Tulsa Water and Sewer Department

SCADA System Improvements

HMI Software Standards

FINAL

PRESENTED TO

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Revision History

After the Supervisory Control and Data Acquisition (SCADA) system has been modified or updated, this document should be revised to reflect the changes. Changes may include software configuration or upgrades, equipment functionality, and user interface modifications.

The version is broken into two parts: major (**X**.0) and minor (1.**X**). A major version is reserved for adding or removing sections of this document. A minor version is reserved for modifications to existing sections.

Version	Date	Description
A	June 24, 2021	Draft delivered to the client.
B	April 4, 2022	Final delivered to the client.

1 PURPOSE

The purpose of this document is to provide standard methods and guidelines for the configuration and development of the Human Machine Interface (HMI) component of the SCADA system. The topics covered in this document include, but are not limited to system security, naming convention, graphics standards, and alarming.

This document is meant to provide a sustainable standard for training and future development. These standards apply to external programmers, engineers, consultants, and internal developers who configure or alter the Wonderware application.

2 BACKGROUND

Previously, HMI applications have been developed, implemented, and operated primarily on a site-by-site or per-project basis. This has led to a disjointed system that is inefficient, inconsistent, and difficult to maintain.

This HMI standard has been developed to provide internal and external programming entities a source for Wonderware standardization across all components of the Tulsa Water and Sewer Department. Consistency within the application increases the development efficiency. Standard graphics can be re-used, allowing for a shorter development time. In addition, modifications are easier to troubleshoot and less likely to contain errors. With a standard in place, multiple integrators can use the system while enforcing the quality of their work.

3 DEFINITIONS

Term	Definition
Alarm	An audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a response.
Aspect Ratio	The ratio between the total horizontal and total vertical pixels on a screen.
Calculations	The formulations necessary to perform the automatic controls that have been defined.
Call Up Time	The lapsed time for all display elements to be refreshed after a display change has been requested.
Commissioning	Procedures prior, or related, to handing over a system for placing into service. These procedures often include acceptance testing (FAT, SAT, and SIT); handing over of drawings and documentation; delivering instructions for operation, maintenance, and repair; and providing training to personnel.
Console	The hardware, software, and furniture or enclosure at which users monitor and/or control the process, which may include multiple stations, communication devices, and other devices (e.g. cameras, barcode devices, pushbutton stations).
Control Room	A room with at least one HMI console from which a process is monitored and/or controlled and possibly containing other control system equipment and/or other facilities for operators.
Control System	A system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner.
Controller	The hardware which executes functions for monitoring and control of one or more process variables.
Dashboard	A graphical summary showing various pieces of important information typically used to give an overview of a process or part of a process.

Display	A visual representation of the process and related information used by the operator for monitoring and control.
Display Style	A description of the generic layout of a display and its presentation of information, not referring to any particular content.
Drill-Down	A method of navigation in which successive displays show increasing detail for smaller subsets of the system scope.
Faceplate	A display, part of a display, or pop-up used for monitoring and/or direct operation of a single control loop, device, sequence, or other entity.
Graphic Element	A component part of a graphic symbol, such as a line or circle.
Graphic Symbol	A visual representation of a process component, instrument, or condition in a display composed of a combination of simple graphic elements.
Human Factors Engineering	A scientific discipline concerned with the understanding of interactions between human and other elements of a system that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance.
Human Machine Interface	The collection of hardware and software used by the operator and other users to monitor and interact with the control system and with the process via the control system.
Keyboard	An input device that allows the user to type characters, values, or command to affect the control system.
Monitor (noun)	An electric device for the display of visual information in the form of text and/or graphics.
Monitor (verb)	To maintain awareness of the state of a process, by observing variables or the change of variables against limits or other variables, to keep track of operations and enable timely and appropriate response to abnormal conditions.
Navigation	A function which supports users in locating desired information in an HMI-based information system, and also in guiding the selection of display, or the act of selecting a display.
Operating System	Computer system software that manages basic computer functions and connected peripherals.
Operator	The primary user of the HMI, the person who monitors and makes changes to the process.
Platform	A particular family of HMI products capable of using a common toolkit.
Pointing Device	An input device which translates physical movements to movements of a pointer, cursor, or other indicator across the screen (e.g. a mouse, trackball, or touchscreen).
Pop-up	A display that appears in the foreground of the screen, possibly obscuring park or all of the other displays.
Qualified Software	Identifies software that has been validated for compatibility and functionality.
Resolution	The size and pixel density of the screen usually specified by the number of vertical and horizontal pixels and the diagonal dimension (e.g. 1920 x 1080). The resolution determines the fineness of detail that can be distinguished in an image on a screen. Alternately, this fineness of detail can be specific in pixels per linear dimension (e.g. 96 DPI).
Remote Terminal Unit	One or more monitoring and/or control devices at a location geographically separate from, but communicating with, the control center.
Salience	Distinctiveness, prominence, obviousness, or conspicuousness of a graphic symbol or other part of a display, for the purpose of quickly drawing operator attention.
Screen	The part of the monitor that shows an image.
Script	A code module which performs tasks executed on the HMI platform and usually invoked by some operator action or other control system event.

Scripting	A feature provided by some HMI platforms to allow execution of scripts.
Situation Awareness	The relationship between the operator's perception of the plant's condition and its actual condition at any given time.
Supervisory Control and Data Acquisition (SCADA)	A system for monitoring and control of processes which are geographically widespread. This includes all equipment and functions for acquiring, processing, transmitting, and displaying the necessary process information.
Tag	The unique identifier assigned to a process measurement, state, calculation, device, or other entity within the HMI or controller.
Task Analysis	A method of extracting a user's requirements based on a review of tasks performed by the user.
Toolkit	A collection of custom or pre-defined HMI configuration items that reduce time and effort to produce a control system.
Trending	A feature for displaying real-time and/or historical data in various chart formats, usually with respect to time.
Usability	The extent to which a system can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.
Validation	Process of demonstrating by examination, testing, or other objective evidence that the HMI, as installed, meets applicable requirements and specifications.
Verification	Process of demonstrating by examination, review, testing, or other objective evidence that the outputs of an HMI lifecycle activity meet the objective and requirements defined for the activity.
Workstation	The primary user interface which includes one or more monitors and supporting software, user input devices (e.g. keyboard, mouse), and output devices (e.g. speaker, printer).

4 PROCEDURE

4.1 REQUIREMENTS FOR DEVIATION FROM STANDARD

There is an understanding that there may be times when it is necessary to deviate from this standard. The Integrator shall discuss and request authorization from the City on an individual project basis. The City shall ensure that the City's vision is being followed. Written approval shall be required before any deviations are implemented. Depending on the type of deviation, the City can at this time decide if it is necessary to update the standard document based on any approved deviations.

4.2 Implementation Process

4.2.1 Create Displays

The section provides information for future development. After reviewing defined requirements for a project, a conceptual design of the HMI displays shall be developed with input from Users. This allows time to review that the project requirements were sufficiently captured. At minimum, a 50% review where basic content it displayed. Later, a 100% review with all information and navigation being displayed. For large or complex projects, additional review may be required. Displays shall be submitted to the City a minimum of 14 days prior to the review workshops. These review workshops shall be prior to implementing modification to existing displays or adding new displays to the existing HMI system. If possible, the new displays shall be tested by the Integrator in a test environment.

4.2.2 Testing and Validation

Testing for the HMI system includes ensuring project and standard requirements for user operability and performance are met. A test plan should be developed for each project and submitted to the City for approval before anyone commissioning occurs. Test plan documentation shall at a minimum address the following:

- Testing procedure
- Validation plan requirements
- Deficiency tracking system
- Change management

Tests that are expected for implantation may include but not limited to:

- Factory Acceptance Test (FAT) – Provides time for the Integrator to verify HMI functionality and compliance with the City of Ann Arbor's standards prior to integration to the existing HMI system.
- Site Integration Testing (SIT) – Systematic process of commissioning the HMI system, system debug, and training of City's Users.
- Site Acceptance Testing (SAT) – Provides the City a chance to view and test a fully functioning system and identify any bugs or deviations. There is typically a continuous system runtime test for a period of time that follows the initial test. Testing is performed by the Integrator and witnessed by the City. The Integrator must fix any bugs identified and redo that portion of the testing prior to final acceptance.

4.2.3 Training

In addition to any formal training required by projects the Integrator shall train the City's HMI Users as new process or stations are brought online. Immediately following each system/process being placed online, preliminary User training shall be taught at the project site. There shall be a training session for each shift. The training program shall provide Users with sufficient knowledge to move from screen to screen within the system, understand the contents of overview and detailed displays, respond and acknowledge alarms, adjust control setpoints and alarm limits, print screens and any configured reports, and control equipment connected to the system.

5 HMI SYSTEM DESIGN

5.1 Vendor Software

The City has chosen AVEVA Wonderware InTouch 2014 R2 SP1 for the HMI system software to provide control and monitoring of the wastewater system. ArchestrA graphics should be used in place of traditional InTouch graphics. Process graphics and pop-ups should be drawn entirely within ArchestrA graphics, and each process graphic should be embedded on an InTouch window as a single embedded graphic.

5.2 HMI to PLC Communication

Ethernet TCP/IP is the communication protocol for PLC to HMI communications on the SCADA network. Each plant has a Kepware I/O Server that is configured to use SuiteLink and facilitates the connection between the PLCs and the Wonderware HMI. Each PLC in the system has an associated channel and device in the KEPServerEX configuration. These device names have a corresponding access name in the Wonderware application, where the topic name is <channel>_<device>. For example, if the KEPServerEX channel name is "NS_HW" and the device name is "HW," the corresponding Wonderware access name "HW" would have a topic name "NS_HW_HW."

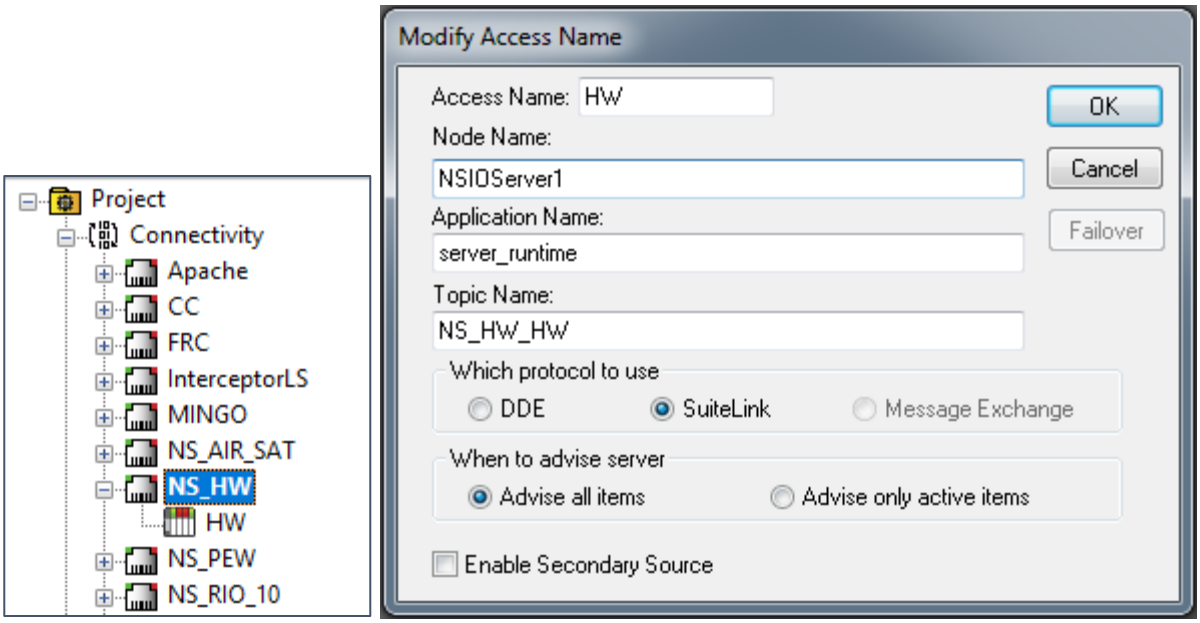


Figure 5-1 KEPServerEX and Access Name Configuration

5.3 Data Historization

Each plant has Wonderware Historian on the development server. Wonderware Historian is a real-time relational database that acquires and stores process data using Microsoft SQL Server. Tags are manually added to the Historian configuration through the System Management Console (SMC).

The following information should be historized:

- Analog input values
- Valve position feedback
- Pump speed feedback
- Pump running feedback
- Setpoints
- Cumulative pump runtime
- Cumulative flow total
- Alarms

It is important to configure the tag properties appropriately for trend visualization as well as database maintenance. Setting the Engineering Units, Min Value, Max Value, and Interpolation Type ensures the data will be suited for trending and usable for Operators. The Storage Method and Deadband determine when the Historian captures the data. Using the Delta storage method with a value deadband ensures reliable data capture without filling up the database with unnecessary information.

