph plots the four pressure points along the distance, or mile post of the pipeline.
- **Tank displays**—These provide the tank data in tabular or graphic formats. Graphic representations of tanks with color-coding to indicate fill level are sometimes used to provide the controller a quick visual indication of the normal or abnormal level of the tanks. Information displayed for each tank can include tank level, tank volume, alarm status, volume to fill or available room. Additional information that can be included is product type, flow rate, strap type, percent full, temperature, observed volume, net volume, time to fill and empty, and volume to pump.
- **Scratch Pad displays—**These allow the controller to keep miscellaneous notes concerning the pipeline systems operated. This might include phone numbers, on-call lists, operational information or shift change notes. The display is typically a "notepad" that allows free format text. The layout of the notes is the responsibility of the controller. The information entered is stored in either the SCADA database or in a text file on the workstation.
- **Help displays**—These might be used throughout the entire set of displays wherever additional information is needed. For example, it might explain the color schemes and symbols used.
- **SCADA Topology displays**—These are typically provided to show the status of the SCADA hardware and connectivity between the hardware. This display is sometimes used to switch between the "hot" and "standby" systems at the primary control center. It can also be used to switch between the primary control center and a backup control center.

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