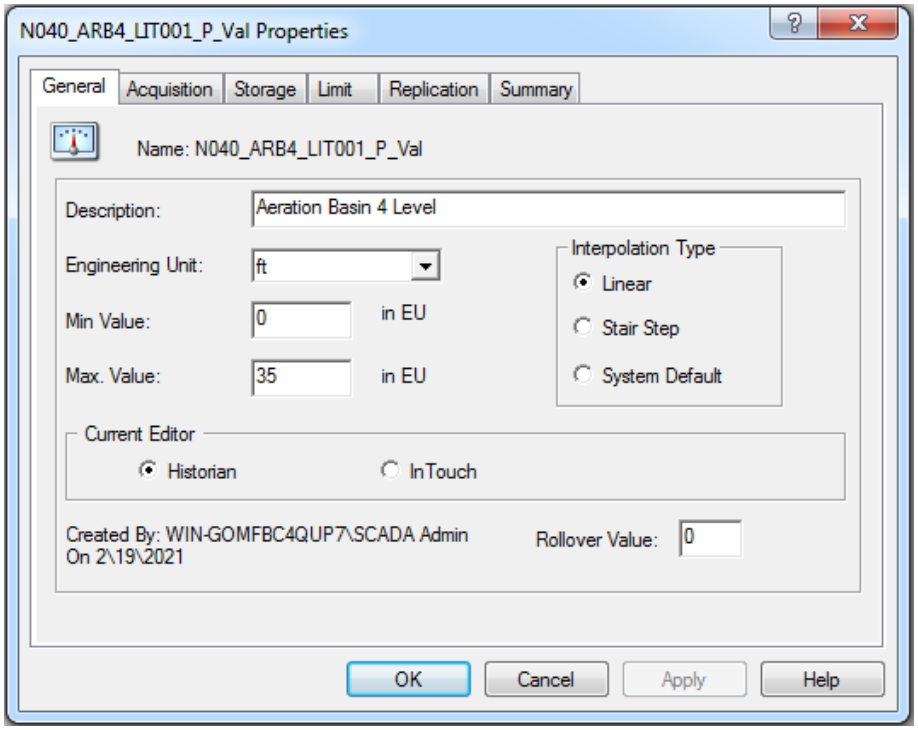


Figure 5-2 Example Historian Tag General Settings

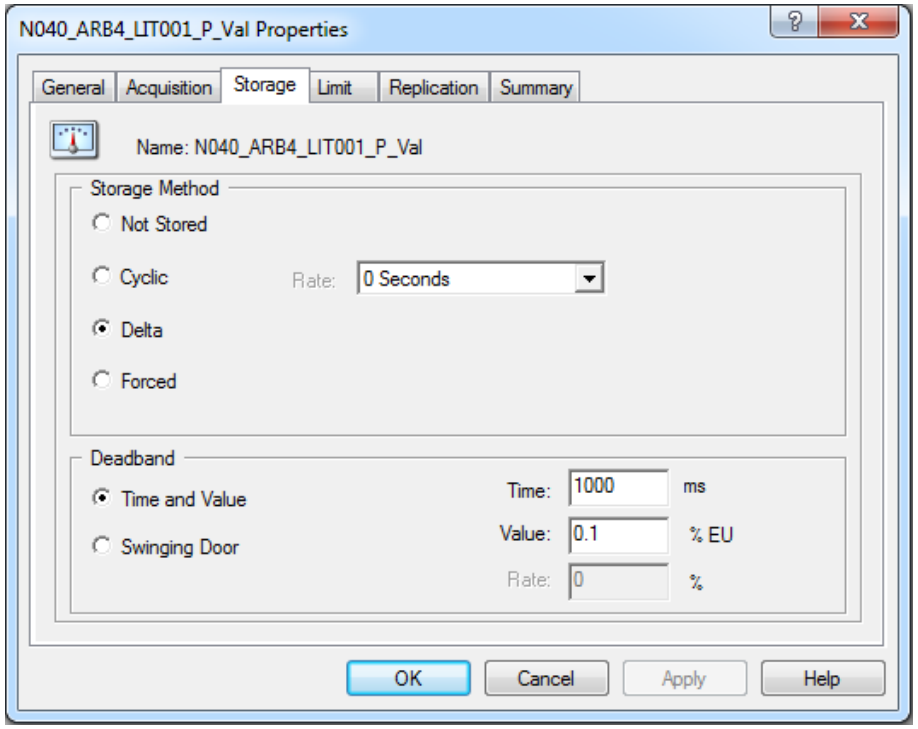


Figure 5-3 Example Historian Tag Storage Settings

5.3.1 Value Deadband

With Delta storage, the value of a tag is logged on change. For analog tags, the deadband value sets a minimum amount by which the tag's scaled value must change before a new value is written to the Historian.

Table 5-1 Historian Deadband Values

Value Type	Deadband
Level	0.1%
Pressure	1%
Small Flow Ranges, <100	1%
Medium Flow Ranges, <1000	5%
Large Flow Ranges, >1000	10%

5.4 Security Configuration

The security configuration within Wonderware is used to control access to development, configuration, and operational parameters of the HMI.

There are two options of security provider: InTouch or Operating System. If InTouch is the security provider, the users are created and managed through WindowMaker. If the security is Operating System-based, users are created and managed through the Windows User Management.

5.4.1 Security Provider

The City of Tulsa Water and Sewer Wonderware applications use InTouch-based security. In this configuration, users are managed within InTouch rather than linked to the Windows operating system. Each user is assigned an account name, password, and access level (0-9999). After a user logs on, access to any protected function is granted upon verification of the user's access level against the security linked to the function.

5.4.2 Password Requirements

Password settings within InTouch security do not expire, and do not inherently have complexity requirements. However, to maintain a secure system, the following password requirements should be followed:

- Minimum length of six characters
- Cannot contain the user's account name
- Must contain characters from three of the following categories:
  - English Uppercase characters (A through Z)
  - English Lowercase characters (a through z)
  - Base 10 digits (0 through 9)
  - Non-alphabetic characters

5.4.3 Wonderware Roles

Each Wonderware application in the City of Tulsa Water and Sewer Department has three users: Operator, Supervisor, and Administrator. Instead of individual users for every member of staff, anyone considered an operator would use the "Operator" login, supervisors would use the

"Supervisor" login, and high-level administrators or integrators would use the "Administrator" login. If there is no one logged in, the application is in view-only mode.

Table 5-2 Wonderware Roles

Wonderware Role	Description
Logged Off	View Only – Anyone can view graphics and data, but cannot control equipment, changes setpoints, or configure alarms. Access Level = 0.
Operator	This user has view-only privileges plus access to equipment control, some setpoints, and alarm acknowledgement. Access Level = 100.
Supervisor	This user has operator privileges plus access to all setpoint control and alarm configuration. Access Level = 500.
Administrator	This user has complete control of everything in the application. Access Level = 9999.

6 VERSION CONTROL

6.1 Application Backup

Backups are taken by opening the InTouch Application Manager and navigating to File > Export. This creates a .aaPKG file that can be imported to restore the project if it is removed or corrupted. A backup should be taken before making changes to the application, and again after the changes have been applied.

6.2 File Storage Location

HMI backup files should be saved to a centralized network shared folder. Contact City of Tulsa Water and Sewer ICS group for file location.

6.3 File naming Convention

Any application backup files that are saved should be named accordingly to maintain consistency. The file naming convention is the Plant ID, followed by an underscore, followed by the date. The date should be formatted as year (four digits), month (two digits), day (two digits). If more than one backup will be taken on the same date, a lowercase letter should be appended to the end of the file name to differentiate. An example file name is: N_20210212a for the Northside Wonderware application.

6.4 Template Version Control

ArchestrA graphics automatically maintain an object version number that is incremented when the graphic has been saved and checked in. This can aid integrators in tracking changes throughout the applications. Each plant uses the same templates, so if a change if made at one plant, that change should be implemented across the system to the other plants.

For standard graphic templates, the version number is appended to the end of the name to match the major revision of the corresponding Add-On Instruction in the PLC. For example, if there is an AOI for an analog input with major revision 1, any corresponding template graphics for an analog input within Wonderware would be named with a "_001" to denote the correct version. This ensures that the correct versions are being used throughout the SCADA system and between the four wastewater applications.

7 PERFORMANCE REQUIREMENTS

The system performance of the HMI application shall be defined by the following:

7.1 Display Load Time

Load time is the time is takes for all elements and values on a display to update when the display is opened. Displays that have large amounts of historical data, e.g. trends, may load slower. Load times are not as critical for displays that are always open, like a Level 1 overview that is shown on a large dedicated monitor. Level 2, 3, and 4 displays should load quickly after navigating to them. To improve performance, displays can be cached.

7.2 Display Refresh Rate

Once a display is rendered for the first time, it shall continually update. The refresh rate should be fast enough so the Operator can detect process changes. This setting may need to be adjusted based on the design of the process control system. Typically, refresh rates less than one second are not beneficial to an Operator and needlessly add to the bandwidth of the network. On the contrary, refresh rates for process control screens greater than 5 seconds can add to the stress of an Operator, especially during a critical event.

7.3 Display Write Time

Write time is the time it takes for a change requested by the Operator to be received by the PLC.

7.4 Display Write Refresh Time

Write refresh time is the time from when the Operator requests a change, to the time the feedback on the HMI display is updated to reflect that change.

Table 7-1 Performance Maximum Allowed Times

	Display Type	Time (seconds)
Load Time	Level 1	10
	Level 2	5
	Level 3	3
	Level 4	3
	Alarm	5
	Trend	10
Refresh Rate	Level 1	5
	Level 2	3
	Level 3	2
	Level 4	2
	Alarm	5
	Trend	1
Write Time	Any	2
Write Refresh Time	Any	5

Table 7-1 assumes that all controllers are connected to the SCADA network with Ethernet. PLCs connected via a telemetry system will have to be adjusted based on the performance of the communications.

8 TAG NAMING CONVENTION

The tag naming development guide provides a standardized approach for the development of instrument tags as related to the design and documentation of the control system. Standardizing the tag naming convention makes identification of instruments, and their use within the control system, consistent throughout the various facilities. In using a consistent tag structure, the engineering effort is reduced by utilizing a standardized approach to instrument tagging. In addition, maintenance of the control system is aided by a standardized tag naming convention from field device to SCADA.

The Tag Naming Standard document identifies the standard tag format for both PLC programming and HMI development. This section summarizes the HMI tag standard that is outlined in that document. For further detail on tag naming, reference the full Tag Naming Standard.

8.1 HMI Tag Format

The HMI tag format closely follows the City's Equipment ID Scheme, with additional nomenclature to categorize the equipment, PLC, and HMI functions required for monitoring and operations of the facilities. The HMI tags use underscores as delimiters to ensure the tag name is clear and easy to read.

Tag names used in the HMI should:

- Identify the source/use of the data
- Identify the process being assessed
- Identify the location in the process
- Be sufficiently generic such that the application does not have to be rewritten to reuse the code in other applications

The tags will have the following format:

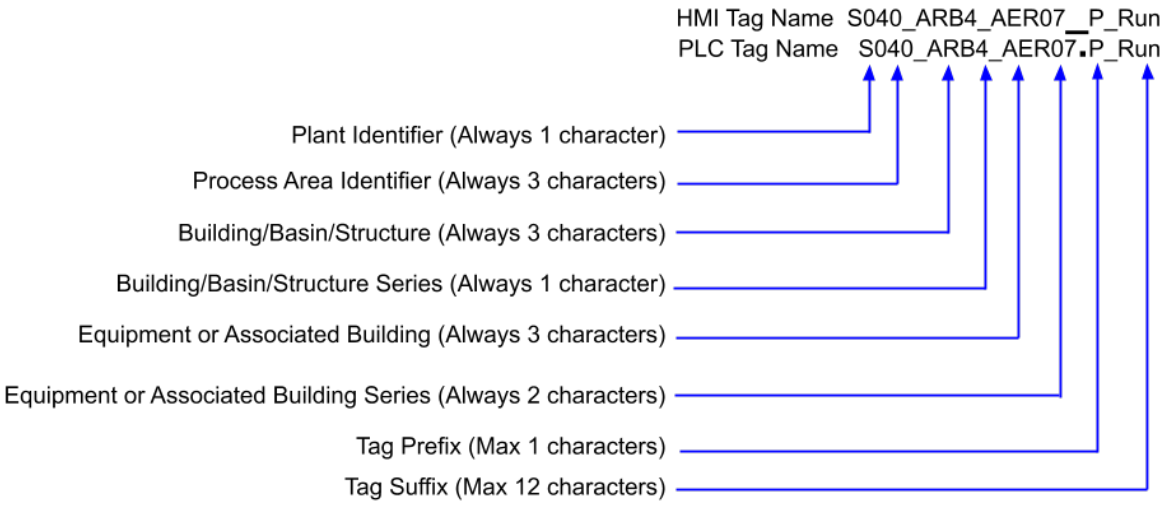


Figure 8-1 HMI Tag Name Format

In the example above, the tag name represents the Southside Aeration Basin 4 Aerator 7 running feedback.

9 HMI DESIGN PHILOSOPHY

9.1 Display Hierarchy

The display hierarchy provides the operator with a structured view of their entire scope of responsibility, while providing the ability to drill down to greater levels of detail and control functionality. Information content convey increasing levels of detail and focus. The hierarchy should have a maximum of four levels, with Level 1 having the broadest scope and Level 4 having the most focused scope. Although hierarchical in nature, display levels are not necessarily aligned with a navigation hierarchy, which may have fewer or more levels.

9.1.1 Level 1 Displays

Level 1 displays provide an overview or summary of the key parameters, alarms, calculated process conditions, and disturbance propagation paths of an operator's entire span of control on one display. These displays have the broadest scope and lowest level of process or system detail. Level 1 displays contain high-level overview information that can be assimilated quickly, provide clear indication of current performance, and highlight anything that required immediate attention. Control should not be performed from this display.

Level 1 displays contain the following types of elements:

- High-level key performance indicators (KPI)
- Critical and high priority alarms
- Important calculated parameters and conditions
- Important information from upstream and downstream units
- Major equipment status
- Embedded trends of important parameters
- Indications of abnormal situations

9.1.2 Level 2 Displays

Level 2 displays are high level process displays that contain more detail than the Level 1 display and are often referred to as subsystem overviews. They should be the operator's primary operating display during normal operations for routine changes and monitoring. Level 2 displays can include process unit overviews or primary displays for every major system. Level 2 displays provide easy navigation to greater detail provided on the Level 3 and Level 4 displays.

Level 2 displays contain the following types of elements that are relevant to the tasks to be accomplished by that display:

- Key performance indicators
- All alarms relevant to this display
- Controls needed to accomplish tasks (or access to controls, such as easy access to faceplates that contain controls)
- Indicators needed to accomplish tasks
- Navigation to related displays
- Navigation to overview display
- Navigation for continuation of flow lines
- Indications of abnormal situations

9.1.3 Level 3 Displays

Level 3 displays are best described as subsystem detail displays. They typically contain more detail than the associated Level 2 displays. Level 3 displays should be used by operators to perform non-routine operations such as lineup changes, equipment switching, or complex routine tasks. They should provide sufficient information to facilitate process diagnostics and should be task-based to allow the operator to perform tasks using a limited number of displays and minimal navigation.

Level 3 displays contain the following types of elements that are relevant to the tasks to be accomplished by that display:

- Alarms of all priorities relevant to that display
- Controls
- Indicators
- Detail view of equipment

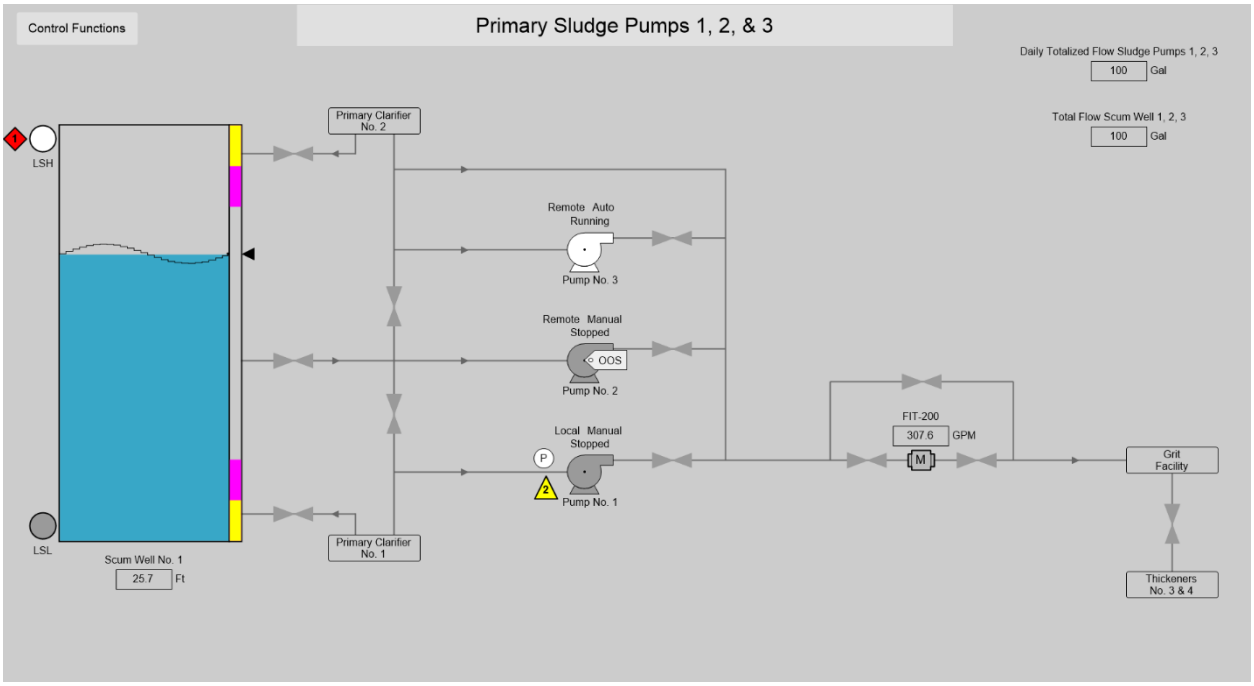


Figure 9-1 Level 3 Display Example

9.1.4 Level 4 Displays

Level 4 displays are best described as diagnostic displays. All system information should be available on displays at this level. Level 4 displays are not intended to be used for process or system control, however, the functionality to perform control may exist in these displays. Level 4 displays may not require a full-screen display, allowing system information to be displayed in faceplates or on a pop-up, due to brevity or intermittence of use.

Level 4 displays are characterized as:

- Providing operating procedures for individual pieces of equipment
- Providing help information for equipment control and diagnostics
- Containing detailed safety shutdowns
- Containing interlock and permissive information

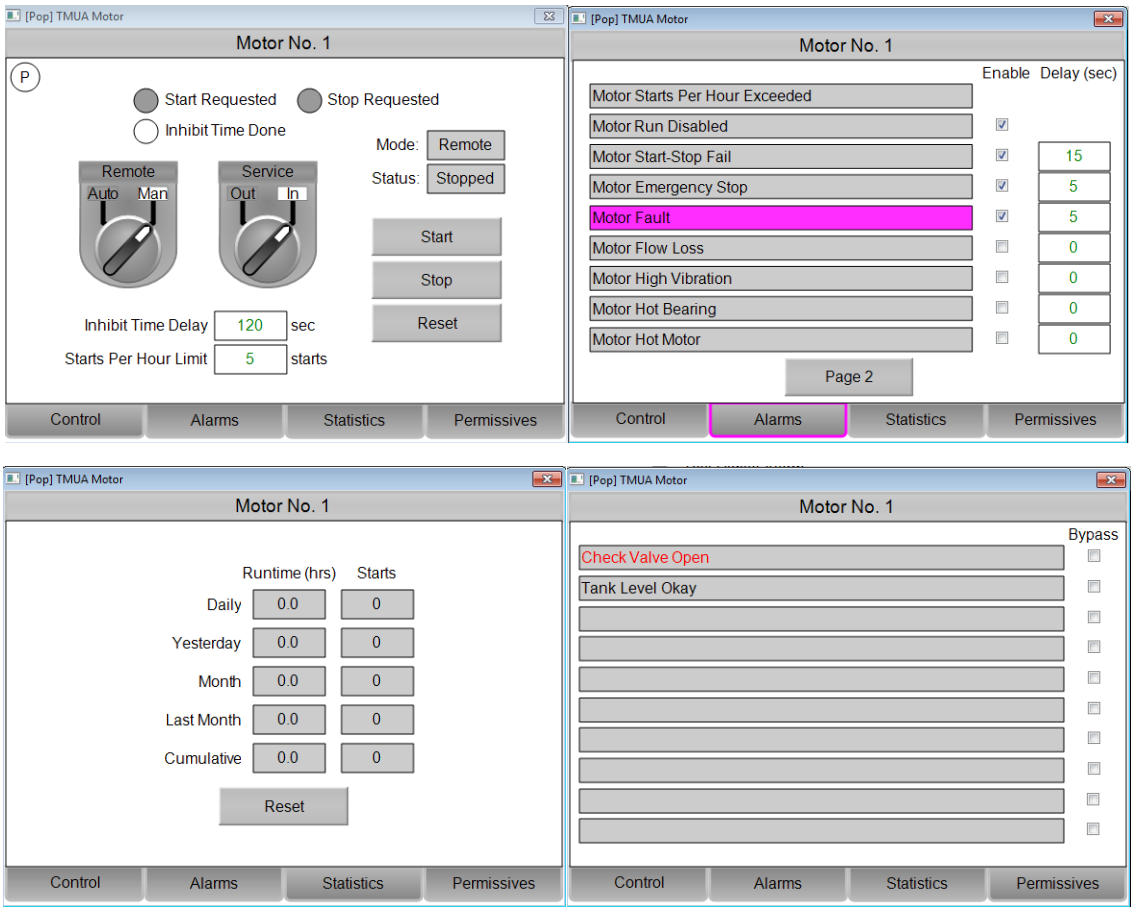


Figure 9-2 Level 4 Display Example

9.2 Display Design

Displays are designed for functional intent rather than trying to depict exact physical layout in the field. Equipment, such as a manual valve, that is not controlled or monitored is not typically displayed.

9.2.1 Navigation

There should be multiple methods of navigation to move through the display hierarchy, including access to the menu and additional navigation on every display that lead to related processes or more detailed graphics. Users should be able to easily navigate without being familiar with the hierarchy. Navigational elements should appear in consistent locations and use consistent buttons, icons, and text.

Each application has a header that contains the page title, alarm metrics, forward/back buttons, and page menus. The back button can navigate through the last 10 open windows. The page menus organize the Level 2 and Level 3 graphics in the application and provide navigation to those graphics. A navigation button in the header turns red when there is a critical alarm in its corresponding process area.

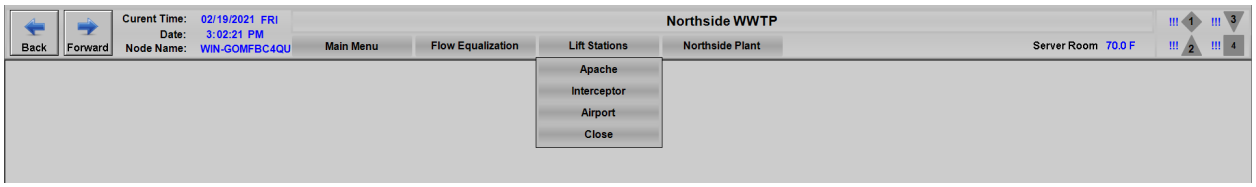


Figure 9-3 Page Header

Navigation buttons that are within the process graphics should be in-line with the process flow to indicate an off-page connection. If the navigation is related to a pop-up window that is not specific to a piece of equipment, the button should be located at the top left corner of the graphic.

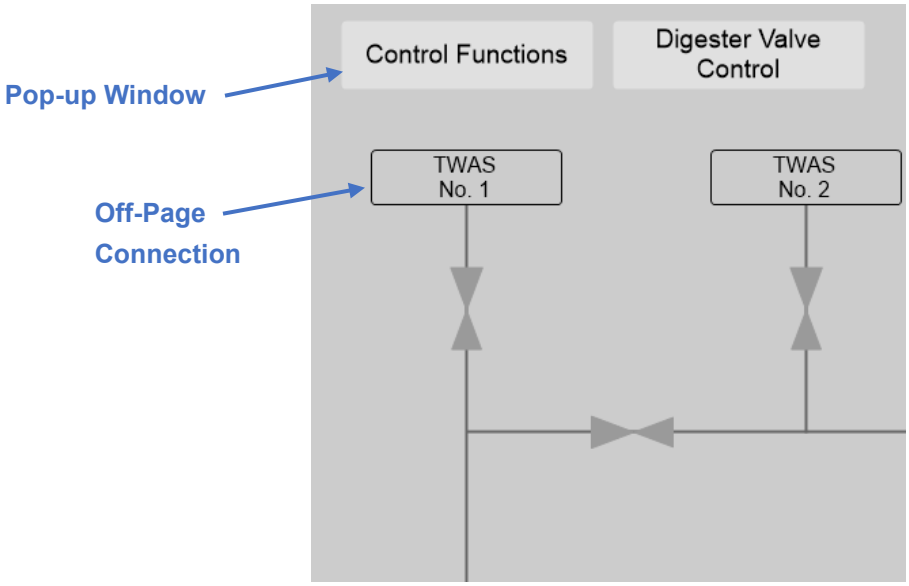


Figure 9-4 Navigation Buttons

Navigation can also be added to process graphics by clicking on a specific section of the graphic to drill down to more detail or open a pop-up. This type of navigation is used on a Level 1 overview to navigate to Level 2 process areas, on a Level 2 process graphic to navigate to a Level 3 detail page, and on an equipment graphic to open its control pop-up.

9.2.2 Window Naming Convention

Windows should be named based on the window type and use elements from the Tag Naming Standard. Window names should adhere to the following format: Process Area ID + Building ID + Associated Equipment ID (if applicable) + [Window Type]

The Building ID can be found in the “All Plant Naming Conventions” appendix of the Tag Naming Standard. The Window Types are:

- [Disp] – full display
- [Pop] – pop-up display
- [Menu] – header, footer, other navigation

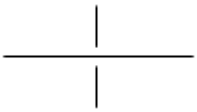
Table 9-1 Example Window Names

Window Name	Description
Plant Overview [Disp]	Level 1 – Plant overview
040 Overview [Disp]	Level 2 – Aeration system overview
040 ARB1 [Disp]	Level 3 – Aeration basin 1 detail display
040 ARB2 [Disp]	Level 3 – Aeration basin 2 detail display
040 ARB3 [Disp]	Level 3 – Aeration basin 3 detail display
040 ARB4 [Disp]	Level 3 – Aeration basin 4 detail display
040 ARB4 AER07 [Pop]	Level 4 – Aeration basin 4 Aerator 7 control pop-up
Header [Menu]	Page Header

9.2.3 Lines

The Wonderware graphics should use lines instead of pipes to show the process flow. For Level 1 displays, black lines should be used with a weight of 1. For Level 2 and Level 3 displays, dark gray lines should be used with a weight of 2. If there are lines that need to cross each other on a display, the vertical line should be broken, and the horizontal line should remain intact to indicate that these lines are not connected.

Table 9-2 Line Types

Display Type	Color/Weight	Example
Level 1	Black, 1	
Level 2, Level 3	Dark Gray, 2	
Level 1	Broken Line	
Level 2, Level 3	Broken Line	

9.2.4 Text

Text on HMI displays should be clear and easy to read, as it is important to the users' understanding of the process and navigation of the displays. Consistent font sizes should be used for data, captions, headers, and labels. All text to be Proper Case.

Table 9-3 Text Style

Element	Font Size	Justification
Live Data	Arial 12	Center Aligned
Dynamic Text	Arial 12	Center Aligned
Engineering Units	Arial 12	Left Aligned
Labels	Arial 12	Center Aligned
Button Labels, in-line	Arial 12	Center Aligned

Button Labels, top of page	Arial 14	Center Aligned
Static Text	Arial 12	Center Aligned
Process Header	Arial 14	Center Aligned

10 GRAPHICAL USER INTERFACE

10.1 Display/Graphic Resolution

The Wonderware application shall be developed at a **1920x1080** resolution. That means the width of the display is 1920 pixels and the height is 1080 pixels. This is a common aspect ratio for wide screen monitors and is now a common tablet option. Modern Wonderware applications utilize vector graphics to insure proper scaling for resolution changes.

10.2 Multiple Monitors

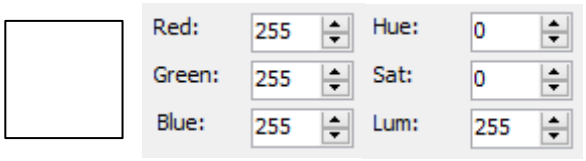
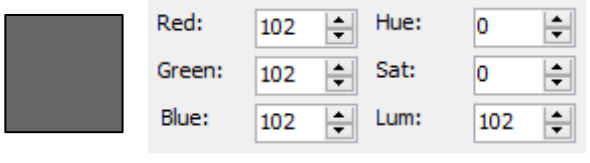
The Northside SCADA architecture includes two Remote Desktop Servers (RDS) that run the Wonderware application. The thin clients can run a remote session to each of these servers simultaneously, thereby utilizing a multi-monitor setup without having to re-position or script the location of windows in the application.

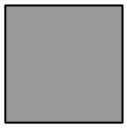
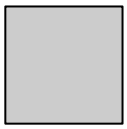
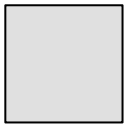
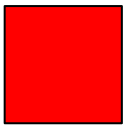
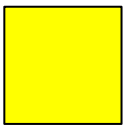
Southside, Lower Bird Creek, and Haikey Creek do not have RDS servers and do not currently utilize multiple monitors to run their Wonderware applications.

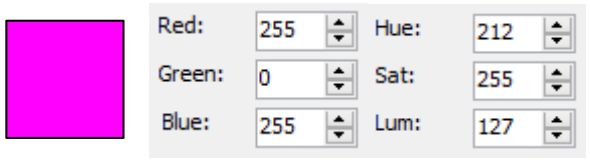
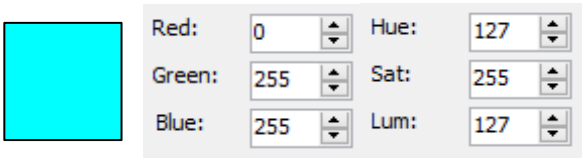
10.3 Standard Colors

To ensure the HMI application maintains a consistent look and feel, developers should adhere to the following color conventions.

Table 10-1 Standard Colors

Name	Definition	Purpose
White		Pump running, valve opened, binary on, Pop-up background
Black		Live data, dynamic text, static text, labels, headers, page titles, engineering units, level 1 process lines
Dark Gray 1		Level 2 and Level 3 process lines

Dark Gray 2	 Red: 132 Hue: 0 Green: 132 Sat: 0 Blue: 132 Lum: 132	Bad data quality indication
Medium Gray	 Red: 154 Hue: 0 Green: 154 Sat: 0 Blue: 154 Lum: 154	Pump stopped, valve closed, valve in transition, binary off, manual valve
Light Gray	 Red: 204 Hue: 0 Green: 204 Sat: 0 Blue: 204 Lum: 204	Window background, button (in-line) background
Pale Gray	 Red: 224 Hue: 0 Green: 224 Sat: 0 Blue: 224 Lum: 224	Button (top of page) background
Blue	 Red: 56 Hue: 137 Green: 167 Sat: 142 Blue: 199 Lum: 127	Tank level fill
Green	 Red: 0 Hue: 85 Green: 132 Sat: 255 Blue: 0 Lum: 66	Setpoints
Red	 Red: 255 Hue: 0 Green: 0 Sat: 255 Blue: 0 Lum: 127	Reserved for critical priority alarms only
Yellow	 Red: 255 Hue: 42 Green: 255 Sat: 255 Blue: 0 Lum: 127	Reserved for high priority alarms only

Magenta		Reserved for medium priority alarms only
Cyan		Reserved for low priority alarms only

10.4 Dynamic Graphics

10.4.1 Equipment Status

Table 10-2 Local/Remote Status Graphics

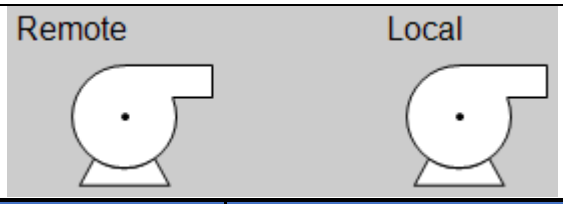
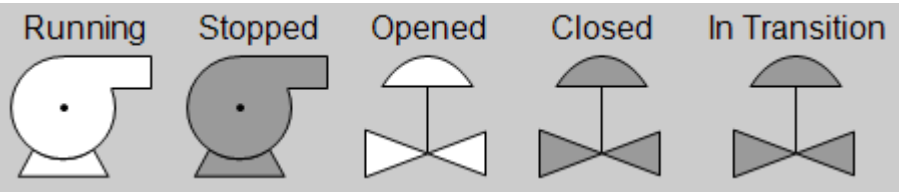
Description	The Local/Remote indication represents the current state of a piece of equipment. While in the Remote state, the equipment is controlled via the PLC. While in the Local state, the equipment is controlled using the local controls in the field.	
Example		
Text	**State**	**Description**
Remote	Remote	Indicates that a device is in the Remote state.
Local	Local	Indicates that a device is in the Local state.

Table 10-3 Auto/Manual Status Graphics

Description	The Auto/Manual indication represents the operational mode of a piece of equipment when that equipment is in the Remote state. While in Auto, the equipment is controlled without operator intervention via the process control algorithms defined in the PLC. While in Manual, the equipment is controlled via the PLC, using operator input.	
Example		
Text	**State**	**Description**

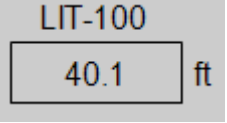
Auto	Auto	Indicates that a device is in the Auto state.
Manual	Manual	Indicates that a device is in the Manual state.

Table 10-4 Operational Status Graphics

Description	The Operation indication represents the current state of a piece of equipment. A motor operational state is either Running or Stopped. A valve operational state is Opened, Closed, or In Transition.	
Example		
Text	**State**	**Description**
Running	Running	Indicates that a motor is running.
Stopped	Stopped	Indicates that a motor is in stopped.
Opened	Opened	Indicates that a valve is opened.
Closed	Closed	Indicates that a valve is closed.
In Transition	In Transition	Indicates that a valve is in transition.

10.4.2 Analog Value Display

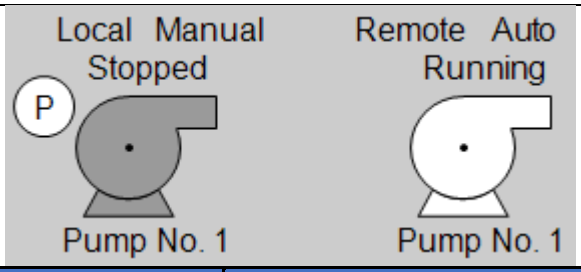
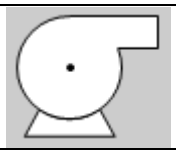
Table 10-5 Analog Value Display Graphics

Description	The Analog Value Display represents process values or calculations in the facility. The symbol shall utilize black for the current value color and be contained in a rectangle. The engineering units should display to the right of the rectangle and the label above.	
Example		
Symbol	**Feature**	**Description**

LIT-100	Label	Indicates the unique device identification for the process value. This can be derived from the Equipment Identification table of the Tag Naming Convention.
40.1	Value	Indicates the current process value.
ft	Engineering Units	Indicates the appropriate engineering units for the process value. Refer to Appendix A for details.

10.4.3 Fixed Speed Pump

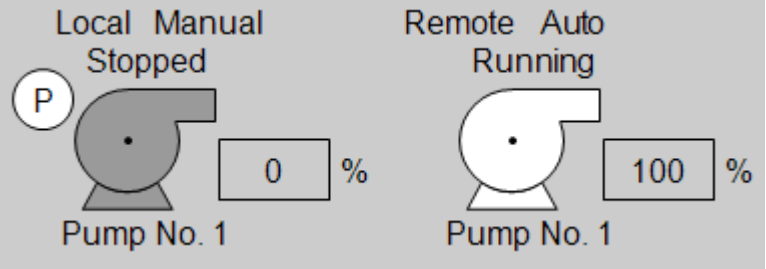
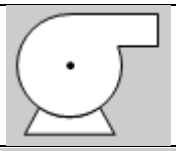
Table 10-6 Fixed Speed Pump Graphics

Description	A fixed speed pump is depicted as shown below. The pump is white while running and medium gray when stopped. The symbol shall have a label that uniquely identities it and display any unsatisfied permissives.	
Example		
Symbol	**Feature**	**Description**
Pump No. 1	Label	Indicates the unique device identification for the pump. This can be derived from the Equipment Identification table of the Tag Naming Convention.
	Pump	Indicates the current state of the pump.
Remote Auto Running	Control Status	Indicates the Local/Remote, Auto/Manual, and Operational status of the pump.
P	Permissive	Indicates that there are unsatisfied permissives that will prevent the pump from running in Remote mode. Invisible when all permissives are satisfied.

10.4.4 Variable Speed Pump

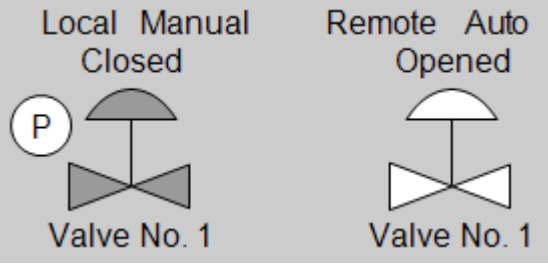
Table 10-7 Variable Speed Pump Graphics

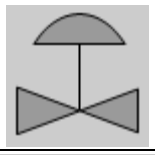
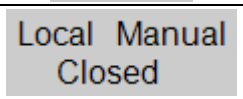
Description	A variable speed pump is depicted as shown below. The pump is white while running and medium gray when stopped. The symbol shall have a label that uniquely identities it and display any unsatisfied permissives. In addition, the variable speed pump displays the VFD speed percentage.

Example		
Symbol	**Feature**	**Description**
Pump No. 1	Label	Indicates the unique device identification for the pump. This can be derived from the Equipment Identification table of the Tag Naming Convention.
	Pump	Indicates the current state of the pump.
Remote Auto Running	Control Status	Indicates the Local/Remote, Auto/Manual, and Operational status of the pump.
P	Permissive	Indicates that there are unsatisfied permissives that will prevent the pump from running in Remote mode. Invisible when all permissives are satisfied.
100 %	Speed	The pump's current speed feedback as a percentage.

10.4.5 Two-State Valve

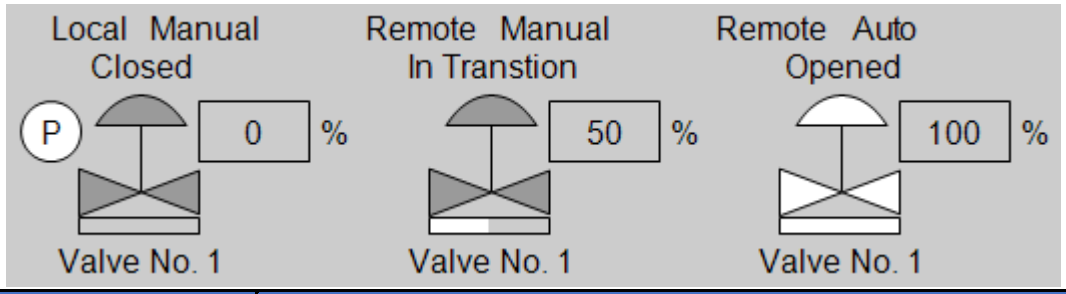
Table 10-8 Two-State Valve Graphics

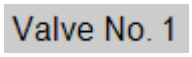
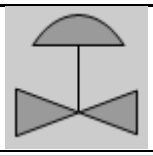
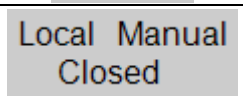
Description	A two-state valve is depicted as shown below. The valve is white when opened and medium gray when closed or in transition. The symbol shall have a label that uniquely identities it and display any unsatisfied permissives.	
Example		
Symbol	**Feature**	**Description**
Valve No. 1	Label	Indicates the unique device identification for the valve. This can be derived from the Equipment Identification table of the Tag Naming Convention.

	Valve	Indicates the current state of the valve.
	Control Status	Indicates the Local/Remote and Auto/Manual status of the valve.
	Permissive	Indicates that there are unsatisfied permissives that will prevent the valve from moving in Remote mode. Invisible when all permissives are satisfied.

10.4.6 Modulating Valve

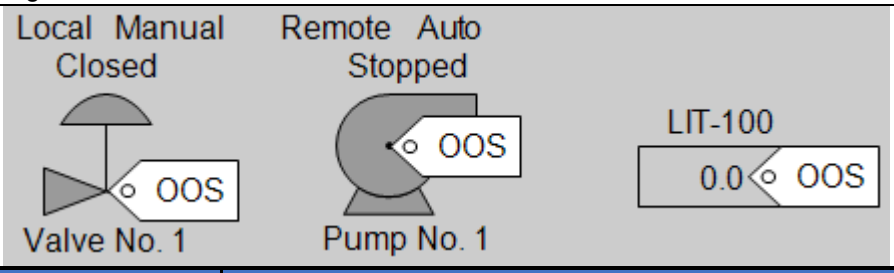
Table 10-9 Modulating Valve Graphics

Description	A two-state valve is depicted as shown below. The valve is white when opened and medium gray when closed or in transition. A bar underneath the valve fills to match the valve position. The symbol shall have a label that uniquely identities it and display any unsatisfied permissives. In addition, the modulating valve displays the valve open percentage.
Example	

Symbol	Feature	Description
	Label	Indicates the unique device identification for the valve. This can be derived from the Equipment Identification table of the Tag Naming Convention.
	Valve	Indicates the current state of the valve.
	Control Status	Indicates the Local/Remote and Auto/Manual status of the valve.
	Permissive	Indicates that there are unsatisfied permissives that will prevent the valve from moving in Remote mode. Invisible when all permissives are satisfied.
	Position	The valve's current position as a percentage of open.
	Position Fill Bar	Horizontal bar that fills to match the valve's position feedback.

10.4.7 Out of Service

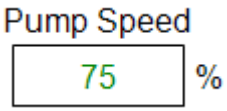
Table 10-10 Out of Service Graphics

Description	The Out of Service tag informs the operator that a piece of equipment or instrumentation has been taken out of service. While out of service, the equipment will not operate, and any associated alarms are disabled. While in the Out of Service state, the tag is visible, and while in the In Service state, the tag is visible.
Example	

Symbol	Feature	Description
	OOS Tag	Indicates that the pump, valve, or instrument has been taken out of service.

10.4.8 Setpoints

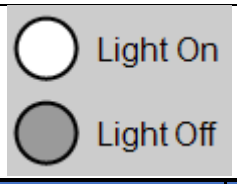
Table 10-11 Setpoint Graphics

Description	The Numeric Entry Display represents an operator-inputted setpoint. The symbol shall utilize green for the current value, contain engineering units, and have an appropriate label.
Example	

Symbol	Feature	Description
Pump Speed	Label	Indicates the unique identification for the setpoint.
75	Value	Indicates the current setpoint value.
%	Engineering Units	Indicates the appropriate engineering units for the setpoint. Refer to Appendix A for details.

10.4.9 Pilot Light

Table 10-12 Pilot Light Graphics

Description	The pilot light graphic indicates the On/Off or True/False state for a binary parameter. This symbol is meant to inform the operator of the state of a single, or aggregated, condition for a binary attribute. While in the On state, the Pilot Light is white, and while in the Off state, the light is medium gray.
Example	

Symbol	State	Description
	On/True	Indicates that a binary state of ON/True is present.
	Off/False	Indicates that a binary state of OFF/False is present.

10.4.10 Selector Switch

Table 10-13 Selector Switch Graphics

Description	The selector switch graphic provides On/Off or True/False selection and indication for a parameter controlled through the HMI. Selector switches are embedded on pop-up graphics to control things such as equipment status.
Example	

10.4.11 Control Buttons

Table 10-14 Control Buttons Graphics

Description	Control buttons are embedded on pop-up graphics and provide control of equipment, such as manual start and stop buttons for a motor.

Example	

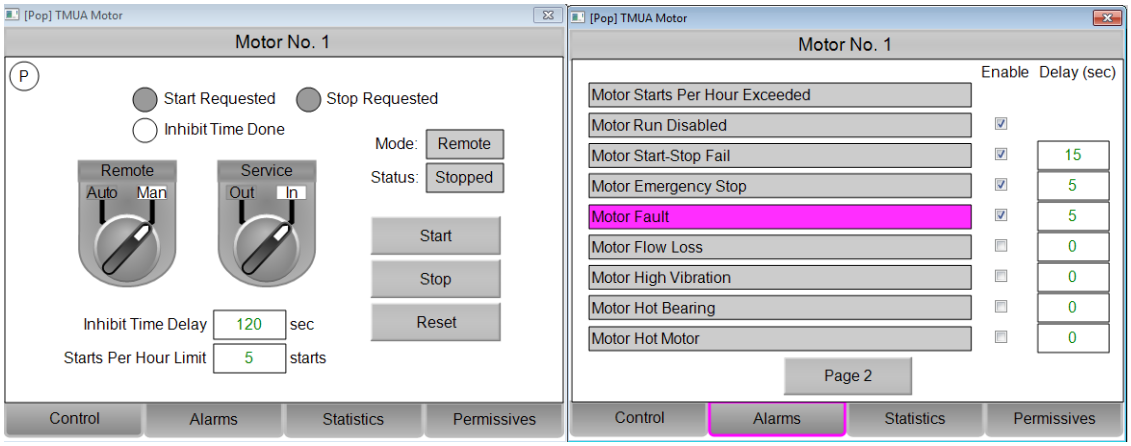
10.5 Pop-up Displays

Although equipment and instrumentation may vary site-to-site, the same look and feel should be maintained within the HMI. These pop-ups shall be used for standard equipment and shall serve as a guide for the development of non-standard controls.

1. The Configuration tab provides the operator relevant information to operate the selected equipment. It contains equipment status, control buttons, and setpoints.
2. The Alarms tab informs the operator of any active alarms associated with the selected equipment. The alarm text is red when the alarm is active, and gray when inactive or disabled.
3. The Statistics tab provides relevant statistical information for the selected equipment. Motor statistics include runtime and number of starts, and analog statistics include minimum, maximum, and average values, as well as flow totals where applicable.
4. The Permissive tab informs the operator of any unsatisfied permissives that are preventing the selected equipment from operating.

10.5.1 Motor

The Motor template pop-up has four tabs. The configuration tab includes: an indication of the remote/local status, a selector switch for auto or manual control, a selector switch to put the motor out of service, start and stop buttons for manual control, and a reset button to indicate if the motor has been locked out and needs to be manually reset. The alarms tab includes a list of all of the configured alarms for the motor, their current status, the ability to enable/disable them, and the delay timer (when applicable). The statistics tab includes the runtime hours and number of starts for the motor in the current day, previous day, current month, previous month, and motor lifetime. The permissives tab includes all of the configured permissives for the motor and indicates whether the permissives are met. All permissives must be met in order for the motor to run.



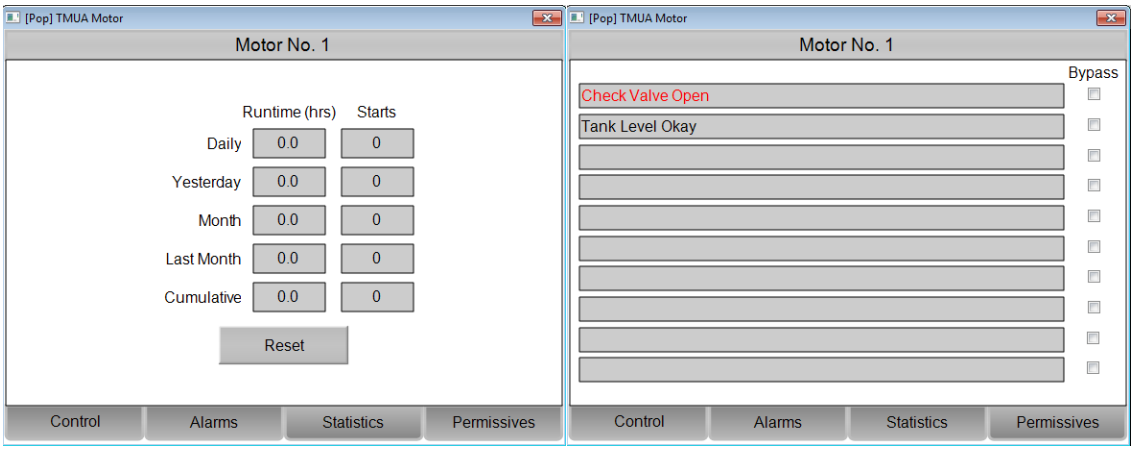
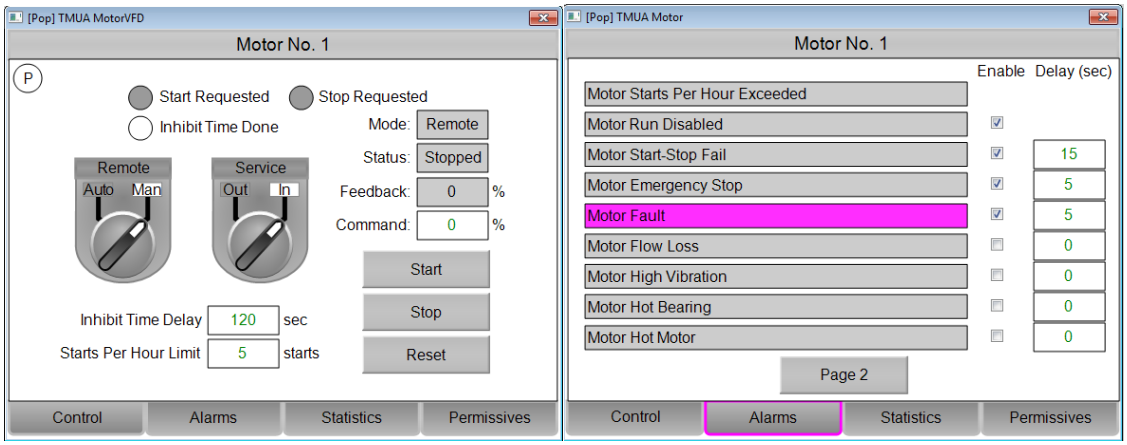


Figure 10-1 Motor Pop-up

10.5.2 Motor VFD

The Motor VFD template pop-up has four tabs. The configuration tab includes: an indication of the remote/local status, indication of the VFD/bypass status (when applicable), a selector switch for auto or manual control, a selector switch to put the motor out of service, the manual speed setpoint, speed feedback, start and stop buttons for manual control, and a reset button to indicate if the motor has been locked out and needs to be manually reset. The alarms tab includes a list of all of the configured alarms for the motor, their current status, the ability to enable/disable them, and the delay timer (when applicable). The statistics tab includes the runtime hours and number of starts for the motor in the current day, previous day, current month, previous month, and motor lifetime. The permissives tab includes all of the configured permissives for the motor and indicates whether the permissives are met. All permissives must be met in order for the motor to run.



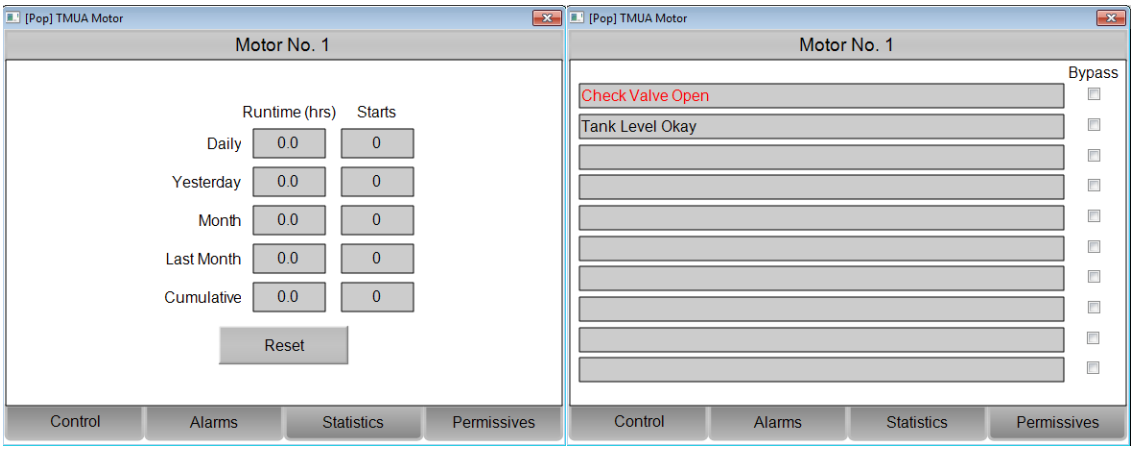
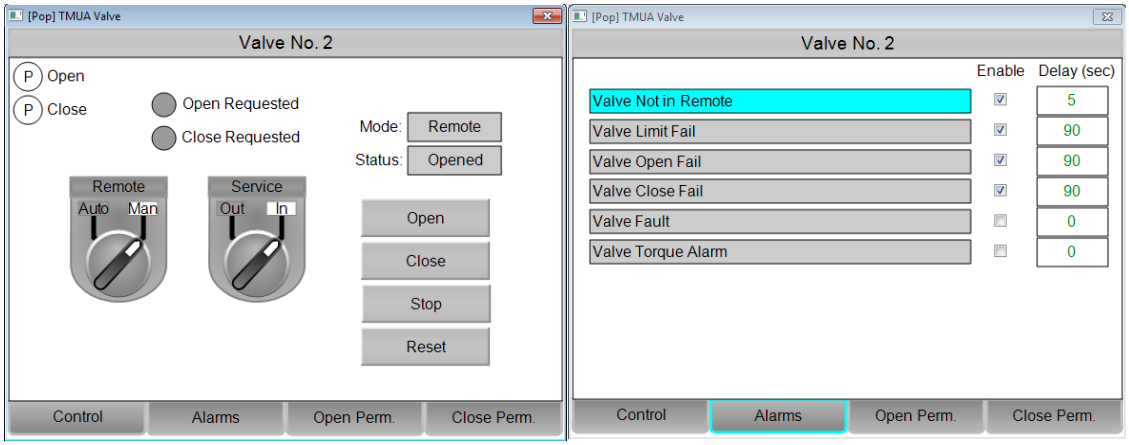


Figure 10-2 Motor VFD Pop-up

10.5.3 Two-State Valve

The Two-State Valve template pop-up has four tabs. The configuration tab includes: an indication of the remote/local status; a selector switch for auto or manual control; a selector switch to put the valve out of service; open, close, and stop buttons for manual control; and a reset button to indicate if the valve has been locked out and needs to be manually reset. The alarms tab includes a list of all of the configured alarms for the valve, their current status, the ability to enable/disable them, and the delay timer (when applicable). The open and close permissive tabs include all of the configured permissives for the valve and indicate whether the open or close permissives are met. All open permissives must be met in order for the valve to open and all close permissives must be met in order for the valve to close.



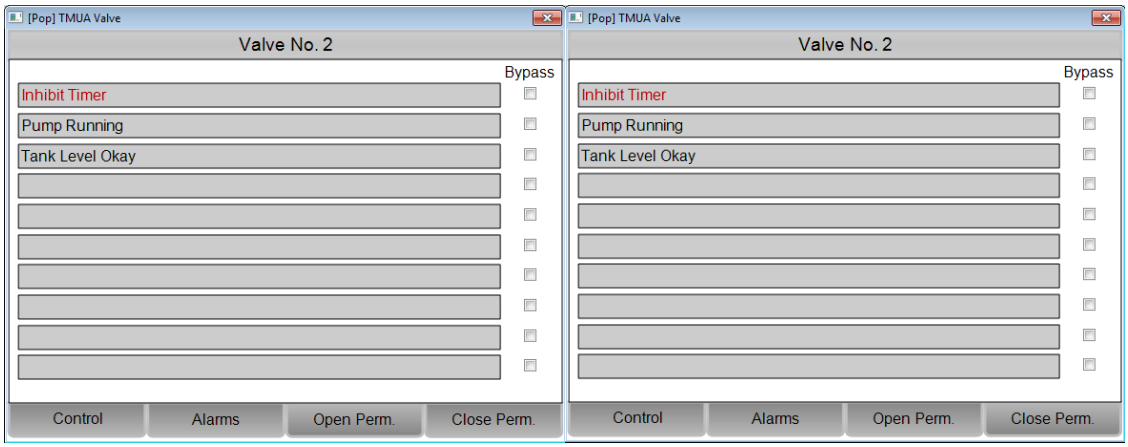
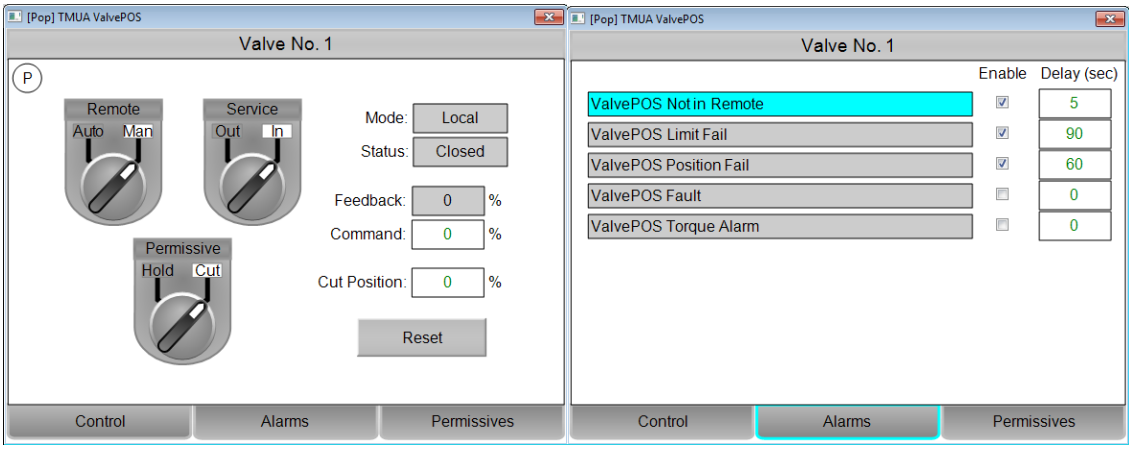


Figure 10-3 Two-State Valve Pop-up

10.5.4 Position Valve

The Position Valve template pop-up has three tabs. The configuration tab includes: an indication of the remote/local status, a selector switch for auto or manual control, a selector switch to put the valve out of service, a selector switch for out of permissive action, the cut permissive position setpoint, the manual position setpoint, position feedback, and a reset button to indicate if the valve has been locked out and needs to be manually reset. The alarms tab includes a list of all of the configured alarms for the valve, their current status, and the ability to enable/disable them. The permissives tab includes all of the configured permissives for the valve and indicates whether the permissives are met. All permissives must be met in order for the valve to move. If all of the permissives are not met the valve either holds the current position of moves to the cut permissive position setpoint.



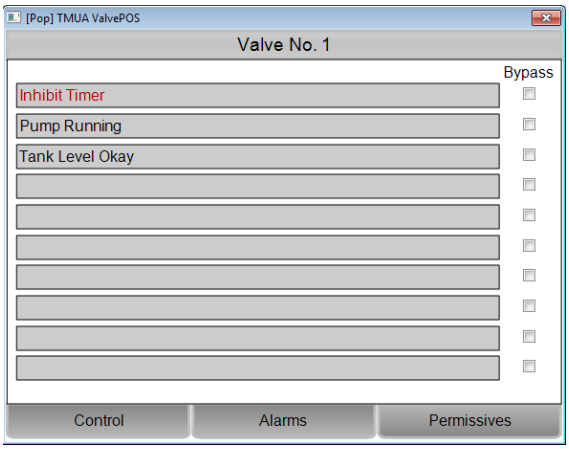
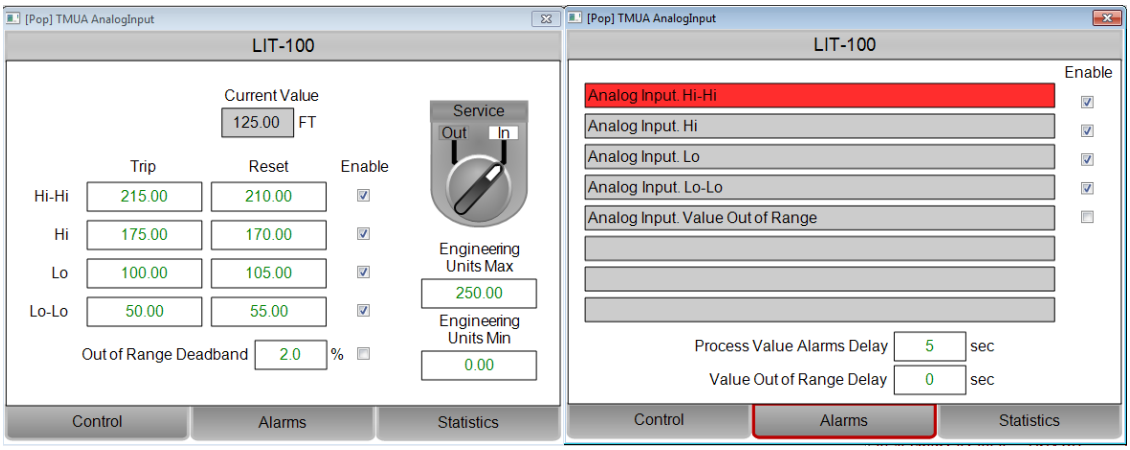


Figure 10-4 Position Valve Pop-up

10.5.5 Analog Input

The Analog Input template pop-up has three tabs. The configuration tab includes: the current analog value, a selector switch to put the value out of service, the minimum and maximum engineering units, the out of range alarm deadband, the alarm trip and reset setpoints, and the alarm enable/disable control. The alarms tab includes a list of all of the configured alarms for the analog value, their current status, the ability to enable/disable them, and the delay timer (when applicable). The statistics tab includes the minimum, maximum and average values in the current and previous day.



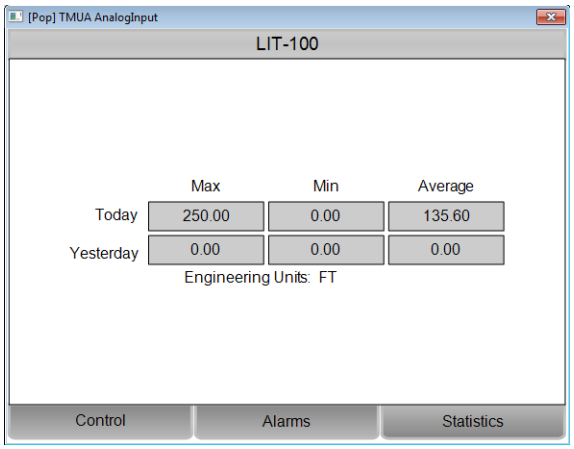
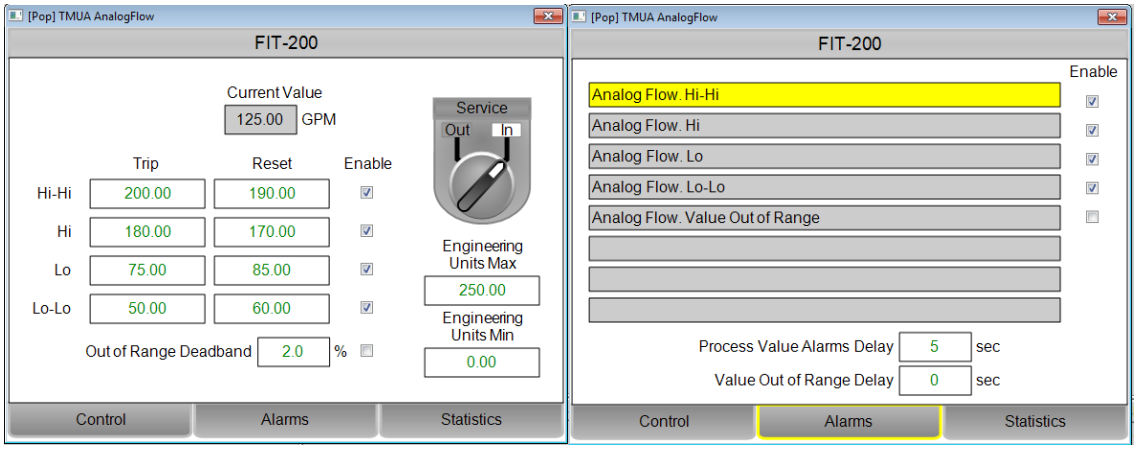


Figure 10-5 Analog Input Pop-up

10.5.6 Analog Flow

The Analog Flow template pop-up has three tabs. The configuration tab includes: the current analog value, a selector switch to put the value out of service, the minimum and maximum engineering units, the out of range alarm deadband, the alarm trip and reset setpoints, and the alarm enable/disable control. The alarms tab includes a list of all of the configured alarms for the analog value, their current status, the ability to enable/disable them, and the delay timer (when applicable). The statistics tab includes the minimum, maximum and average values in the current and previous day, as well as the flow totals for current day, previous day, current month, previous month, and overall total.



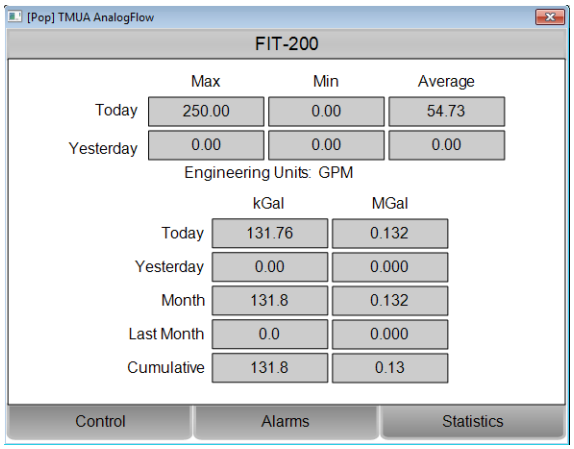


Figure 10-6 Analog Flow Pop-up

10.5.7 Discrete Alarm

The Discrete Alarm template pop-up has only one tab. This includes: the current alarm status and symbol, the alarm delay setpoint, the alarm enable/disable control, alarm invert control, and the alarm reset button.

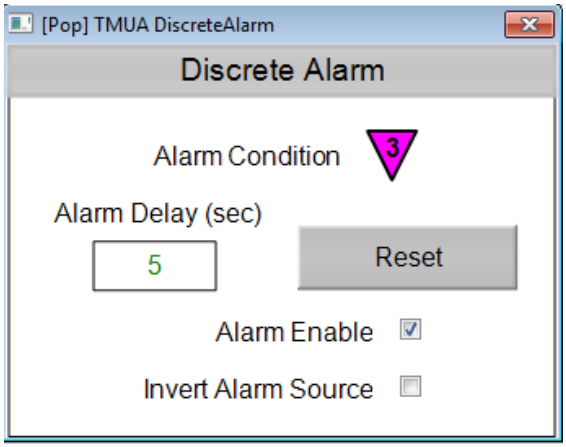


Figure 10-7 Discrete Alarm Pop-up

10.5.8 PLC

The PLC template pop-up has only one tab. This includes: the current PLC date and time setting, as well as setpoints to update the PLC date and time.

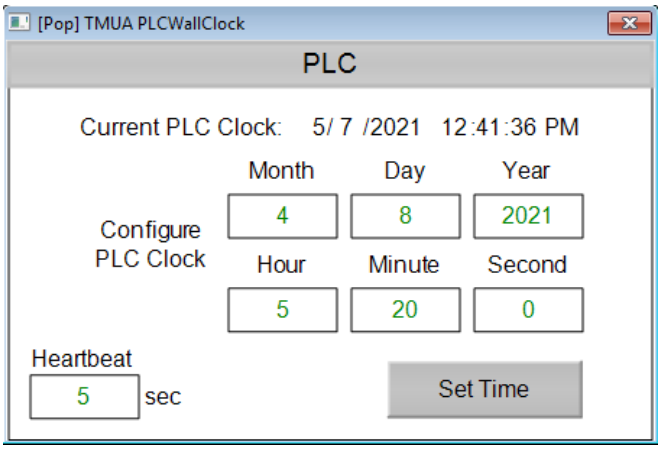


Figure 10-8 PLC Pop-up

11 ALARMS

The purpose of the alarm system is to notify the operator of abnormal situations requiring timely operator action and to direct their attention so that they can take corrective action and prevent an undesired consequence. The alarm system is designed for effective handling of a single alarm during normal operation and the handling of many alarms during major upsets.

The Alarm Standard document provides more information on the alarm standardization philosophy. The Alarm Design Guide document provides details on which alarms should be provided for standard equipment. This section outlines how the alarms should be grouped, controlled, and how they should appear on the HMI.

11.1 Alarm Generation

Alarms should be generated by the PLC rather than the HMI. Generating alarms in the PLC is preferred because it is a more accurate and reliable connection to the field equipment. If the alarms are generated in the HMI, they can be affected by communication drops or delays. The HMI should read the alarms from the PLC as discrete input tags. There may be exceptions where an alarm is generated in the HMI, such as a PLC-to-HMI communication failure alarm.

11.2 Alarm Permissions

Control of the alarms is dependent on the user privileges. The View-Only user can view alarms, but cannot disable, acknowledge, or suppress alarms. The Operator user can view and acknowledge alarms. The Supervisor and Administrator users have full privileges to disable, acknowledge, and suppress alarms.

11.3 Alarm Groups

Each alarm should be assigned to an alarm group based on its process area and alarm priority. Alarm groups have been organized into a hierarchy that corresponds with the menus of the page header. There is an alarm group for each alarm priority (critical, high, medium, low) with sub-groups for each process area. The figure below shows an example of the Low priority alarm group hierarchy.

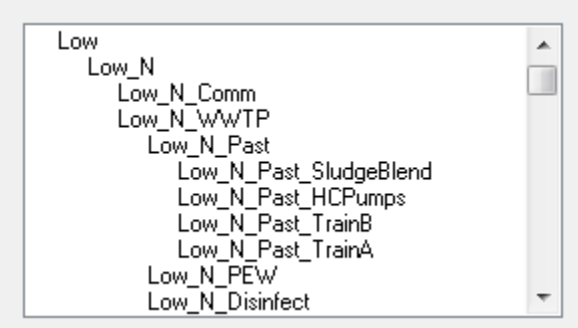


Figure 11-1 Example Alarm Group Hierarchy

11.4 Alarm Comment

The alarm comment should be written so that the alarm is easily identified and understood. Wonderware InTouch allows a maximum of 131 characters for the alarm comment. The Tulsa Department of Water and Sewer Wonderware applications have alarm viewers that are configured to fit around 50-60 characters for the alarm comment. If more characters are used, it may require the user to stretch the column during runtime in order to view the entire alarm comment.

Alarm comments should include the following information, in order: Plant Identifier, Process Area, Building/Basin/Structure, Equipment, Alarm Condition. The first three items should be taken from the Tag Naming Standard. All words should be spelled out, except for the Plant Identifier or anything in the abbreviations table below. If the alarm comment results in the same word repeated back-to-back, it should only be used once to avoid confusion and save characters. An example of this would be if the process area is “Aeration” and the building/basin/structure is “Aeration Basin 1.”

Example alarm comments:

- S Aeration Basin 4 Aerator 7 Start-Stop Fail
- N Chlorination Building Emergency Eyewash in Use
- L Spunky Creek Wetwell Level Hi-Hi

Table 11-1 Alarm Comment Abbreviations

Abbreviation	Description
FEB	Flow Equalization Basin
Hi	High
Lo	Low
LS	Lift Station
PEW	Plant Effluent Water

11.5 Alarm State Values

The alarm On and Off state messages are used for discrete alarms to assign a description to the true and false states. These messages are used in the alarm viewer to show the value of the alarm. The alarm viewer can fit around 10 characters for these state messages. The standard Off message is “Normal” and the On message is more specific to the alarm. Some examples are below.

Table 11-2 Alarm State Values

Alarm Comment	On Value	Off Value
L Spunky Creek Wetwell Level Hi-Hi	Hi	Normal
N Chlorination Building Emergency Eyewash in Use	In Use	Normal
S Aeration Blower Building UPS Bypassed	Bypass	Normal
H FEB Return Pump 1 Start-Stop Fail	Fail	Normal

11.6 Alarm Summary

The alarm summary provides a list of active alarms within the alarm system, as well as any alarms that have returned to normal but have not been acknowledged. The display provides the following information for each alarm:

- Time/Date that the alarm last changed state
- Alarm Comment
- Alarm State
- Alarm Priority
- Alarm Group
- Alarm Type – used for existing analog alarms that do not follow the standard
- Alarm Value
- Alarm Limit – used for existing analog alarms that do not follow the standard
- Tag Name

The alarm summary is configured with the color settings shown below.

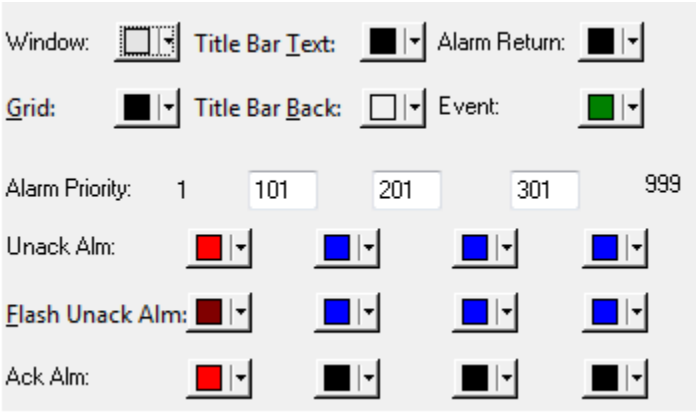


Figure 11-2 Alarm Summary Color Settings

The alarm summary includes filter buttons at the bottom of the page that allow the user to select which process area or priority to show in the viewer.

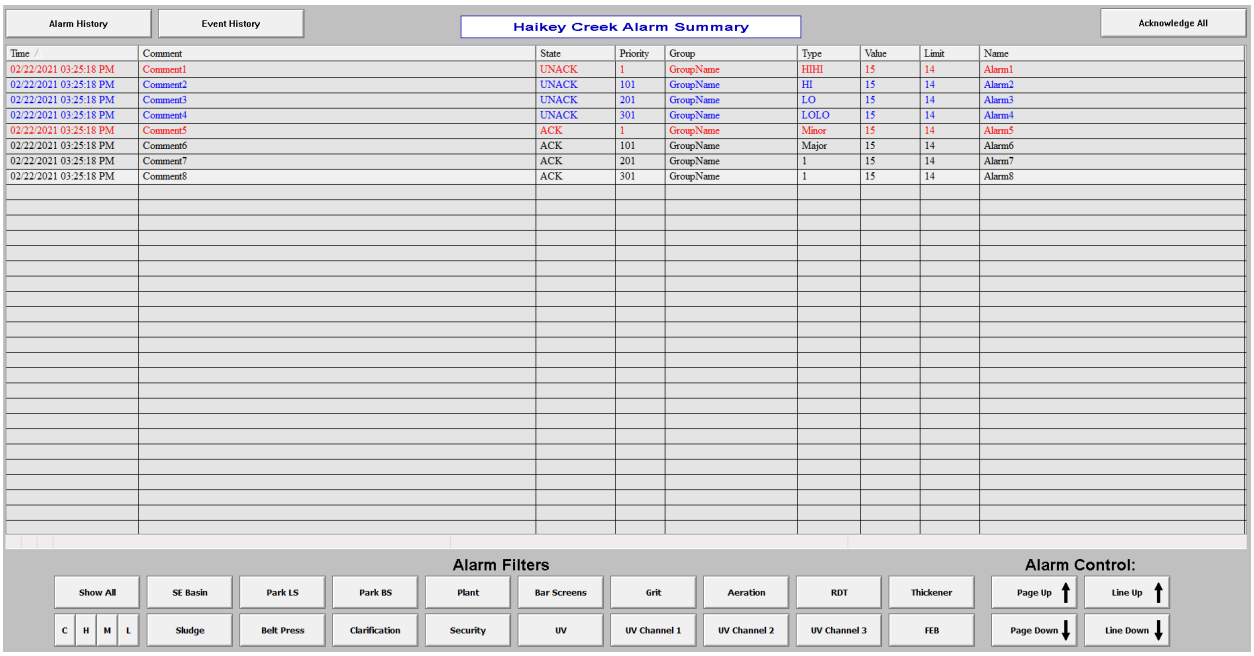


Figure 11-3 Alarm Summary Viewer

11.7 Alarm History

The alarm history provides a list of all alarms that have occurred within a designated time period. The time and date range can be adjusted during runtime. Any time an alarm changes state, it appears as a new row in the alarm history. The display provides the following information for each alarm:

- Time/Date
- Alarm Comment
- Alarm State
- Alarm Priority
- Alarm Group
- Alarm Type – used for existing analog alarms that do not follow the standard
- Alarm Value
- Alarm Limit – used for existing analog alarms that do not follow the standard
- Tag Name

The alarm history is configured with the color settings shown below.

Figure 11-4 Alarm History Color Settings

The alarm history includes filter buttons at the bottom of the page that allow the user to select which process area or priority to show in the viewer.

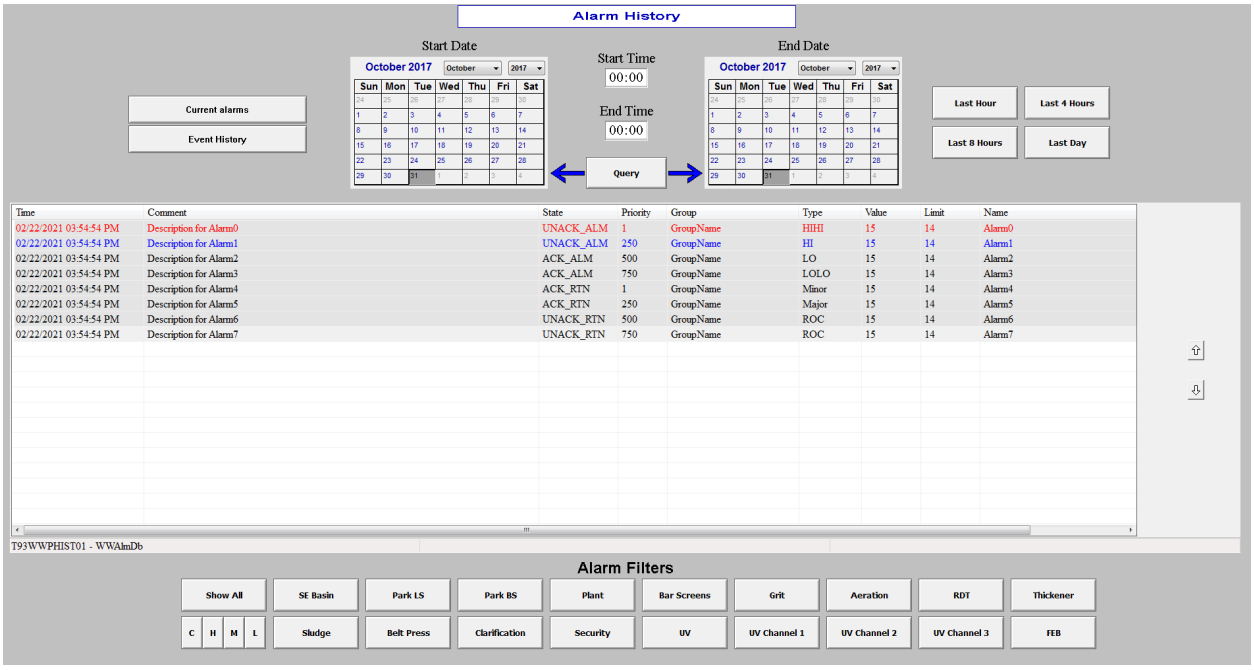


Figure 11-5 Alarm History Viewer

11.8 Standard Alarm Symbols

Alarm colors and symbols are the most important graphical objects on the HMI, and therefore, use the brightest colors. Each alarm priority has a symbol with a distinct color and shape that is dedicated to that priority and is not used anywhere else in the application. This makes the alarms easily identifiable on the process graphics, even if the user is colorblind.

Alarm symbols should be placed within process graphics next to the instrument or equipment that the alarm represents. Alarm symbols are embedded into the standard equipment templates and linked to the standard alarms for that equipment. The symbol changes based on the priority of the alarms that are active. The symbol shown represents the highest priority of the active alarms. Alarm priorities must be set in the Wonderware and in the PLC add-on instruction instances in order for the dynamic alarm symbols to work properly.

Table 11-3 Alarm Indication Matrix

Priority	Color	Shape
Critical	Red	Diamond
High	Yellow	Triangle (up)
Medium	Magenta	Triangle (down)
Low	Cyan	Square

Priority 100 alarm conditions represent critical alarms that need immediate action. They are represented by a red diamond with the number one inset.

Figure 11-6 Priority 100 Alarm Symbol

Priority 200 alarm conditions represent high alarms that need rapid action. They are represented by a yellow triangle point up with the number two inset.

Figure 11-7 Priority 200 Alarm Symbol

Priority 300 alarm conditions represent warnings that need operator action. They are represented by a magenta triangle pointing down with the number three inset.

Figure 11-8 Priority 300 Alarm Symbol

Priority 400 alarm conditions represent notices that do not need immediate action. They are represented by a cyan square with the number four inset.

Figure 11-9 Priority 400 Alarm Symbol

12 TRENDING

Wonderware Historian Client is a tool used to retrieve and visualize data from the Historian. The client is embedded into the runtime application and provides access to pre-configured and customizable trends.

The following options are available for viewing trends within the application:

- Click any trended value that is drawn on a process graphic to open a trend of that tag in a pop-up.
- The Trend page, accessible from the main menu tab in the page header.
- Draw a button that will open a preconfigured trend as a pop-up or send tags into the full-page trend.
- Draw an embedded trend within a process graphic.

12.5 Dynamic Trend Pop-ups

Click on an object that represents an analog or digital historized tag to open a pop-up trend of that tag. Click additional objects to add more pens to the graph. The time span of the trend is adjustable while viewing but will reset to the default the next time the trend pop-up is opened.

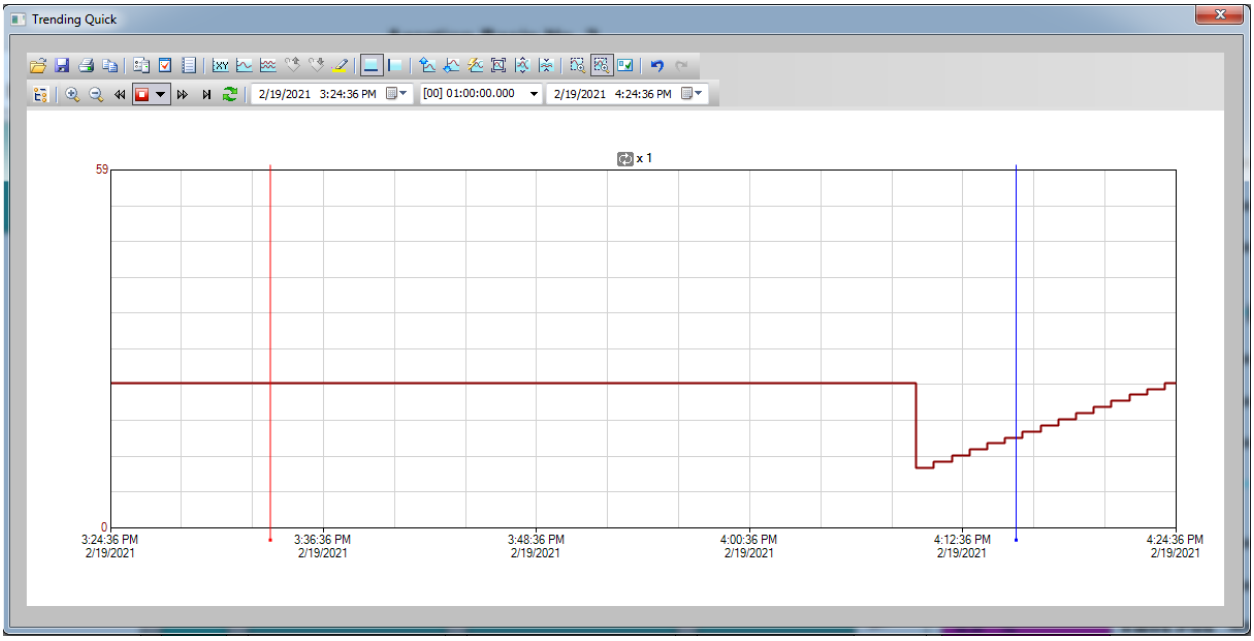


Figure 12-1 Dynamic Trend Pop-up

12.6 AD-HOC Trends

The trend page is accessible from the main menu tab in the page header. This opens a blank trend, where individual tags can be added using the Tag Picker on the left. Custom trends can be saved and re-opened using the menu at the top. The area below the trend shows a legend and allows for pen configuration.

12.7 Preconfigured Trends

Commonly viewed trends can be pre-built for easy access. Buttons within process graphics or on a trend menu are configured with a script to open a trend with specific tags, trend duration, and pen settings.

12.8 Embedded Trends

Trends should be embedded in the process graphics for tank displays. The tank should have fill animation to dynamically show the level changing, and include a trend overlay to show the past hour of level data. Additionally, there should be a bar graph next to the tank that depicts the High-High, High, Low, and Low-Low alarm trip setpoints.

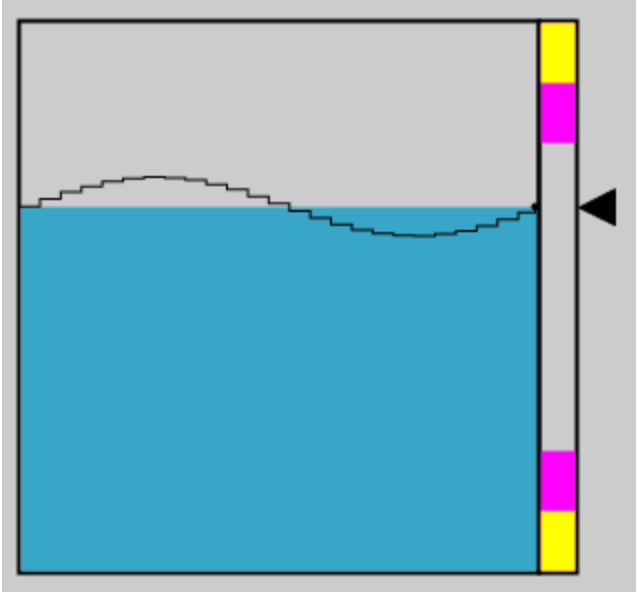


Figure 12-2 Tank Level Embedded Trend

12.9 Trend Properties

12.9.1 Background Color

The color settings for the trend are configured in the Window Scripts of the trend page. They can be adjusted while viewing the trend during runtime but will reset to the default settings the next time the trend page is opened. The trend pages have a white background with black text and gray gridlines. The white background allows for easier printing of trends.

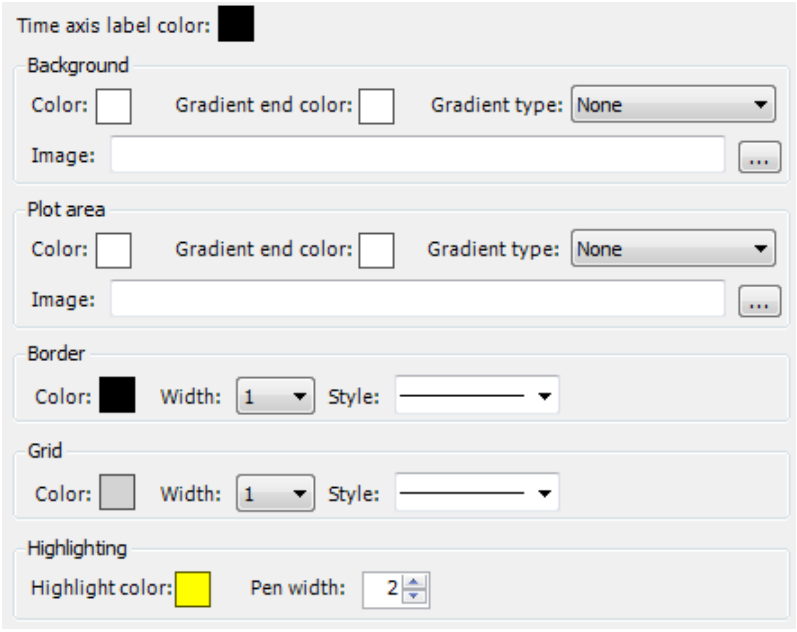


Figure 12-3 Trend Color Settings

12.9.2 Pen Color and width

The standard pen width is 2 for all trend pages. The pen color and width can be adjusted during runtime, but the changes will not save once the user navigates away from the page. Default pen colors can be scripted for preconfigured trend pages as desired.

APPENDIX A ENGINEERING UNITS

Table A1-1 Engineering Units

Name	Label
Amperes	A
Byte	B
Centimeter	cm
Centipoise	cP
Characters	Char
Counter	COUNTER
Cubic centimeter	cm^3
Cubic meter	m^3
Cubic meters per minute	m^3/min
Cycles	Cyc
Day	d
Degrees Celsius	°C
Degrees Fahrenheit	°F
Direction	Dir
Feet	ft
Feet per minute	ft/min
Feet per second	ft/s
Gallons	gal
Gallons per day	gal/d
Gallons per hour	gal/h
Gallons per minute	gpm
Hectoliter	hl
Hectoliters per day	hl/d
Hectoliters per hour	hl/h
Hectoliters per minute	hl/min
Hour	h
Inch	in
Inches of water column	in/WC
Kilogram	kg
Kilograms per minute	kg/min
Kilovolt	kV
Kilowatt	kW
Liter	L
Liters per day	L/d
Liters per hour	L/h
Liters per minute	L/min
Liters per second	L/s
Megabit	Mb
Megawatt	MW

Meter	m
Meters per minute	m/min
Meters per second	m/s
Milligrams per liter	mg/L
Milligrams per minute	mL/min
Million gallons	M-gal
Million gallons per day	MGD
Minute	min
Month	month
Pascal	Pa
Percentage	%
Pound	lb
Pounds per gallon	lb/gal
Pounds per minute	lb/min
Pounds per second	lb/s
Pounds per square inch	psi
Revolutions per minute	rpm
Second	s
Ton	t
Tons per day	t/d
Tons per hour	t/h
Tons per minute	t/min
Turbidity	ntu
Volt	V
Watt	W
Year	y